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POSTOPERATIVE REHABILITATION FOR ACHILLES TENDON RUPTURE: A COMPREHENSIVE STUDY

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Advisor: Prof. Dr. Jeam Marcel Geremia

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Perseverance is the hard work you do
after you get tired of doing the
hard work you already did.

– Newt Gingrich

ABSTRACT

POSTOPERATIVE REHABILITATION FOR ACHILLES TENDON RUPTURE: A COMPREHENSIVE STUDY

Achilles tendon rupture (ATR) is a disabling injury. Four in five people who have suffered an ATR are able to return to their previous sports practice level, while most have persistent and severe functional impairments. Although the optimal treatment remains controversial, surgical approaches are considered effective. Postoperatively, the rehabilitation programs are mainly structured based on weight bearing and lower limb exercises applied in an early (<2 weeks postoperatively) or conservative (>2 weeks postoperatively) approach. Compared to conservative rehabilitation (CR), early rehabilitation (ER) approaches have a therapeutic potential by increasing patient satisfaction and reducing the time to return to pre-injury activities without increasing the risk of re-rupture. However, divergent findings in structural (calf's muscle mass) and functional (heel-rise ability, plantar flexion strength and range of motion) outcomes have been reported with CR versus ER. Therefore, the aim of this master's degree dissertation is to investigate the effects of different rehabilitation approaches on clinical and functional outcomes after ATR surgical repair. This dissertation consists of three chapters. In Chapter I, we aimed to critically review the evidence from systematic reviews on postoperative rehabilitation for ATR. Three databases were searched to identify systematic reviews that synthesized the effects of postoperative rehabilitation programs on clinical and functional outcomes. Methodological analysis was performed using AMSTAR-2 and ROBIS tool. We found 192 studies, of which six were eligible for inclusion. Methodological quality of the studies was rated as critically low (n=5) and moderate (n=1). The risk of bias was rated as high (n=4), unclear (n=1), and low (n=1). ER can be safely applied after ATR surgical repair, providing higher satisfaction than CR. However, evidences of poor methodological quality and high risk of bias suggests that ER may not effectively attenuate clinical and functional deficits after ATR compared with CR. In Chapter II, to better understand the effects of postoperative approaches after ATR, we performed a systematic review of randomized controlled trials. Three databases were searched to identify studies that evaluated the effects of rehabilitation approaches after ATR surgical repair on clinical and functional outcomes. The methodological analysis was performed using the PEDro Scale and RoB-2 tool. The rehabilitation reporting was assessed using the CERT checklist. The results were presented by meta-analysis and narrative synthesis. The certainty in evidence was assessed using the GRADE tool. Of the 790 studies found, 20 were eligible for inclusion. The methodological quality of the studies was rated as fair (n=7) and good (n=13). Our findings (with low to very low certainty in evidence) suggest that: ER are safe and could reduce the time to return to work. Although these approaches lead to better outcomes on multi-item scoring scales in the short and mid-term, these improvements do not persist in the long-term. Different postoperative rehabilitation approaches do not appear to attenuate the post-ATR calf's muscle loss and functional deficits. Most studies lack clear intervention reporting, which limits both clinical applicability and scientific advancement, as most rehabilitation programs are difficult to implement and replicate. Therefore, in Chapter III, we aimed to provide a detailed description of a controlled postoperative ER program and to investigate clinical and functional outcomes comparing CR and ER. Thirty-one male participants underwent either CR (n=14) or ER (n=17) following open surgical repair of ATR. Participants were evaluated at the surgery admission for anthropometrics and injury characteristics, post-12 (P12), and post-26 (P26) weeks of surgery for limb symmetry index of active plantarflexion (PF) and dorsiflexion (DF) ROM, and American Orthopaedic Foot and Ankle Society Score, Ankle-Hindfoot Scale ($\text{AOFAS}_{\text{AHS}}$). No between-group differences were found in anthropometrics and injury characteristics. At P12, compared to CR, the ER group presented a higher limb symmetry index of PF_{ROM} and better outcomes in $\text{AOFAS}_{\text{AHS}}$, while no group differences were found for limb symmetry index of DF_{ROM}. At P26, no between-group differences were found for limb symmetry index of PF_{ROM} and DF_{ROM}, as well for $\text{AOFAS}_{\text{AHS}}$ outcomes. No re-rupture occurred during the follow-up. At the end of rehabilitation (P12), better clinical and functional outcomes without tendon re-ruptures were achieved with ER than CR program, demonstrating that our controlled ER program can safely accelerate the recovery of clinical and functional outcomes following the ATR surgical repair. Finally, taken together, our findings suggest a therapeutic potential in favor of early over late approaches in postoperative rehabilitation for ATR. Furthermore, our findings highlight the importance of control and clear reporting of exercises within a rehabilitation program, as well as the need to further explore complementary post-rehabilitation strategies to support long-term recovery.

Keywords: Early mobilization; Accelerated rehabilitation; Functionality.

RESUMO

REABILITAÇÃO APÓS O REPARO CIRÚRGICO DA RUPTURA DO TENDÃO DE AQUILES: UM ESTUDO ABRANGENTE

A ruptura do tendão de Aquiles (RTA) é uma lesão incapacitante. Embora o tratamento ideal permaneça controverso, as abordagens cirúrgicas são consideradas opções efetivas. No pós-operatório, os programas de reabilitação são estruturados principalmente com base na sustentação de peso e na aplicação de exercícios de membros inferiores, seguindo uma abordagem precoce (<2 semanas de pós-operatório) ou conservadora (>2 semanas de pós-operatório). Comparada à reabilitação conservadora (RC), a reabilitação precoce (RP) pode gerar maior satisfação do paciente e reduzir o tempo de retorno às atividades, sem elevar o risco de rerruptura. Entretanto, resultados divergentes em termos estruturais (massa muscular) e funcionais (capacidade de elevação do calcanhar, força de flexão plantar e amplitude de movimento) são relatados com RC *versus* RP. Assim, o objetivo desta dissertação é investigar os efeitos de diferentes abordagens de reabilitação pós-operatória sobre desfechos clínico-funcionais após a RTA. No Capítulo I, nosso objetivo foi avaliar criticamente revisões sistemáticas que investigaram o efeito da reabilitação pós-operatória da RTA. Foram realizadas buscas em três bancos de dados para identificar revisões sistemáticas sobre os efeitos de programas de reabilitação pós-operatória sobre desfechos clínico-funcionais. A avaliação metodológica foi conduzida com as ferramentas AMSTAR-2 e ROBIS. 192 estudos foram identificados e seis foram considerados elegíveis para inclusão. A qualidade metodológica dos estudos foi classificada como criticamente baixa (n=5) e moderada (n=1). O risco de viés foi considerado alto (n=4), incerto (n=1) e baixo (n=1). Comparada à RC, a RP pode ser aplicada com segurança, proporcionando maior satisfação do participante. Por outro lado, a RP não reduz efetivamente os prejuízos clínico-funcionais quando comparada à RC. Contudo, esses achados são provenientes de estudos com potenciais vieses, o que ressalta a necessidade de estudos com maior rigor metodológico. No Capítulo II, para entender melhor os efeitos das abordagens de reabilitação pós-operatória da RTA, realizamos uma revisão sistemática de ensaios controlados aleatorizados. Três bancos de dados foram pesquisados para identificar estudos que avaliaram os efeitos de diferentes abordagens de reabilitação pós-cirúrgica sobre desfechos clínico-funcionais. A análise metodológica foi realizada usando a escala PEDro e a ferramenta RoB-2. O relato da reabilitação foi avaliado por meio do CERT *checklist*. Os resultados foram sintetizados por meio de meta-análises e síntese narrativa. A certeza da evidência foi avaliada com a ferramenta GRADE. Dos 790 estudos encontrados, 20 eram elegíveis para inclusão. A qualidade metodológica dos estudos foi classificada como regular (n=7) e boa (n=13). Abordagens baseadas na RP são seguras e podem reduzir o tempo de retorno ao trabalho. Embora essas abordagens levem a melhores resultados em escalas clínico-funcionais em curto e médio prazo, em longo prazo RC e RP são similares. Diferentes abordagens de reabilitação pós-operatória não parecem atenuar os déficits funcionais após a RTA. A maioria dos estudos carece de descrições claras da intervenção, o que limita a aplicabilidade clínica e o avanço científico, pois a maioria dos programas tornam-se difíceis para implementar e replicar. Portanto, no Capítulo III, nosso objetivo foi reportar detalhadamente um programa controlado de RP após a cirurgia da RTA; e investigar os diferentes efeitos clínico-funcionais comparando a RC com a RP. Trinta e um participantes do sexo masculino foram submetidos à RC (n=14) ou à RP (n=17) após o reparo cirúrgico aberto da RTA. Os participantes foram avaliados no período de admissão da cirurgia quanto às características antropométricas e de lesão, pós-operatório de 12 (P12) e 26 (P26) semanas quanto ao índice de simetria da amplitude de movimento ativa (ADM) de flexão plantar (FP) e dorsiflexão (DF), além dos escores na *American Orthopaedic Foot and Ankle Society Score, Ankle-Hindfoot Scale* ($\text{AOFAS}_{\text{AHS}}$). Não houve diferenças entre os grupos nas características antropométricas e de lesão. No P12, em comparação com o RC, o grupo RP apresentou um maior índice de simetria de PF_{ADM} e melhores resultados na $\text{AOFAS}_{\text{AHS}}$. Não foram encontradas diferenças entre os grupos para o índice de simetria de DF_{ADM}. Em P26, não houve diferenças entre os grupos para o índice de simetria de PF_{ADM} e DF_{ADM}, bem como na $\text{AOFAS}_{\text{AHS}}$. Não houve nenhuma rerruptura durante o acompanhamento. No final da reabilitação (P12), foram obtidos melhores resultados clínico-funcionais de forma segura com a RP do que com a RC. Por fim, nossos achados, sugerem um potencial terapêutico a favor de abordagens precoces em relação às tardias/conservadoras na reabilitação pós-operatória da RTA. Além disso, destaca-se a importância do controle e da descrição dos exercícios nos programas de reabilitação, bem como a necessidade de investigar estratégias complementares para auxiliar a recuperação a longo prazo.

Palavras-chave: Mobilização precoce; Reabilitação acelerada; Funcionalidade.

SUMMARY

PREFACE

Achilles tendon rupture (ATR) is a disability injury with a high incidence (2.5 to 32.3/100.000 person-year) (Leino et al., 2022). People who have suffered an ATR are absent from work (1-3 months) and sports (3-6 months) (Massen et al., 2022; Zellers et al., 2016) and have severe and long-lasting impairments (Hoeffner et al., 2022). Therefore, treatment and rehabilitation play an important role in attenuating the effects of this public health problem.

Although the optimal treatment (i.e., surgical or non-surgical) remain under debate, operative approaches have been considered a safe option with positive outcomes (Meulenkamp et al., 2018; Ochen et al., 2019). Postoperatively, the rehabilitation programs are mainly structured based on weight bearing and lower limb exercises (Massen et al., 2022; Zellers et al., 2019) applied in an early (<2 weeks postoperatively) or late (>2 weeks postoperatively) approach (Massen et al., 2022; Zellers et al., 2019). The early postoperative period is critical for repair healing (Pajala et al., 2002; Rettig et al., 2005). Traditionally the rehabilitation programs were based on conservative approach with late weight bearing and/or lower limb exercises to avoid compromising the repair (i.e., tendon's stump separation or re-rupture) (Pajala et al., 2002; Rettig et al., 2005). Although conservative load application postoperatively may prevent tendon's repair complications, it can intensify the disuse period (Hoeffner et al., 2022), potentially resulting in muscle mass loss and functional deficits (Hoeffner et al., 2022; Svensson et al., 2019).

Therefore, early rehabilitation (ER) (i.e., early weight bearing and/or lower limb exercises) has been proposed as an alternative to conservative rehabilitation (CR) (i.e., late lower limb exercises and/or weight bearing) approaches (Massen et al., 2022; Zellers et al., 2019). Several studies have investigated the effects of different postoperative rehabilitation approaches for ATR (Zhao et al., 2017). Contrary to initial concerns, conducting rehabilitation with an early approach does not increase tendon re-rupture rates (Massen et al., 2022), suggesting potential therapeutic benefits for ATR postoperative management. Nonetheless, while some studies suggest that ER may improve clinical and functional outcomes (Brumann et al., 2014; Huang et al., 2015), these findings are not consensus (Gould et al., 2021; Massen et al., 2022). These contrasting findings should be further explored to better understand the effect of different rehabilitation approaches in the postoperative management of ATR.

Therefore, our purpose with this dissertation was to evaluate current knowledge, identify gaps, and propose strategies to enhance understanding and clinical management of postoperative rehabilitation for ATR. To accomplish these purposes, we conducted three studies, which are presented in three chapters, each with a graphical abstract to improve scientific communication (which will be enclosed with future publications) (Krukowski and Goldstein, 2023).

In Chapter I, we critically reviewed evidence from systematic reviews on postoperative rehabilitation after ATR, with the purpose of summarizing previous knowledge and highlighting points that could be further explored. In this study, we identified potential methodological concerns that could limit the understanding and interpretation of previous systematic reviews. Thus, In Chapter II, to better understand the effects of postoperative rehabilitation approaches for ATR, we performed a systematic review of randomized controlled trials. In this study, our purpose was to review the available evidence focusing on: clinical and functional outcomes, the influence of assessment timeframe on these outcomes, and providing a critical summary of rehabilitation reporting methods. Importantly, we found that most studies lack clear intervention reporting, which limits both clinical applicability and scientific advancement. In Chapter III, therefore, we aimed to provide a detailed description of a controlled postoperative ER program and to investigate clinical and functional outcomes comparing CR and ER approaches.

Moreover, we believe that the Master's program includes not only the completion of the dissertation, but also a comprehensive scientific education. Therefore, after the final conclusions were presented the research, teaching, and outreach activities undertaken throughout the Master's period. We also present the abstract of an additional study completed during the Master's program. We consider that this study, because of its distinct scope, would be better understood as a production of the Master's period rather than as part of the main chapters of the dissertation.

CHAPTER I

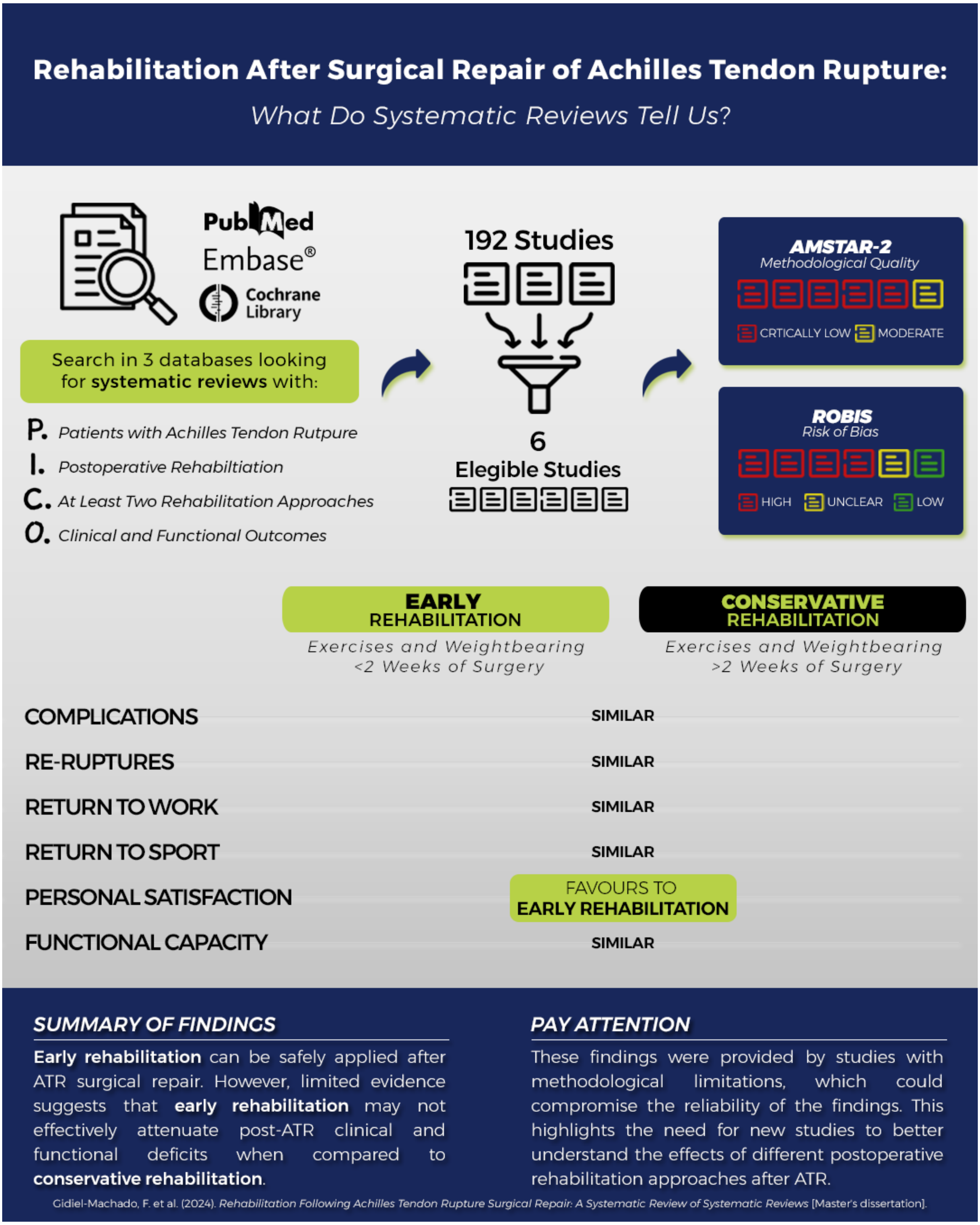
Rehabilitation Following Surgical Repair of Achilles Tendon Rupture: A Systematic Review of Systematic Reviews

ABSTRACT

Background: Postoperative rehabilitation for Achilles tendon rupture (ATR) has been extensively investigated. Although several systematic reviews have been published, the clinicians may feel overwhelmed by the abundance of evidence. **Purpose:** To critically review the available evidence from systematic reviews on postoperative rehabilitation of ATR, providing a summary and identifying gaps in the field. **Methods:** We conducted this study according to Cochrane recommendations and PRISMA guidelines (PROSPERO: CRD42024566281). Three databases (MEDLINE, Cochrane CENTRAL, and Embase) were searched to identify systematic reviews that synthesized the effects of at least two postoperative rehabilitations for ATR on clinical and functional outcomes. Methodological analysis was performed using AMSTAR-2 and ROBIS tools. The overlap assessed using the corrected covered area method. Results were presented by narrative synthesis. **Results:** We found 192 studies, of which six were eligible for inclusion. Methodological quality of the studies was rated as critically low (n=5) and moderate (n=1). The risk of bias was rated as high (n=4), unclear (n=1), and low (n=1). Early rehabilitation (ER) did not increase the re-ruptures and complications compared to conservative rehabilitation (CR). Similar functional performance (i.e., range of motion, strength, heel-rise) and time to return to work/sports were reported with CR and ER. Better outcomes on clinical and functional scales were found with ER than CR in the short-term (<3 months postoperatively), but not in the long-term (>12 months postoperatively). **Conclusion:** ER can be safely applied postoperatively with good participant’s satisfaction. Although similar functional performance and time to return to pre-injury activities was achieved with both approaches, ER resulted in better outcomes on clinical and functional scales in the short-term, potentially accelerating the patient's recovery. However, these findings are based on overlapping systematic reviews with important methodological limitations, which could limit these results. Taken together, our findings highlight the need for well-designed studies to better understand the clinical and functional effects of different postoperative rehabilitation approaches for ATR.

Keywords: Early functional rehabilitation, Accelerated rehabilitation, Tendon tear.

GRAPHICAL ABSTRACT



1. INTRODUCTION

The Achilles tendon rupture (ATR) is a high incidence and disabling injury (Leino et al., 2022; Lemme et al., 2018), causing absence from work (1-3 months) and sports (3-6 months) (Kearney et al., 2012). Four out of five people who have suffered an ATR are able to return to their previous level of sports practice (Zellers et al., 2016), while most of these people have severe and persistent (>10 years) functional impairments (Hoeffner et al., 2022; Zellers et al., 2016).

Although the optimal treatment (i.e., surgical or non-surgical) remains under debate, operative approaches have been considered a safe option with positive outcomes (Meulenkamp et al., 2018; Ochen et al., 2019). Postoperatively, the rehabilitation programs are mainly structured based on lower limb exercises (i.e., ankle, knee and hip) and weight bearing (Zellers et al., 2019) applied in an early (<2 weeks postoperatively) or late (>2 weeks postoperatively) approach. The early postoperative period is critical for repair healing (Pajala et al., 2002; Rettig et al., 2005). Traditionally, rehabilitation programs have been based on late exercise application and/or late weight bearing to avoid compromising the repair (i.e., tendon stump separation or re-rupture) (Pajala et al., 2002; Rettig et al., 2005). Although conservative load application postoperatively may prevent tendon's repair complications, it can intensify the disuse period (Hoeffner et al., 2022), potentially resulting in muscle mass loss and functional deficits (Hoeffner et al., 2022; Svensson et al., 2019). Thus, early rehabilitation (ER) (i.e., early weight bearing and/or lower limb exercises) has been proposed as an alternative to conservative rehabilitation (CR) (i.e., late weight bearing and/or lower limb exercises) approaches (Zellers et al., 2019; Zhao et al., 2017).

Several controlled trials have examined the effects of rehabilitation approaches following ATR surgical repair, and their findings have been summarized in multiple systematic reviews (Zhao et al., 2017). Compared to CR, ER approaches can promote higher personal satisfaction (McCormack and Bovard, 2015; Suchak et al., 2006) and reduce the time to return to pre-injury activities (Gould et al., 2021; McCormack and Bovard, 2015), potentially anticipating the patient's recovery without increasing the risk of re-ruptures (Massen et al., 2022). Nonetheless, the potential to attenuate functional deficits using ER instead of CR remains controversial, with conflicting results across reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015). In addition, while systematic reviews are useful for the clinical practice

(Biondi-Zoccai, 2016; Gurevitch et al., 2018), the professionals can find themselves getting “soaking wet” under “a rain of evidence” (Biondi-Zoccai, 2016). Therefore, our study aimed to critically review systematic reviews on postoperative rehabilitation for ATR and synthesize their findings on complications (re-rupture, major and minor postoperative complications), return to activity (work and sports), participant satisfaction, and functional performance (functional scales, heel-rise ability, strength, and range of motion).

2. METHODS

We conducted this systematic review in accordance with Cochrane recommendations (Chandler et al., 2019), following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021) (for more details see Appendix 1A and 1B). The protocol was registered at the PROSPERO database (CRD42024566281). During the review process, we identified aspects of our protocol that could be better described or altered. Adjustments were applied to the search strategy, intervention and comparator, context, and data synthesis. Detailed justifications for adjusts and deviations from the original protocol are provided in the Appendix 1C. Two independent investigators performed the study selection, data extraction, methodological assessment, and content analysis. Disagreements between investigators were resolved by consensus.

2.1. Search Strategy

On April 20, 2024, we performed the systematic search in the databases MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (Cochrane CENTRAL), and Embase (search updated on October 19, 2024). Although similar keywords were used across all databases, combinations of terms were adapted for each platform using specific terms (Medical Subject Headings for MEDLINE and Cochrane Library, and Emtree terms for Embase) and boolean operators. In the MEDLINE and Embase databases, terms for searching for systematic reviews proposed by Hennessy et al. (2019) were applied in the search strategy. However, we adjusted the filter to retain only terms related to systematic reviews and added the specific terms of each database (see Appendix 1D for details). For a comprehensive search, we did not consider temporal and language restrictions. To identify other potentially eligible studies, the reference lists of all included studies and review registries (PROSPERO database) were checked, as well as experts in the field were consulted. The studies identified from database searches were exported to Rayyan (https://rayyan.ai) (Ouzzani et al., 2016), the duplicates were identified and deduplicated. Full texts were assessed if their abstract were considered eligible by at least one investigator. Finally, the full texts of potentially eligible studies were independently screened against the eligibility criteria.

2.2. Eligibility Criteria

The eligibility criteria were mainly based on PICOS (Population, Intervention, Comparator, Outcomes, and Study design) strategy: P) People treated surgically for Achilles tendon rupture; I) postoperative rehabilitation following ATR repair; C) At least two different types of rehabilitation after surgical treatment; O) Complications (re-rupture, major, and minor complications events; calf's muscle loss, and/or tendon elongation); participant's satisfaction; time to return to pre-injury activities (work and/or sport); clinical and functional outcomes assessed by multi-item scoring scales; and/or functionality outcomes (ankle range of motion, plantar flexion strength, heel-rise performance). A specific timeframe for follow-up was not considered; S) Systematic reviews.

Therefore, we considered studies eligible for inclusion if they reported at least one outcome of interest comparing two or more postoperative rehabilitation approaches in the population of interest. Studies considering non-surgical or both surgical and non-surgical treatment, as well as systematic reviews of systematic reviews/observational studies, non-systematic reviews (narrative reviews, overviews, critical reviews, and state-of-the-art reviews), clinical practice guidelines, evidence summaries, critically appraised, and evidence-based topics (consumer information sheets, clinical pathways, practice information sheets, and technical reports) were excluded.

2.3. Data Extraction

We performed the data extraction using a standardized spreadsheet, considering the systematic reviews characteristics and the description of its included studies: 1) Systematic review characteristics (authors, publication year, purpose, PICOS strategy, conflict of interest statement, number of included studies, and total sample size); 2) Participants' characteristics (sex, age, and body mass index); 3) Injury characteristics (context and time between injury treatment); 4) Surgical characteristics (approach and suture technique); 5) Rehabilitation characteristics (time to weight bearing, weekly training frequency, total intervention/session duration, exercises types, and management of volume and load during exercises); 6) Results of main outcomes assessed (re-rupture occurrence, major complications occurrence [deep venous thrombosis, deep wound infection, and/or nerve damage], minor complications occurrence [superficial wound infection, delayed wound healing, muscle-tendon complex stiffness and/or tissue irritation due to scarring or similar], calf's muscle loss, tendon elongation, participant's satisfaction, time to return to work, time to return to sports, scores on multi-item scoring scales [American Orthopaedic Foot and Ankle Society Score - Ankle-Hindfoot Scale, Leppilahti Score, and/or Achilles Tendon Rupture Score], and/or functionality outcomes [ankle range of motion, plantar flexion strength, heel-rise performance]); 7) Methodological assessments approaches (tools and results for methodological quality and risk of bias); 8) Quantitative data synthesis and its analysis procedures (estimated summary effect combined with a 95% confidence interval, model effects, heterogeneity, and the assessment of publication bias) if available. All results of the quantitative data synthesis were presented using descriptive statistics in the same unit of outcome measurement as reported in the systematic review. For unclear information, we contacted the corresponding author of the respective review. If no response was received, a new contact was made 7 days after the initial contact. If the author responded positively, an additional 14 days was allowed to receive the requested information. However, if there was still no response after 7 days (from the second contact) or 14 days (from a positive response to the first contact), the data were considered as incomplete reporting. After data extraction, the spreadsheets were exchanged between investigators for review to identify errors or discrepancies in data extraction. Divergences were resolved by consensus.

2.4. Methodological Quality and Risk of Bias Assessment

The methodological quality of the included studies was assessed using AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews 2) tool (Shea et al., 2017). The AMSTAR-2 contains 16 questions, each addressing different aspects of the methodological approach to the review process. The responses to the AMSTAR-2 items were not used to calculate an overall score; instead, we aimed to differentiate between critical and non-critical domains, as recommended by Shea et al. (2017). The overall confidence in the results of the included systematic reviews was rated as high (no or one non-critical weakness), moderate (more than one non-critical weakness), low (one critical flaw with or without non-critical weaknesses), or critically low (more than one critical flaw with or without non-critical weaknesses) (Shea et al., 2017).

Considering the high heterogeneity in the methodological quality assessment tools used for rating the intervention studies included in the systematic reviews, we applied the PEDro (Physiotherapy Evidence Database) Scale to obtain a common rating for these studies. Scores were obtained from the PEDro website (https://search.pedro.org.au/search). If the study score was not available on the website, two independent investigators assessed the study. The studies were rated based on their total PEDro scores, categorized as poor (0-3), fair (4-5), good (6-8), or excellent (>8) methodological quality (Cashin, 2020).

The risk of bias of the included systematic reviews was assessed using the ROBIS (Risk of Bias in Systematic Reviews) tool (Whiting et al., 2016). This tool evaluates the risk of bias in (1) study eligibility criteria; (2) identification and selection of studies; (3) data collection and study appraisal; and (4) synthesis and results were considered to assess the (4) overall risk of bias in the review. The risk of bias for each domain in the included studies was categorized as low, high, or unclear risk, following the ROBIS criteria (Whiting et al., 2016).

2.5. Overlap Assessment

The degree to which primary studies were commonly included in systematic reviews (i.e., overlap) was quantified and managed at synthesis stage (Lunny et al., 2021). We used the corrected covered area method (Pieper et al., 2014) to quantify the overlap, which was classified as low (0-5%), moderate (6-10%), high (11-15%), and very high (>15%) (Pieper et al., 2014).

To provide an overview of the literature, we summarized all overlapping systematic reviews. To prevent overlap from giving a false impression of a greater volume of evidence than actually exists, we selected the best evidence for each research question raised in our review (Lunny et al., 2021). The following criteria were employed to select the best-evidence systematic review: 1) better methodological quality; 2) lowest risk of bias; 3) larger number of primary studies included in the synthesis (Lunny et al., 2021).

2.6. Data Synthesis

We performed a narrative synthesis of all included reviews. The results of the systematic reviews were summarized and grouped based on their synthesis approach (i.e., quantitative or narrative synthesis). The rehabilitation approaches were categorized as CR (weight bearing and/or lower limb exercises beginning after 2 weeks postoperatively) or ER (weight bearing and/or lower limb exercises within the first 2 weeks postoperatively). To provide a systematic and reproducible summary of the included systematic reviews that present their results using a narrative synthesis, we performed a deductive content analysis (Elo and Kyngäs, 2008; Krippendorff, 2018), focusing on two themes in the results and discussion/conclusion sections: (1) complications and (2) clinical and functional outcomes following postoperative rehabilitation for ATR. The results and conclusions of all included systematic reviews were summarized in a coding matrix according to the respective themes (Elo and Kyngäs, 2008; Krippendorff, 2018). The meaning units (i.e., results/conclusions reporting) were categorized using specific codes [established on the theoretical basis of Spennacchio et al. (2016) and Hoeffner et al. (2022)] (Table 1). During the coding process, non-identical but similar terms were aligned with the predefined categories and codes (i.e., unstructured coding matrix) (Elo and Kyngäs, 2008). Intercoding agreement was assessed by considering the code existence and overlapping codes (>80% of overlap) within the meaning unit. Common codes were merged, while divergent codes were discussed between investigators until consensus was reached. We performed all content analysis using MAXQDA software (VERBI Software, 2020). Further details of all coded sentences are presented in Appendix 1F. Between-investigator agreement in study selection, and methodological and risk of bias assessments was verified using Cohen's Kappa analysis in Jamovi Software (The Jamovi Project, version 2.5.6, https:// jamovi.org). Agreement was considered adequate if the level of consensus was at least 80% or the kappa result was strong ($\kappa > 0.80$) (McHugh, 2012).

Table 1. Example of sentences coded in the coding matrix considering complications and clinical and functional outcomes following postoperative rehabilitation for Achilles tendon rupture (ATR).

Theme	Categories	Codes	Example of Meaning Unit
Complications following postoperative rehabilitation approaches of ATR	Complications	Re-rupture Complications Tendon Elongation Calf Muscle Loss	"…there was no evidence for increased rerupture rate…" "…none of these studies reported a significant difference in complication rate…" "…no difference was found between groups with regard to tendon elongation." "…calf muscle atrophy…was comparable..."
Clinical and functional outcomes following postoperative rehabilitation approaches of ATR	Return to Pre-Injury Activities	Return to Work Return to Sport	"…resulted in a significantly earlier return to work and sports…"
	Functional Performance	Participant's Satisfaction Heel-Rise Performance Plantarflexion Strength Range of Motion	"…no difference in heel-raise testing was found…" "…no difference between groups in…plantarflexion torque" "No significant differences were observed for range of motion…"
	Multi-Item Scoring Scales	Achilles Tendon Rupture Score American Orthopaedic Foot and Ankle Society Score Leppilahti Score	"…group performed better in term of…AOFAS and ATRS outcome scores." "…no difference between groups in Leppilahti score…"

3. RESULTS

3.1. Study Selection

A flow diagram of the literature search and screening is presented in Figure 1. In the initial search, we identified 192 studies in MEDLINE (PubMed) (n=111), Cochrane Library (n=1), and Embase (n=80). Fifty-four duplicated records were excluded. After screening the titles and abstracts, eight studies were assessed against the eligibility criteria. Two studies did not meet the inclusion criteria, as they considered both surgical and non-surgical treatment for ATR (Lu et al., 2019; Wang et al., 2024). Six reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015; Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006) met all the eligibility criteria and were included in this study. One potentially eligible study (Braunstein et al., 2018) was found in the reference lists of the included reviews. After assessing eligibility, this study was not included because it did not meet the inclusion criteria (included non-comparative studies). No other eligible studies were found using the complementary search strategies.

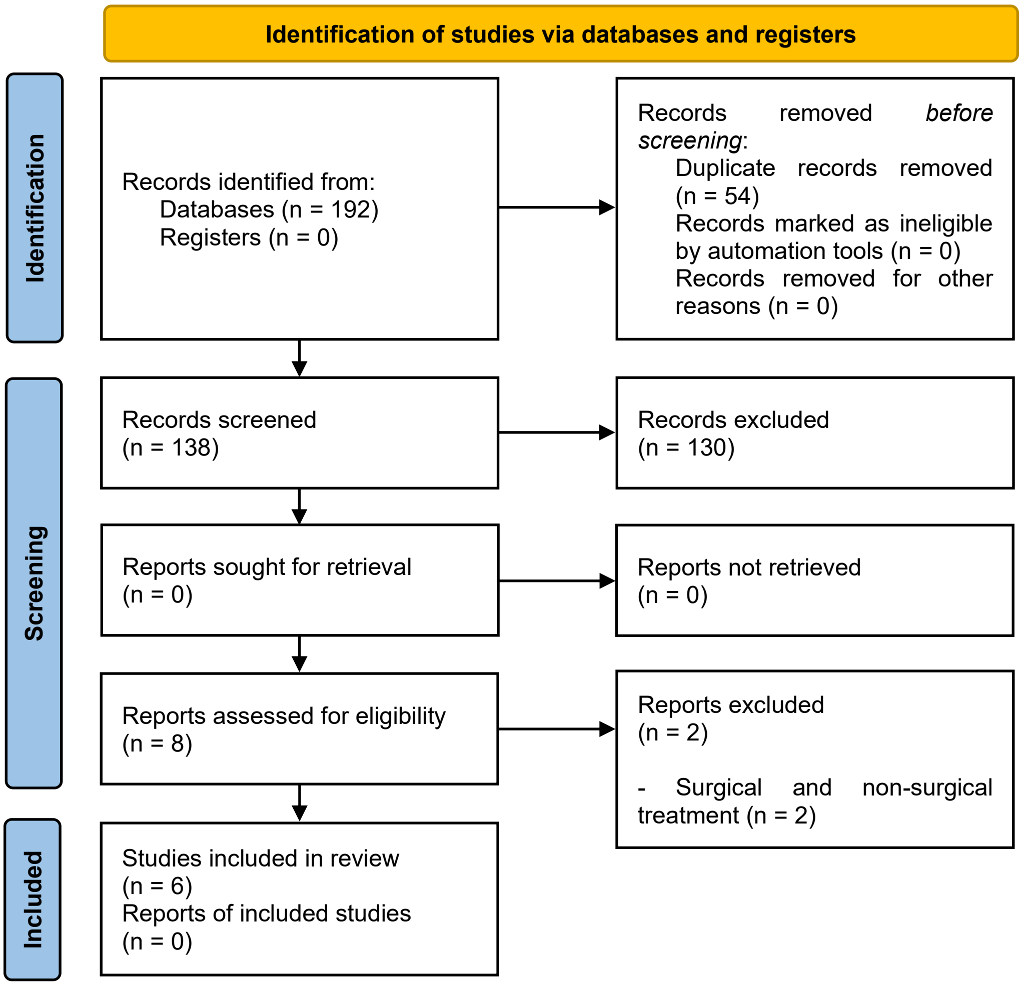


Figure 1. PRISMA Flow Diagram.

3.2. Between-Investigators Agreement

There was 100% agreement for study selection. Results section coding had 91% and 74% agreement for existing and overlapping codes in the document, respectively. In the conclusion section, coders achieved 81% agreement for existing and 78% for overlapping codes. The inter-rater agreement in AMSTAR-2, PEDro, and ROBIS assessments was 90% (κ=0.83), 95% (κ=0.91), and 93% (κ=0.89), respectively.

3.3. Studies Characteristics

The summary of the systematic reviews characteristics is presented in Table 2. Five reviews (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006) declared no potential conflicts of interest. One study (Huang et al., 2015) declared that an author received a source of funding, but the implications and management of this potential conflict were not addressed. The reporting of participants' characteristics in the primary studies included in each systematic review varied. Four reviews (Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006) presented information about sex proportion, which reported a higher proportion of men than women (~6:1) in the intervention studies. Four reviews (Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006) reported the participants' ages, with a mean of 40 years (ranging from 19 to 73 years). Reviews summarizing the context of ATR (Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006) have reported that ATR occurs primarily during sports practice. Among the reviews, the time between injury and surgery was less than 14 days in intervention studies.

According to AMSTAR-2, The overall confidence rating in the systematic review's results was critically low for five reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015; McCormack and Bovard, 2015; Suchak et al., 2006) and moderate for one study (Massen et al., 2022) (Table 3).

Table 2. Summary of included systematic reviews characteristics. *(Continued)*

Review	Included Studies (Sample Size)	Context/Purpose	PICOS	Main Findings and Conclusions
Suchak et al. (2006)	6 (315)	To determine if using early functional protocol for ATR surgical repair improves subjective patient satisfaction without increase in re-rupture rates.	**P:** People with acute ATR treated surgically. **I:** Rehabilitation approaches based on early weight bearing and/or lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Re-rupture rate, rate of major and minor complications, participant's satisfaction, ankle range of motion, and plantar flexion strength. **S:** Prospective randomized or quasi-randomized controlled trials.	ER approaches provide better participant's satisfaction without increasing complications and re-rupture rates than CR approaches. Similar ankle range of motion, and plantar flexion strength were found in both approaches.
Brumann et al. (2014)	12 (555)	To systematically search the evidence available on rehabilitation after ATR surgical repair and define a precise postoperative rehabilitation program.	**P:** People with acute and isolated ATR treated surgically. **I:** Rehabilitation approaches based on early weight bearing and/or lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Re-rupture rate, major complications rate, participant's satisfaction, time to RTW and RTS, clinical-functional outcomes by MIS, ankle range of motion, plantar flexion strength, heel-rise performance, and tendon elongation. **S:** Randomized controlled trials.	ER approaches seem to provide greater participant's satisfaction, shorter time to RTW/RTS, as well better outcomes in plantarflexion strength, calf muscle loss, and tendon elongation compared to CR approaches in the short-term. No differences in complications and re-rupture were found.
Huang et al. (2014)	9 (402)	To provide a comprehensive comparison between early functional rehabilitation and cast immobilization (i.e., late lower limb exercises), and present a subgroup analysis considering two different early functional regimens.	**P:** People with acute (diagnosed <3 weeks of injury) ATR treated surgically (<7 days of injury). **I:** Rehabilitation approaches based on early (<2 weeks of surgery) weight bearing and lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Re-rupture rate, rate of major and minor complications, participant's satisfaction, time to RTW and RTS, ankle range of motion, plantar flexion strength, heel-rise performance, calf muscle loss, and tendon elongation. **S:** Randomized controlled trials, quasi-randomized studies, or prospective comparative studies.	Compare to CR, ER approaches are safe, as similar re-ruptures and complications events were reported using both approaches. Similar clinical and functional outcomes were reported using CR and ER.

Table 2. Summary of included systematic reviews characteristics. *(Ended)*

Review	Included Studies (Sample Size)	Context/Purpose	PICOS	Main Findings and Conclusions
McCormack & Bovard (2015)	11 (570)	To determine which postoperative rehabilitation is superior: early lower limb exercises and weight bearing or late lower limb exercises and weight bearing.	**P:** People with acute ATR treated surgically. **I:** Rehabilitation approaches based on early weight bearing and/or lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Re-rupture rate, rate of major complications, participant’s satisfaction, time to RTW and RTS, ankle range of motion, plantar flexion strength, calf muscle loss, and tendon elongation. **S:** Randomized controlled trials.	ER approaches provide greater participant's satisfaction with no differences in re-ruptures and complications events, while no differences were reported for time to RTW and RTS. Similar functional and structural outcomes were achieved with CR and ER.
Gould et al. (2021)	25 (1171)	To characterize rehabilitation protocols following ATR surgical treatment, summarize the key components of these protocols, and compare their clinical outcomes.	**P:** People with acute ATR treated surgically. **I:** Rehabilitation approaches based on early weight bearing and/or lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Participant’s satisfaction, time to RTW and RTS, clinical-functional outcomes by MIS, ankle range of motion, plantar flexion strength, and heel-rise performance. **S:** Poorly described.	Surgical techniques, rehabilitation protocols, and outcome measures varied widely among the included studies. Compared to CR, ER approaches appear to provide greater participant’s satisfaction, shorter time to RTW/RTS, but divergent results in clinical and functional outcomes.
Massen et al. (2022)	20 (1007)	To compare re-rupture rates, complication rates, functional outcomes, and time to RTW and RTS among different rehabilitation protocols following surgical treatment of ATR.	**P:** People with acute (treated <2 weeks of injury) and isolated ATR treated surgically. **I:** Rehabilitation approaches based on early weight bearing and/or lower limb exercises (ER). **C:** Rehabilitation approaches based on late weight bearing and/or lower limb exercises (CR). **O:** Re-rupture rate, rate of major complications, participant’s satisfaction, time to RTW and RTS, and clinical-functional outcomes by MIS. **S:** Randomized controlled trials.	Similar re-ruptures and complications events occurred in rehabilitation approaches based on early lower limb exercises and/or WB (ER) and late lower limb exercises and/or WB (CR), while the time to RTW/RTS seemed to be smaller using ER than CR approaches. Similar outcomes in MIS were reported, despite CR or ER approaches.

P: population; I: intervention; C: control; O: outcomes; S: study design; ATR: Achilles tendon rupture; ER: early rehabilitation (i.e., early weight bearing and/or lower limb exercises); CR: conservative rehabilitation (i.e., late weight bearing and/or lower limb exercises); RTW: return to work; RTS: return to sport.

Table 3. Results of methodological assessment using A Measurement Tool to Assess Systematic Reviews 2 (AMSTAR-2).

Review	AMSTAR-2 Items																Overall Confidence in the Study's Results
	1	2*	3	4*	5	6	7*	8	9*	10	11*	12	13*	14	15*	16	
Suchak et al. (2006)	Y	N	N	N	Y	N	Y	N	N	N	N	N	N	Y	NA	Y	Critically Low
Brumann et al. (2014)	Y	N	N	N	Y	N	N	N	N	N	NMC	NMC	N	Y	NMC	Y	Critically Low
Huang et al. (2014)	N	N	N	PY	Y	Y	N	N	N	N	N	N	N	N	NA	N	Critically Low
McCormack & Bovard (2015)	Y	N	N	PY	Y	Y	Y	PY	Y	N	Y	Y	Y	N	N	Y	Critically Low
Gould et al. (2021)	N	N	Y	PY	Y	Y	N	PY	N	N	NMC	NMC	N	Y	NMC	Y	Critically Low
Massen et al. (2022)	Y	Y	N	PY	Y	Y	PY	PY	Y	N	Y	Y	Y	Y	NA	Y	Moderate

AMSTAR-2 Items: **(1)** Did the research questions and inclusion criteria for the review include the components of PICOS? **(2)** Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol? **(3)** Did the review authors explain their selection of the study designs for inclusion in the review? **(4)** Did the review authors use a comprehensive literature search strategy? **(5)** Did the review authors perform study selection in duplicate? **(6)** Did the review authors perform data extraction in duplicate? **(7)** Did the review authors provide a list of excluded studies and justify the exclusions? **(8)** Did the review authors describe the included studies in adequate detail? **(9)** Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review? **(10)** Did the review authors report on the sources of funding for the studies included in the review? **(11)** If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results? **(12)** If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis? **(13)** Did the review authors account for RoB in primary studies when interpreting/discussing the results of the review? **(14)** Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review? **(15)** If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review? **(16)** Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?
Legend: *: Critical domain; Y: Yes; PY: Partial yes; N: No; NMC: No meta-analysis was conducted; NA: Not applicable.

The methodological quality of the primary studies included in each systematic review is detailed in Appendix 1E. All systematic reviews included studies that, on average, were rated as having fair methodological quality.

The risk of bias was high for four reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015; Suchak et al., 2006), unclear for one study (McCormack and Bovard, 2015), and low for one study (Massen et al., 2022) (Table 4).

Table 4. Risk of bias of the systematic reviews included.

	Phase 2				Phase 3
Review	**1. Study Eligibility Criteria**	**2. Identification and Selection of Studies**	**3. Data Collection and Study Appraisal**	**4. Synthesis and Findings**	**Risk of Bias**
Suchak et al. (2006)	High	Low	High	High	High
Brumann et al. (2014)	High	Low	High	High	High
Huang et al. (2014)	High	Low	High	High	High
McCormack & Bovard (2015)	Unclear	Low	Unclear	Unclear	Unclear
Gould et al. (2021)	High	Low	High	High	High
Massen et al. (2022)	Low	Low	Low	Low	Low

There is a very high overall overlap (41.5%), as well as in the pairwise comparisons (Table 5). The degree to which primary studies were commonly included in systematic reviews decreased as the difference between their publication dates increased. The comprehensive citation matrix, listing the primary studies included in each systematic review, is presented in Appendix 1E.

Table 5. Citation matrix of overlap assessment through corrected covered area method.

Review	Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
Suchak et al. (2006)	-					
Brumann et al. (2014)	50.0%	-				
Huang et al. (2014)	66.7%	75.0%	-			
McCormack & Bovard (2015)	54.5%	76.9%	81.8%	-		
Gould et al. (2021)	24.0%	37.0%	45.0%	33.3%	-	
Massen et al. (2022)	30.0%	60.0%	55.0%	66.7%	66.7%	-

3.4. Treatment and Rehabilitation Characteristics

The treatment and suture approach used in the primary studies was summarized by three reviews (Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015), the use of open repair was commonly reported, as well the use of Kessler suture technique. The narrative synthesis of rehabilitation characteristics was heterogeneity among the included systematic reviews. The time to weight bearing in CR (21 to 42 days after surgery) and ER (immediately to 14 days after surgery) approaches was described by four reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015; McCormack and Bovard, 2015; Suchak et al., 2006). The exercises types applied during early lower limb exercises were reported by one study (Gould et al., 2021), which reported that the ER programs were primarily composed by ankle range of motion, isometric plantar flexion, and balance exercises. All included reviews lack information about weekly frequency, total intervention/session duration, and management of exercise's volume and load during the early lower limb exercises.

The rehabilitation approaches were grouped into different categories across the included systematic reviews. Suchak et al. (2006) and McCormack and Bovard (2015) present their findings grouped into one rehabilitation comparison: ER (approaches based on early weight bearing and/or lower limb exercises) versus CR (approaches based on late weight bearing and/or lower limb exercises). Brumann et al. (2014) and Gould et al. (2021) present their findings considering three rehabilitations comparisons: 1) early weight bearing versus late weight bearing; 2) early lower limb exercises versus late lower limb exercises; 3) early weight bearing and lower limb exercises versus late weight bearing and lower limb exercises. Huang et al. (2015) presented the results grouped into two rehabilitations comparisons: 1) early lower limb exercises and weight bearing versus late lower limb exercises; 2) early lower limb exercises versus late lower limb exercises. Massen et al. (2022) presented the results considering four rehabilitations approaches: 1) early lower limb exercises and weight bearing; 2) late lower limb exercises and early weight bearing; 3) early lower limb exercises and late weight bearing; 4) late lower limb exercises and weight bearing.

3.5. Complications

3.5.1. Re-rupture

Three reviews performed meta-analysis (Huang et al., 2015; Massen et al., 2022; Suchak et al., 2006), which reported no difference in re-rupture rates using different rehabilitation approaches (CR: 1% to 6%; ER: 2% to 4%) (Table 6). From the content analysis of the narrative synthesis presented by the included systematic reviews (Brumann et al., 2014; Gould et al., 2021), our inference suggests that different ER approaches did not increase the re-rupture events compared to CR approaches.

3.5.2. Minor and Major Complications

Four reviews presented meta-analysis synthesis (Huang et al., 2015; Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006), which indicate no differences in major complications between CR (3% to 7%) and ER (3% to 4%) approaches (Table 6). McCormack and Bovard (2015) reported no differences in major complications (considering the re-rupture a complication) with CR (7%) and ER (4%). For minor complications, three reviews presented meta-analysis synthesis (Huang et al., 2015; Massen et al., 2022; Suchak et al., 2006), which indicate no difference in minor complications rates with CR (14% to 27%) and ER (6% to 25%) approaches (Table 6). Considering reviews that performed a narrative synthesis, our inference from the content analysis indicates that the use of ER or CR approaches did not alter the complication events (Brumann et al., 2014; Gould et al., 2021).

Table 6. Summary of quantitative data synthesis reported by the included systematic reviews. *(Continued)*

Review	Postoperative Rehabilitation Approaches	Outcomes	Quantitative Data Synthesis			
			Included Studies (Sample Size)	Model Characteristics	Summary Effect (95% CI)	Inconsistency test
Suchak et al. (2006)	ELE vs LLE	Re-rupture rate	6 (310)	OR (Random Effect)	0.62 (0.17 – 2.28)	I^2= 0%
		Major Complications	6 (310)	OR (Random Effect)	0.75 (0.22 – 2.49)	NR
		Minor Complications	6 (310)	OR (Random Effect)	0.30 (0.12 – 0.75)	NR
		Participant's Satisfaction	5 (270)	OR (Random Effect)	5.14 (2.61 – 10.12)*	I^2= 0%
Huang et al. (2014)	EWB+ELE vs LLE	Re-rupture rate	6 (279)	OR (M-H, Fixed Effect)	1.36 (0.38 – 4.91)	I^2= 0%
		Major Complications	6 (279)	OR (M-H, Fixed Effect)	0.67 (0.24 – 1.87)	I^2= 0%
		Minor Complications	6 (279)	OR (M-H, Fixed Effect)	0.51 (0.27 – 0.95)	I^2= 0%
		Participant's Satisfaction	3 (IR)	OR (M-H, Fixed Effect)	4.46 (1.54 – 12.95)*	I^2= 0%
		Return to Work (Days)	2 (106)	MD (IV, Random Effect)	17.93 (0.55 – 36.41)	I^2= 91%
		Return to Sports (Weeks)	5 (212)	MD (IV, Fixed Effect)	2.45 (1.57 – 3.33)*	I^2= 0%
	LWB+ELE vs LLE	Re-rupture rate	2 (111)	OR (M-H, Fixed Effect)	0.47 (0.08 – 2.70)	I^2= 0%
		Major Complications	2 (111)	OR (M-H, Fixed Effect)	1.34 (0.28 – 6.31)	I^2= 0%
		Minor Complications	2 (111)	OR (M-H, Fixed Effect)	1.12 (0.39 – 3.24)	I^2= 0%
		Participant's Satisfaction	2 (111)	OR (M-H, Fixed Effect)	1.55 (0.25 – 9.69)	I^2= 0%

Table 6. Summary of quantitative data synthesis reported by the included systematic reviews. *(Ended)*

Review	Postoperative Rehabilitation Approaches	Outcomes	Quantitative Data Synthesis			
			Included Studies (Sample Size)	Model Characteristics	Summary Effect (95% CI)	Inconsistency test
McCormack & Bovard (2015)	EWB+ELE vs LWB+LLE	Major Complications	10 (561)	RD (M-H, Fixed Effect)	-0.03 (-0.06 – 0.01)	I^2= 0%
		Participant's Satisfaction	6 (309)	OR (M-H, Fixed Effect)	3.13 (1.30 – 7.53)*	I^2 0%
		Return to Work (Weeks)	6 (319)	MD (IV, Random Effect)	-1.53 (-4.02 – 0.95)	I^2= 92%
		Return to Sports (Weeks)	6 (248)	MD (IV, Random Effect)	-2.38 (-8.95 – 4.19)	I^2= 84%
Massen et al. (2022)	EWB+ELE vs EWB+LLE	Re-rupture Rate	4 (170)	OR (M-H, Random Effect)	0.63 (0.16 – 2.55)	I^2= 0%
		Major Complications	4 (191)	OR (M-H, Random Effect)	0.97 (0.21 – 4.52)	I^2= 0%
	EWB+ELE vs LWB+LLE	Re-rupture Rate	7 (342)	OR (M-H, Random Effect)	0.61 (0.15 – 2.47)	I^2= 0%
		Major Complications	6 (292)	OR (M-H, Random Effect)	0.82 (0.24 – 2.83)	I^2= 0%
	EWB+LLE vs LWB+LLE	Re-rupture Rate	4 (171)	OR (M-H, Random Effect)	2.13 (0.33 – 13.61)	I^2= 0%
		Minor Complications	4 (171)	OR (M-H, Random Effect)	0.96 (0.47 – 1.96)	I^2= 0%

95% CI: 95% of confidence interval; ELE: early lower limb exercises; LLE: late lower limb exercises; EWB: early weight bearing; LWB: late weight bearing; MD: mean difference; OR: odds ratio; RD: risk difference; IV: inverse variance method; M-H: Mantel-Haenszel method; IR: incomplete reporting; *: significant result in favor of early rehabilitation approach.

3.5.3. Tendon Elongation

One study performed meta-analysis for tendon elongation (Huang et al., 2015). The authors reported less tendon elongation with postoperative approaches based on early lower limb exercises and weight bearing (ER) than late lower limb exercises (CR) at 3 months postoperatively (One study [n=60]; Inverse variance method and fixed effect model; MD [95% CI]=1.40 [0.20 – 2.60]; I^2=Not reported), and at 12 months postoperatively (One study [n=60]; Inverse variance method and fixed effect model; MD [95% CI]=7.40 [2.11 – 12.69]; I^2=Not reported). Huang et al. (2015) reported no differences for tendon elongation with postoperative approaches based on early lower limb exercises (ER) and late lower limb exercises (CR) at 3 months postoperatively (Two studies [n=111]; Inverse variance method and random effect model; MD [95% CI]=1.39 [-2.96 – 5.74]; I^2=0%); at 12 months postoperatively, less tendon elongation were reported for ER than CR (One study [n=50]; Inverse variance method and fixed effect model; MD [95% CI]=3.00 [1.93 – 4.07]; I^2=Not reported). From the content analysis of the reviews that performed a narrative synthesis (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015), our inference suggests that different ER approaches did not increase tendon elongation compared to CR approaches.

3.5.4. Calf's Muscle Loss

One study presented a quantitative synthesis for calf's muscle loss (Huang et al., 2015). The authors reported similar calf circumference decrease with postoperative approaches based on late lower limb exercises (CR) and early lower limb exercises and weight bearing (ER) (Two studies [n=111]; Inverse variance method and random effect model; MD [95% CI]=0.03 [-1.36 – 1.41]; I^2=90%), as well for postoperative approaches in based on late lower limb exercises (CR) and early lower limb exercises (ER) (One study [n=61]; Inverse variance method and fixed effect model; MD [95% CI]=0.25 [-0.27 – 0.77]; I^2=Not reported). Four reviews presented a narrative synthesis (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006). Based on content analysis of the reviews that presented a narrative synthesis, our inference indicates that ER led to similar outcomes in calf's muscle mass loss when compared to CR.

3.6. Clinical and Functional Outcomes

3.6.1. Return to Pre-Injury Activities

Two reviews presented data synthesis using meta-analysis models (Huang et al., 2015; McCormack and Bovard, 2015). Huang et al. (2015) found an earlier return to work (~18 days) and sports (~17 days) with early lower limb exercises and weight bearing (ER) than late lower limb exercises (CR). McCormack and Bovard (2015) found no differences for return to work and sports with CR and ER approaches (Table 6). Three reviews presented a narrative synthesis (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022). Our inference from the content analysis suggests that ER approaches, compared to CR, could led to earlier return to work (5 to 60 days sooner) (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022), as well as shorter time to return to sport (30 to 90 days earlier) (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022).

3.6.2. Satisfaction and Functional Performance

Participant satisfaction was reported through quantitative data synthesis by three reviews (Huang et al., 2015; McCormack and Bovard, 2015; Suchak et al., 2006). Suchak et al. (2006) and McCormack and Bovard (2015) found that ER resulted in 3-5 times more good/excellent participant satisfaction responses compared to CR approaches. Huang et al. (2015) found similar proportion of good/excellent satisfaction between approaches based on early lower limb exercises and late weight bearing (ER) than based on late lower limb exercises (CR). On the other hand, the authors found that approaches based on early lower limb exercises and weight bearing (ER) resulted in 4.5 times more good/excellent participant's satisfaction than approaches based on late lower limb exercises (CR) (Huang et al., 2015). Based on content analysis of the reviews that presented a narrative synthesis (Brumann et al., 2014; Gould et al., 2021), our inference indicates that similar participant's satisfaction was achieved with CR and ER approaches.

The heel-rise performance was presented by three reviews (Brumann et al., 2014; Gould et al., 2021; Huang et al., 2015). Huang et al. (2015) reported a larger number of participants able to perform a heel-rise at 6 months postoperatively using approaches based on early lower limb exercises and weight bearing (ER) compared to those based on late lower limb exercises (CR) (One study [n=60]; Mantel-Haenszel method and fixed effect model; OR [95% CI]=19.47 [1.06 – 358.38]; I^2=Not reported). On the other hand, no differences between approaches based on early lower limb exercises (ER) and late lower limb exercises (CR) (One study [n=61]; Mantel-Haenszel method and fixed effect model; OR [95% CI]=3.20 [0.13 – 81.78]; I^2=Not reported) were reported (Huang et al., 2015). Based on content analysis of reviews that performed a narrative synthesis (Brumann et al., 2014; Gould et al., 2021), our inference suggest that heel-rise performance was not different regardless of whether CR or ER postoperative approaches were used.

The plantar flexion strength performance was presented using meta-analysis by one study (Huang et al., 2015), and using a narrative synthesis by four reviews (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006). Huang et al. (2015) reported smaller percentage of plantarflexion strength loss with postoperative approaches based on early lower limb exercises and weight bearing (ER) late lower limb exercises (CR), at 3 months postoperatively (One study [n= 60]; Inverse variance method and fixed effect model; MD [95% CI]=12.20 [9.35 – 15.05]; I^2=Not reported) and 12 months postoperatively (One study [n=60]; Inverse variance method and fixed effect model; MD [95% CI]=7.60 [4.05 – 11.15]; I^2=Not reported). However, the authors reported no difference for plantarflexion strength loss using postoperative approaches based on early lower limb exercises (ER) and late lower limb exercises (CR), at 3 months postoperatively (One study [n=50]; Inverse variance method and fixed effect model; MD [95% CI]=1.10 [-2.78 – 4.98]; I^2=Not reported) and 12 months postoperatively (One study [n=50]; Inverse variance method and fixed effect model; MD [95% CI]=8.80 [-1.42 – 19.02]; I^2=Not reported) (Huang et al., 2015). Based on content analysis of the reviews that presented a narrative synthesis (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006), our inference suggest that ER could not attenuate/improve the plantarflexion strength deficits when compared to CR approaches.

Ankle range of motion performance was presented using meta-analysis by one study (Huang et al., 2015), and using a narrative synthesis by four reviews (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006). Huang et al. (2015) reported a larger proportion of participants returning to normal ankle range of motion with postoperative approaches based on early lower limb exercises and weight bearing (ER) than late lower limb exercises (CR) (One study [n=60]; Mantel-Haenszel method and fixed effect model; OR [95% CI]=10.55 [1.23 to 90.66]; I^2=Not reported); while no differences were reported using early lower limb exercises (ER) or late lower limb exercises (CR) (Two studies [n=111]; Mantel-Haenszel method and fixed effect model; OR [95% CI]=1.33 [0.60 – 2.93]; I^2=0%). From the content analysis of reviews that presented a narrative synthesis (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006), our inference indicates that ankle range of motion outcomes were not different regardless of whether CR or ER postoperative approaches were used.

3.6.3. Multi-Item Scoring Scales

The clinical and functional outcomes evaluated by multi-item scoring scales (i.e., American Orthopaedic Foot and Ankle Society Score - Ankle-Hindfoot Scale, Leppilahti Score, and/or Achilles Tendon Rupture Score) were narratively synthetized by two reviews (Gould et al., 2021; Massen et al., 2022). Our inference, based on content analysis of the reviews that presented a narrative synthesis, suggests that ER may achieve better outcomes than CR in the short-term (<3 months postoperatively) (Gould et al., 2021), though no differences were observed in the long-term (>12 months postoperatively) (Gould et al., 2021; Massen et al., 2022).

3.7. Best-Evidence Synthesis

Although we provided an overview of the results from all the included systematic reviews, which present considerable agreement in their conclusions, the best available evidence was provided by three reviews (Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015). The findings of Massen et al. (2022) indicated that ER approaches did not increase the rate of re-ruptures and complications after ATR surgical repair (Massen et al., 2022). The results of Gould et al. (2021) suggest that ER approaches based on early lower limb exercises and weight bearing did not result in excessive tendon elongation, while these approaches did not prevent the post-ATR calf's muscle losses. The findings of McCormack and Bovard (2015) indicate that higher satisfaction with ER than CR approaches. Nonetheless, no significant differences between postoperative approaches were reported for time to return to work and sports (McCormack and Bovard, 2015).

Finally, the results of Gould et al. (2021) indicated that similar functional performance was achieved with both CR and ER postoperative approaches. However, the authors found that ER presented better outcomes on clinical and functional scales in the short-term (<3 months postoperatively), but not in the long-term (>12 months postoperatively) (Gould et al., 2021).

4. DISCUSSION

In this study we aimed to critically review systematic reviews on postoperative rehabilitation after ATR and synthesize their findings on clinical and functional outcomes. Our findings indicate that ER approaches (early lower limb exercises and weight bearing) safely led to greater patient satisfaction compared to CR approaches (late lower limb exercises and weight bearing), as similar re-ruptures or complications events were reported using both postoperative rehabilitation approaches. Moreover, similar functional performance was achieved with CR and ER postoperative approaches, while better results on clinical and functional scales were found with ER than CR in the short-term (<3 months postoperatively), but not in the long-term (>12 months postoperatively). However, most systematic reviews had important methodological limitations that may limit the interpretation of these findings and should be considered with caution.

The risk of bias in the included systematic reviews was rated as high (3/6 reviews), unclear (1/6 reviews), and low (1/6 reviews). Reviews that presented high risk of bias did not implement procedures to reduce bias during the definition of eligibility criteria, data collection, and data synthesis (Whiting et al., 2016). The overall confidence in the results of the included systematic review was rated as critically low (5/6 reviews) to moderate (1/6 reviews) according to the AMSTAR-2 criteria (Shea et al., 2017). The critically low methodological quality could be attributed mainly to two critical flaws: the absence of an explicit a priori statement of the review methods (item 2); and the use of inadequate techniques for assessing the risk of bias in the individual studies included (item 9). Although Massen et al. (2022) provided a clear and well-reported description of the systematic review process (without critical flaws), the absence of an explanation for the selection of study designs for inclusion (item 3) and the lack of a report on the sources of funding for the included studies (item 10) resulted in a moderate quality rating. Although the methodological quality of the systematic review is important, the quality of the primary studies should also be considered when appraising the review findings.

The methodological quality of the intervention studies was homogeneous across the systematic reviews. On average, the primary studies were of fair methodological quality according PEDro scores. Although some studies established prior criteria to include high quality studies (Gould et al., 2021; McCormack and Bovard, 2015), the methodological quality of primary studies was similar to the other systematic reviews (Brumann et al., 2014; Huang et al., 2015; Massen et al., 2022; Suchak et al., 2006), considering the PEDro scores evaluated in our study. Therefore, it is important to consider that the evidence for all systematic reviews was provided by intervention studies with potential methodological limitations.

The very high overlap in the systematic reviews included in our study was expected, given that our eligibility criteria and research question implied it. Nonetheless, we quantified and managed the overlap during the synthesis stage (Lunny et al., 2021), as our primary aim was to provide an overview of the evidence from systematic reviews on postoperative rehabilitation following ATR surgical repair. Despite the high level of overlap, we have endeavored to report this phenomenon explicitly. To prevent the overlapping evidences from giving the false impression of a greater volume of evidence than actually exists, we selected the best evidence for each research question raised in our review (Lunny et al., 2021).

Postoperatively, CR (i.e., late weight bearing and/or lower limb exercises) were applied to avoid compromising the tendon's repair (e.g., tendon's stump separation or re-rupture) (Pajala et al., 2002; Rettig et al., 2005; Suchak et al., 2006). Nonetheless, our findings suggest that ER (i.e., early lower limb exercises and/or early weight bearing) did not increase tendon elongation, complications, and re-rupture events compared to CR. Although a clear mechanism has not been identified for these outcomes, the early and progressive loading has been suggested to improve the healing process (Valkering et al., 2017) and mechanical properties (Schepull and Aspenberg, 2013) of a ruptured Achilles tendon. These effects on the healing process may influence tendon tensile strength, which, although speculative, may be associated with no increase in these complications using ER approaches. As a safe alternative to CR, ER approaches have been used with the aim of reducing the disuse period due to absent from work/sport, which can lead to muscle mass losses (Eliasson et al., 2018; Heikkinen et al., 2017). However, our findings do not support a significant effect of ER in attenuating the post-ATR calf's muscle mass loss compared to CR, which may be related to the low profile of loads commonly used in rehabilitation programs (Christensen et al., 2020; Zellers et al., 2019). Therefore, it is plausible to suggest that the low-load exercises used in ER programs may be insufficient to induce significant muscle adaptations or attenuate disuse effects.

Through a meta-analysis, Huang et al. (2015) and McCormack and Bovard (2015) reported similar time to return to work with CR and ER approaches. Although these studies reported similar findings, it is important to consider that both exhibited high heterogeneity (I^2>90%) in data synthesis, which can affect the precision of the estimated effects (Gurevitch et al., 2018). The high heterogeneity could be related to different employment activities (e.g., manual or office workers) that were not controlled/reported in the primary intervention studies, as reported by authors. For time to return to sport, Huang et al. (2015) found a return 17 days sooner with ER than CR, while McCormack and Bovard (2015) reported no statistically differences with ER and CR approaches. These contrasting findings could be related to the effects models applied in each study. Huang et al. (2015) used a fixed-effects model to summarize this outcome, while McCormack and Bovard (2015) conducted the meta-analysis using a random-effects model. Fixed-effects models provide narrow confidence intervals with precise effect estimates by assuming that all studies estimate the same effect, while random-effects models provide wider confidence intervals and effect estimates that account for uncertainty due to heterogeneity (Borenstein et al., 2009). Considering the potential heterogeneity in rehabilitation protocols and outcome assessments across the primary intervention studies, a random-effects model may be a suitable methodological approach for analyzing this outcome (Borenstein et al., 2009). Therefore, it seems reasonable to consider that the findings of McCormack and Bovard (2015) may provide a more reliable result for the time to return to pre-injury activities, suggesting a similar time for returning to work and sports with CR and ER approaches.

From the content analysis of the narrative synthesis (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022), our findings suggest an earlier return to pre-injuries activities. Most studies reported that participants who received ER returned earlier to work (5-60 days) and sport (30-90 days) compared to those who received CR approaches (Brumann et al., 2014; Gould et al., 2021; Massen et al., 2022). However, it should be considered that narrative syntheses of quantitative effects are characterized by a lack of transparency, which leads to difficulties in assessing the validity of their findings (Campbell et al., 2019). Taken together, our findings regarding time to return to pre-injury activities should be considered with caution when considering the effect of different rehabilitation approaches after ATR surgical repair.

Divergent findings on participant's satisfaction were found by studies that performed meta-analysis. Although some studies reported greater satisfaction with ER compared to CR (McCormack and Bovard, 2015; Suchak et al., 2006), other found similar outcomes (Huang et al., 2015). Huang et al. (2015) compared approaches focusing only on lower limb exercises (i.e., late lower limb exercises versus early lower limb exercises). Thus, comparable results may be associated with weight bearing restrictions during rehabilitation, as early ambulation promotes greater independence in daily activities (Maffulli et al., 2003), while weight bearing limitations may hinder it. Conversely, Suchak et al. (2006) and McCormack and Bovard (2015) compared approaches based early lower limb exercises and weight bearing (ER) to those based on late lower limb exercises and weight bearing (CR), finding greater satisfaction with ER compared to CR. Therefore, given that early postoperative rehabilitation approaches do not appear to increase the risk of re-ruptures or complications, it is reasonable to suggest that both early lower limb exercises application and weight bearing can be safely applied, potentially improving participant satisfaction.

Studies that performed a narrative synthesis reported divergent findings for participant's satisfaction outcomes (Brumann et al., 2014; Gould et al., 2021). Although Gould et al. (2021) avoided suggesting that greater participant's satisfaction could be achieved with ER than CR approaches, Brumann et al. (2014) concluded that ER resulted in better participant satisfaction compared to CR approaches. However, the narrative synthesis of primary studies presented by the authors indicated no statistically significant difference between these rehabilitation approaches (Brumann et al., 2014). Moreover, it should be considered that the narrative synthesis of the included studies lacks detailed reporting, which may lead to a potential misrepresentation of the evidence (Campbell et al., 2019). Thus, considering the best available evidence, a greater participant satisfaction can be achieved with ER than CR approaches (McCormack and Bovard, 2015), although these findings should be interpreted with caution due to the methodological limitations of the study.

Studies have continuously investigated the potential of ER to attenuate functional deficits after ATR compared to CR (Zellers et al., 2019). These impairments include deficits in plantar flexion range of motion (~20%) (Agres et al., 2020; Silbernagel et al., 2012) and plantar flexion strength (~30%) (Mullaney et al., 2006; Svensson et al., 2019), which are associated with poor performance during heel-rise tasks (Silbernagel et al., 2012; Svensson et al., 2019). It has been reported that post-ATR functional deficits are consistently associated with significant myotendinous structural remodeling (Heikkinen et al., 2017; Silbernagel et al., 2012; Svensson et al., 2019). As an inherent adaptation of the healing process, the ruptured tendon exhibits an increase in length, reducing the myotendinous capacity of transmitting tension to the calcaneus bone (Stäudle et al., 2021; Svensson et al., 2019). Along with tendon elongation, disuse-related calf's muscle loss can lead to poor functional performance during plantarflexion movements after an ATR (Heikkinen et al., 2017; Svensson et al., 2019).

Although ER approaches have been applied in order to attenuate disuse effects and functional deficits (Zellers et al., 2019), our findings do not support better functional outcomes using ER than CR. Despite some studies suggest better short-term outcomes (i.e., <3 months postoperatively) for ankle range of motion with ER, the results from the primary studies included in their narrative synthesis were not statistically significant (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006). Similarly, no significant differences were reported for plantar flexion strength and heel-rise performance between ER and CR approaches (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015; Suchak et al., 2006). It is possible that the low load profile of ER (Christensen et al., 2020; Zellers et al., 2019) may not be sufficient to promote effective adaptations, suggesting that ER may not be able to attenuate functional deficits after ATR. Nonetheless, it should be considered that these findings were reported by studies lacking detailed information in their narrative synthesis, which can compromise the interpretation of findings (Campbell et al., 2019).

On the other hand, the findings of Gould et al. (2021) indicate that better outcomes in multi-item scoring scales were achieved using ER than CR. Based on content analysis of narrative synthesis reported by Gould et al. (2021), our findings suggest that better clinical and functional outcomes achieved using ER occurred mainly in the short-term (<3 months postoperatively), whereas these effects were not sustained in the long-term (>12 months postoperatively). Similarly, Massen et al. (2022) reported no differences in clinical and functional outcomes between CR and ER approaches at 12 months postoperatively. Taken together, these results could suggest that ER approaches may accelerate participants' recovery compared to CR, but may not be able to reduce long-term impairments. However, most of the systematic reviews included in our study did not explicitly examine the timing of the post-rehabilitation assessments. Therefore, it is relevant to suggest the importance of further studies to evaluate the effectiveness of rehabilitation at different timeframes after injury, which could help improve and develop strategies for postoperative rehabilitation of ATR.

Some limitations imply caution to interpret our findings. Our study was not planned to provide quantitative, but a narrative summary of the available evidence from systematic reviews. Therefore, we have endeavored to reduce the bias during the narrative synthesis, providing a reproducible process of this synthesis using a deductive content analysis. However, this approach requires a reflexive process during analysis, making it difficult to avoid information and confirmation biases. While efforts were made to reduce potential bias during narrative synthesis (i.e., coding process in duplicates), this inherent limitation should be considered. Our findings were provided by overlapping systematic reviews, which could give the false impression of a greater amount of evidence than actually exists. However, we strive to explicitly report the high level of overlap and provide a best-evidence synthesis, discussing points of divergence and providing an overview of the current literature. Finally, our systematic review did not aim to perform a critical analysis of the primary studies included in the systematic reviews, but instead provided a critical appraisal and summary of these systematic reviews. Therefore, we strongly recommend reading the individual systematic reviews to assess the intervention studies included, in order to broaden understanding of their findings.

5. CONCLUSION

Taken together, our findings suggest that ER could be applied safely after the ATR surgical repair, leading to greater participant’s satisfaction than CR.

Furthermore, although similar functional performance and time to return to pre-injury activities was achieved with the CR and ER approaches, ER resulted in better outcomes on clinical and functional scales in the short-term (<3 months postoperatively) but not in the long-term (>12 months postoperatively). However, it is important to consider that these findings are based on overlapping systematic reviews with important methodological limitations. Taken together, our findings highlight the need for well-designed studies to better understand the effects of different postoperative rehabilitation approaches after ATR.

ADDITIONAL INFORMATION

Felipe Gidiel Machado received a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, from Brazil (88887.798480/2022-00), and expressed his acknowledgement for the support. However, this financial support does not imply any conflicts of interest, as well as there are no other potential conflicts of interest. To minimize the impact of cross-cultural language adaptation, the text grammar and concordance were checked using artificial intelligence translation tools from DeepL Translate Software (https://deepl.com) and OpenAI's ChatGPT (https://openai.com/chatgpt).

CHAPTER II

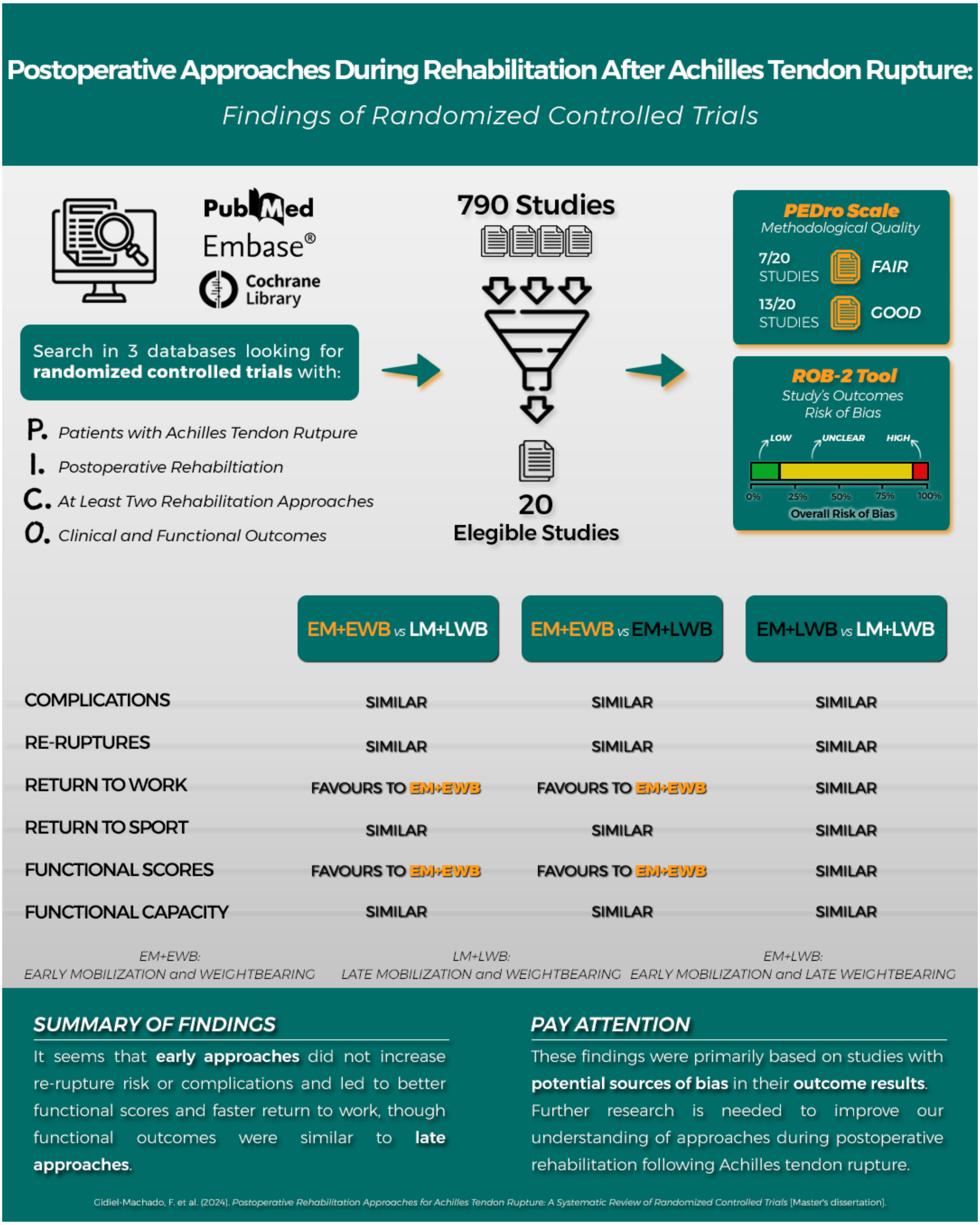
Postoperative Rehabilitation Approaches for Achilles Tendon Rupture: A Systematic Review of Randomized Controlled Trials

ABSTRACT

Background: Achilles tendon rupture (ATR) leads to severe and long-lasting functional deficits. Although several systematic reviews have been published, these studies have important methodological concerns that limit their findings and conclusions. **Purpose:** To systematically review the evidence for postoperative ATR rehabilitation on clinical and functional outcomes, assessment timeframes, and rehabilitation reporting. **Methods:** We conducted this study following the Cochrane recommendations and reported according to PRISMA guidelines. The study was registered in PROSPERO (CRD42024569508). Three databases were searched to identify randomized controlled trials that evaluated the effects of rehabilitation approaches after ATR surgical repair on clinical and functional outcomes. The methodological analysis was performed using the PEDro Scale and RoB-2 tool. The rehabilitation reporting was assessed using the CERT checklist. The results were summarized using meta-analysis and narrative synthesis. The certainty in evidence was assessed using the GRADE tool. **Results:** Of the 790 studies, 20 were eligible for inclusion. The methodological quality of the studies was rated as fair (7 studies) and good (13 studies). Rehabilitation based on early approaches provide a faster return to work than late approaches, with similar occurrences of re-rupture and complications. Better outcomes in multi-item scoring scales were found at short-term (≤12 weeks postoperatively) and mid-term (12-48 weeks postoperatively) using early than late rehabilitation approaches. However, different rehabilitation approaches do not appear to influence other clinical and functional outcomes. **Conclusion:** Compared to late, early approaches are safe and could reduce the time to return to work. Although these approaches lead to better outcomes on multi-item scoring scales in the short- and mid-term, but not at long-term (≥48 weeks postoperatively). Furthermore, the different postoperative rehabilitation approaches do not seem to attenuate the functional deficits after ATR, which could be related to the low load achieved during the exercises. Taken together, our findings suggest the importance of exercise control and reporting within a rehabilitation program, as well as the need to develop complementary strategies to improve long-term recovery outcomes.

Keywords: Evidence synthesis, Meta-analysis, Functional recovery, Tendon repair.

GRAPHICAL ABSTRACT



1. INTRODUCTION

Achilles tendon rupture (ATR) is a disabling injury (Leino et al., 2022; Lemme et al., 2018). People who have suffered an ATR are absent from work for up to 1-3 months (Massen et al., 2022), and return to previous sports activities were possible up to 6-12 months after surgery (Massen et al., 2022; Zellers et al., 2016), although only 1 in 5 people successfully return to sports (Zellers et al., 2016). Therefore, several efforts are being directed towards advances in the treatment and rehabilitation of ATR.

Although the optimal treatment (i.e., surgical or non-surgical) remain controversial, operative approaches have been considered a safe option with positive outcomes (Meulenkamp et al., 2018; Ochen et al., 2019). Postoperatively, the rehabilitation programs are mainly structured based on lower limb exercises and weight bearing conducted in an early (<2 weeks postoperatively) or late (>2 weeks postoperatively) approach (Zellers et al., 2019). Nonetheless, the best approach to conduct the postoperative rehabilitation remains under debate (Massen et al., 2022; McCormack and Bovard, 2015).

Several controlled trials have been conducted addressing the effects of different rehabilitation approaches following ATR surgical treatment. The findings of intervention studies have been summarized by multiple systematic reviews (Zhao et al., 2017). These studies provide evidences that early approaches did not lead to increase in complications (Massen et al., 2022; McCormack and Bovard, 2015), while potentially reducing time to return to pre-injury activities (Gould et al., 2021; McCormack and Bovard, 2015). However, its efficacy on attenuating functional impairments remains under debate (Gould et al., 2021; McCormack and Bovard, 2015). Moreover, the previous systematic reviews on postoperative rehabilitation present some theorical and methodological aspects that should be further explored (as presented in the Chapter I).

Firstly, most of the systematic reviews present important methodological limitations, such as low methodological quality and high risk of bias, which could limit their conclusions. Secondly, although some studies have been reported that better outcomes in early rehabilitation approaches seemed to occur in short-term assessments (<3 months postoperatively) (Gould et al., 2021; Suchak et al., 2006), no systematic reviews have clearly explored the effects of different rehabilitation approaches considering the timeframe of assessments. Thirdly, while the evidence syntheses provided by systematic reviews are useful for professionals involved in the treatment and rehabilitation process (Gurevitch et al., 2018), most of the studies failed to provide a critical appraisal on the rehabilitation methods and its reporting (as discussed in the Chapter I). Addressing this gap is essential for supporting clinical decisions during rehabilitation management and advancing the scientific field. Therefore, our study aims to critically review the available evidence from randomized controlled trials on postoperative rehabilitation for ATR, with a focus on: (1) evaluating the effects on complications (re-rupture, major and minor postoperative complications), return to activity (work and sports), and functional performance (functional scales, heel-rise ability, strength, and range of motion; (2) examining the influence of assessment timeframes on these outcomes; and (3) providing a critical appraisal of rehabilitation reporting.

2. METHODS

We performed and reporting our systematic review following the Cochrane recommendations (Chandler et al., 2019) and the Preferred Reporting Items for Systematic Reviews and Meta Analyzes (PRISMA) guidelines (Page et al., 2021) (for more details see Appendix 2A and 2B). The protocol was registered at PROSPERO database (CRD42024569508). During the review process, we identified aspects of our protocol that could be better described or altered. Adjustments were applied to the search strategy, intervention and comparator, outcomes, data extraction, and data synthesis. Therefore, the detailed justifications for adjusts and deviations from the original protocol are provided in the Appendix 2C. Two independent investigators performed the study selection, data extraction, methodological quality, risk of bias, and certainty in evidence assessments. Disagreements between the investigators were resolved by consensus. If no consensus was reached, a third investigator adjudicated.

2.1. Search Strategy

On July 16, 2024, we performed the systematic search in the databases MEDLINE (PubMed), Cochrane Central Register of Controlled Trials (Cochrane CENTRAL), and Embase (search updated on September 06, 2024). Although similar keywords were used across all databases, combinations of terms were adapted for each platform using specific terms (i.e., Medical Subject Headings for MEDLINE and Cochrane Library, and Emtree terms for Embase) and boolean operators. Searches filters for randomized clinical trials were applied for MEDLINE (PubMed) (Glanville et al., 2019) and Embase (Glanville et al., 2020) (for further details refer to Appendix 2D). For a comprehensive search, temporal and language restrictions were not applied. To identify other potentially eligible trials, the reference lists of all included trials and trial registries (https://ClinicalTrials.gov) were checked. Experts in the field were consulted. The studies identified from database searches were exported to Rayyan (https://rayyan.ai) (Ouzzani et al., 2016), the duplicates were identified and deduplicated. Full texts were assessed if their abstract were considered eligible by at least one investigator. Finally, we independently screened the full texts of potentially eligible studies against the eligibility criteria.

2.2. Eligibility criteria

The eligibility criteria were mainly based on PICOS (Population, Intervention, Comparator, Outcomes, and Study design) strategy: P) Participants treated surgically for acute (<14 days) Achilles tendon rupture; I) Postoperative rehabilitation following ATR repair (randomized rehabilitation assignment); C) At least two different types of rehabilitation after surgical treatment; O) Re-rupture rate; major complications (deep venous thrombosis, deep wound infection, or nerve damage); minor complications (superficial wound infection, delayed wound healing, and tissue irritation due to scarring or similar); calf's muscle mass/loss; tendon length/elongation; time to return to work; time return to sport; clinical and functional outcomes evaluated by Achilles Tendon Rupture Score, American Orthopedic Foot and Ankle Society Ankle-Hindfoot Scale ($AOFAS_{AHS}$), and/or Leppilahti Score; ankle range of motion; isometric plantar flexion strength; heel-rise performance (height, number, and/or work). Although a specific follow-up timeframe was not considered, the included studies were categorized into short-term (≤12 weeks postoperatively), mid-term (12-48 weeks postoperatively), and long-term (≥48 weeks postoperatively) follow-up (the rationale for this is presented in the data synthesis); S) Randomized controlled trials [this study design was chosen because it is considered the gold standard for testing causal hypotheses in clinical context (Hariton and Locascio, 2018)]. Therefore, we considered studies eligible for inclusion if they reported at least one outcome of interest comparing two or more postoperative rehabilitation approaches in the population of interest. We excluded studies considering both surgical and non-surgical treatment, delayed surgical treatment (>14 after injury), only one rehabilitation group, non-randomized rehabilitation assignment, and discordant outcomes to the PICOS. Moreover, were excluded systematic reviews, meta-analyses, editorials, comments, letters to the editor, annals of events, in vitro or animal model studies, and non-peer-reviewed studies (books, dissertations and theses, and pre-print studies).

2.3. Data Extraction

We performed the data extraction using MAXQDA software (VERBI Software, 2020), considering as codes: 1) Study characteristics (authors, publication year, country, purpose, conflict of interest statement); 2) Sample characteristics (sex, age, body mass index, and total sample size); 3) Injury characteristics (context, and injury-treatment time); 4) Treatment characteristics (approach and suture technique); 5) Rehabilitation characteristics (immobilization approach, time to weight bearing, exercise descriptors, and duration/frequency of interventions); 6) Results of outcomes and its assessment methods. For unclear information, we contacted the corresponding author of the respective study. If no response was received, a new contact was made 7 days after the initial contact. If the author responded positively, an additional 14 days was allowed to receive the requested information. However, if there was still no response after 7 days (from the second contact) or 14 days (from a positive response to the first contact), the data were considered as incomplete reporting. Alternatively, if contacting the corresponding author was unsuccessful and it was possible to obtain descriptive statistics from graphical figures, we manually extracted the data using the ImageJ tool (version 1.54g, National Institutes of Health, Bethesda, MA, USA) to measure and analyze plot sizes from the figures. After data extraction, agreement was assessed by considering the existence of codes across studies. Common codes were merged, while divergent codes were discussed between investigators until consensus was reached.

2.4. Methodological Quality Assessment

The methodological quality of included studies was assessed using the PEDro (Physiotherapy Evidence Database) Scale (Maher et al., 2003). The studies were rated based on their total PEDro scores, categorized as poor (0-3/10), fair (4-5/10), good (6-8/10), or excellent (>8/10) methodological quality (Cashin, 2020).

2.5. Risk of Bias Assessment

The risk of bias of included studies was assessed using the RoB-2 tool (Revised tool for Risk of Bias in randomized trials), following the intention-to-treat effect approach (Sterne et al., 2019). This tool evaluates five domains of risk of bias: (1) randomization process, (2) deviations from the intended interventions, (3) missing outcome data, (4) measurement of the outcome, and (5) selection of the reported result. The risk of bias for each study's outcome was determined using the RoB-2 algorithm, considering five domains to rate an overall risk of bias.

2.6. Rehabilitation Programs Reporting Assessment

The appraisal on rehabilitation reporting was performed using the Consensus on Exercise Reporting Template checklist (Slade et al., 2016). This checklist consists of 16 items, addressing aspects such as exercise description, dose, frequency, progression, context and supervision. We evaluated the interventions reporting of included studies considering if the items were reported, not reported, or not applicable.

2.7. Certainty in Evidence Assessment

The certainty in evidence for quantitative and narrative synthesis was assessed using the GRADE (Grading of Recommendations, Assessment, Development, and Evaluations) tool (Guyatt et al., 2008), following the recommendations of Guyatt et al. (2008) and Ryan and Hill (2016).

The initial certainty in evidence was rated as high for all meta-analyses, as only randomized controlled trials were included in the analysis. The certainty in evidence was downgraded if the meta-analysis presented: 1) studies with some concerns in RoB-2 analysis (1 level); 2) studies with high risk of bias in RoB-2 analysis (2 levels); 3) moderate heterogeneity (I^2=25-50%) (1 level); 4) high heterogeneity (I^2>50%) (2 levels); 5) low statistical power (1-β<0.80) (1 level); and 6) very low statistical power (1-β<0.50) (2 levels). The publication bias was not considered, as our analyses were performed with less than 10 studies (Chandler et al., 2019).

The initial certainty in evidence was high for all narrative syntheses because only randomized controlled trials were included. The certainty in evidence was downgraded if the narrative synthesis were composed by: 1) studies with some concerns in RoB-2 analysis (1 level); 2) studies with high risk of bias in RoB-2 analysis (2 levels); 3) some inconsistency was present (at least one study presented divergent directions of effect) (1 level); 4) severe inconsistency was present (two or more studies present divergent direction of effects) (2 levels); 5) high imprecision (sample size: n<300 [dichotomous outcomes]; n<400 [continuous outcomes]) following a "rule of thumb" presented by Ryan and Hill (2016) (2 levels).

2.8. Data Synthesis

Due to scarcity and methodological issues of previous systematic reviews with meta-analysis (as presented in the Chapter I), an a priori sample size calculation was not performed. On another hand, we performed quantitative data synthesis (i.e., meta-analysis) if two or more studies presented common designs and outcomes, reporting the post hoc statistical power of meta-analysis. To deal with the inherent heterogeneity of studies, meta-analysis models were based on the comparison of rehabilitation approaches and, when possible, the outcome assessment timeframe. Two main factors were considered in grouping rehabilitation approaches: lower limb exercises and weight bearing in an early (≤2 weeks postoperatively) or late (≥2 weeks postoperatively) approach (Zellers et al., 2019). Additionally, considering that most postoperative rehabilitation interventions last around 12 weeks (Gould et al., 2021; Zellers et al., 2019), we established the assessment timeframes to explore the effects of the interventions in the short-term (≤12 weeks postoperatively), mid-term (12 to 48 weeks postoperatively), and long-term (≥48 weeks postoperatively). The meta-analyses were performed using random effects models fitted by Paule-Mandel method (Paule and Mandel, 1982; Veroniki et al., 2016). For dichotomous outcomes, the pooled results were presented as odds ratio with a 95% confidence interval. For continuous outcomes, standardized mean differences (Hedges' g) with 95%

confidence intervals were used to report the pooled results. The magnitude of effect size Hedges' g was categorized as trivial (≤0.2), small (>0.2 to <0.5), moderate (≥0.5 to <0.8), large (≥0.8 to <1.29) and very large (≥1.30) (Fritz et al., 2012).

The publication bias analysis was not performed, as the meta-analysis models included a small number of studies (<10 studies) (Chandler et al., 2019; Guyatt et al., 2008). The statistical heterogeneity was assessed using the I^2 statistic, and meta-analyses with I^2>50% were considered as high heterogeneity (Higgins et al., 2003). Sensitivity analysis was performed systematically removing one study and repeating the analysis, in order to determine if any specific study can account for the observed heterogeneity (Deeks et al., 2019). The post hoc statistical power for each meta-analysis was calculated using the respective models estimates. Although previous studies suggest that meta-analyses exhibiting high heterogeneity should be omitted to avoid compromising the reliability and clinical applicability of the findings (Fletcher, 2007; Israel and Richter, 2011; Nunes et al., 2022), guidance for dealing with models with low statistical power remains unclear. Therefore, given that there is no clear consensus on the acceptable thresholds for heterogeneity and statistical power required to report a trustworthy meta-analysis (Fletcher, 2007; Israel and Richter, 2011; Nunes et al., 2022), we chose to present all results from the meta-analyses, regardless of whether the models exhibited high heterogeneity (I^2>50%) or low statistical power (1-β<80%). This approach aims to provide a comprehensive understanding of the current state of the literature (Nunes et al., 2022) and to support future meta-analyses in their sample size calculations.

If it was not possible to conduct a meta-analysis, we performed a narrative synthesis following the Synthesis Without Meta-analysis guidelines (Campbell et al., 2020). The information reported by the included studies did not allow present a standardized metric by summarizing effect estimates or combining p-values (McKenzie and Brennan, 2019). Although a vote counting based on direction of effect could be performed to provide a standardized synthesis (Campbell et al., 2020; McKenzie and Brennan, 2019), this approach has been cautioned about its limitations and the potential for misleading conclusions (Cumpston et al., 2023; Gurevitch et al., 2018). Therefore, we have provided a structured summary of the descriptive results for the outcomes reported individually by the studies (Campbell et al., 2020; Cumpston et al., 2023), presented based on the rehabilitation comparisons and assessment timeframes (described previously).

The meta-analysis was performed using R Project for Statistical Computing (version 4.4; https://R-project.org) with metafor (Viechtbauer, 2010) and metapower (Griffin, 2021) packages. The between-investigator agreement was assessed for study selection, methodological quality, risk of bias, and certainty in evidence assessments using Cohen's Kappa analysis in Jamovi Software (The Jamovi Project, version 2.5.6, https:// jamovi.org). Agreement was considered adequate if the level of consensus was at least 80% or the kappa result was strong (κ>0.80) (McHugh, 2012). All analyses were performed using a level of significance of 5% (alpha≤0.05).

3. RESULTS

3.1. Study Selection

A flow diagram of the literature search and screening is presented in Figure 1. In the initial search, we identified 790 studies in MEDLINE (PubMed) (n=387), Cochrane Library (n=105), and Embase (n=298). There were 230 duplicate records excluded. After screening the titles and abstracts, 44 studies were assessed against the eligibility criteria. A detailed report of the 25 excluded studies and the reason for exclusion is presented in Appendix 2E. Finally, 19 studies that met all the eligibility criteria were included in this study (Agres et al., 2018; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; Costa et al., 2006; De la Fuente et al., 2016a; De la Fuente et al., 2016b; Deng et al., 2022; Eliasson et al., 2018; Groetelaers et al., 2014; Hoeffner et al., 2024; Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015; Okoroha et al., 2020; Porter and Shadbolt, 2015; Schepull and Aspenberg, 2013; Suchak et al., 2008; Valkering et al., 2017). One potentially eligible study (Aufwerber et al., 2020a) was found in the reference lists of the included studies and was included after eligibility assessment. No other eligible studies were found using the complementary search strategies.

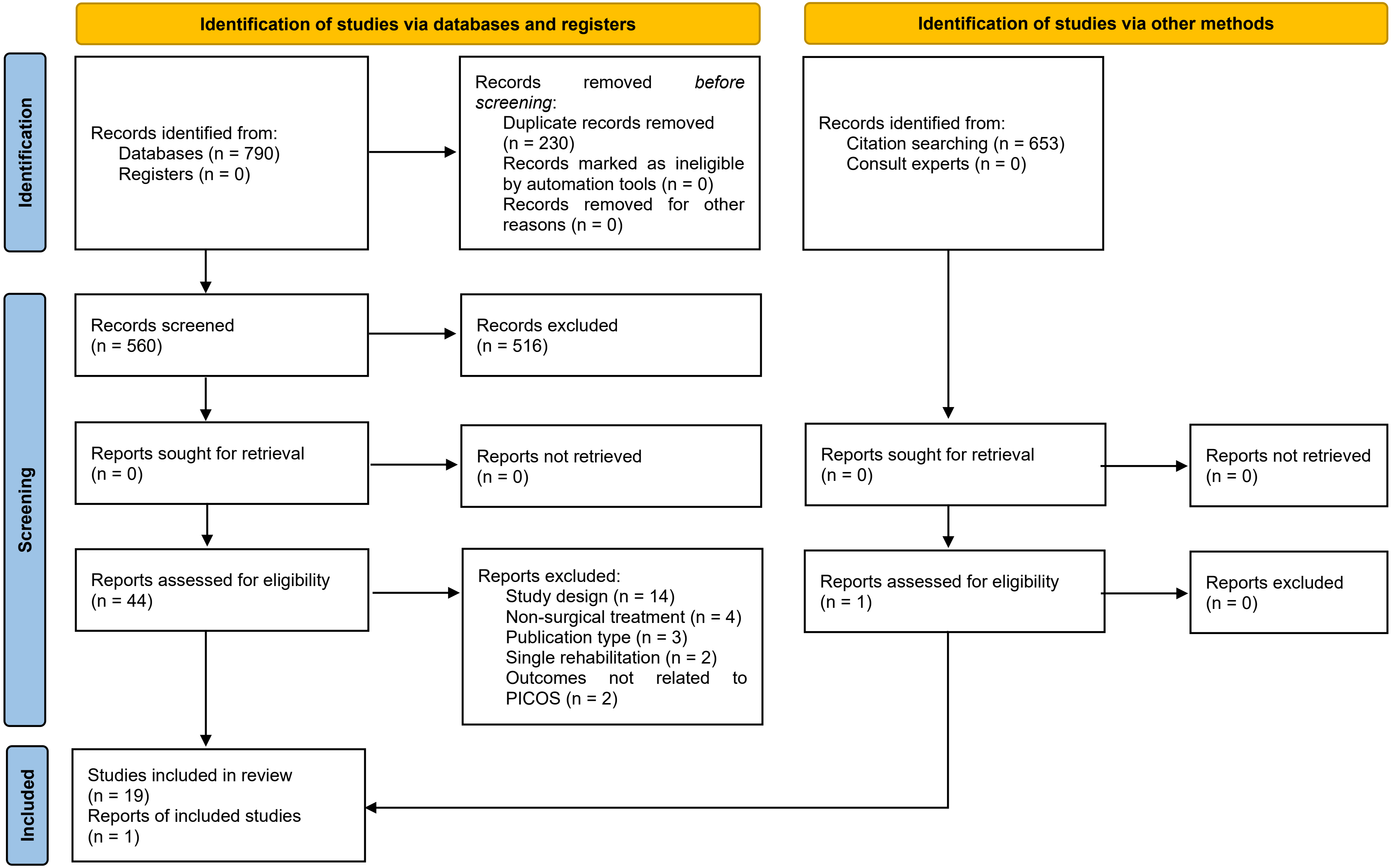


Figure 1. PRISMA Flow Diagram.

3.2. Between-Investigator Agreement

Investigators reached 96% of agreement study selection (43 of 45 studies; κ=0.91), and 88% of agreement in data extraction (κ=0.75). There was a high inter-rater agreement in the PEDro (98%; κ=0.95) and RoB-2 (98%; κ=0.97) analysis. Investigators reached 95% of agreement for Consensus on Exercise Reporting Template checklist analysis (κ=0.86). There was a high agreement in GRADE analysis of quantitative (95%; κ=0.94) and narrative (96%; κ=0.94) synthesis.

3.3. Studies Characteristics

Table 1 presents a summary of studies characteristics. Seven studies declared no potential conflicts of interest (Agres et al., 2018; De la Fuente et al., 2016a; Deng et al., 2022; Groetelaers et al., 2014; Kangas et al., 2007; Lantto et al., 2015; Valkering et al., 2017). Nine studies declared potential conflicts of interest (Aufwerber et al., 2020a; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024; Okoroha et al., 2020; Schepull and Aspenberg, 2013; Suchak et al., 2008). Four studies did not declare possible conflicts of interest (Costa et al., 2006; De la Fuente et al., 2016b; Kangas et al., 2003; Porter and Shadbolt, 2015). The country where the studies were conducted was Finland (Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015), Sweden (Aufwerber et al., 2020a; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; Schepull and Aspenberg, 2013; Valkering et al., 2017), Denmark (Eliasson et al., 2018; Hoeffner et al., 2024), England (Costa et al., 2006), the Netherlands (Groetelaers et al., 2014), Germany (Agres et al., 2018), Canada (Suchak et al., 2008), the United States of America (Okoroha et al., 2020), Chile (De la Fuente et al., 2016a; De la Fuente et al., 2016b), Australia (Porter and Shadbolt, 2015), and China (Deng et al., 2022).

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Kangas et al. (2003)	To evaluate the effect of postoperative rehabilitation programs based on LWB+LLE and LWB+ELE in the clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 24/1 LWB+ELE: 22/3 **Age (years):** LWB+LLE: 37 (23 to 53) LWB+ELE: 35 (21 to 55) **BMI (Kg/m²):** LWB+LLE: 26 (20 to 38) LWB+ELE: 26 (20 to 31)	**Injury mechanism:** SP/NSP: 48/2 **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with Kessler suture technique.	Re-rupture and major complications occurrence; Leppilahti Score (post-60 weeks); PF strength (post-12 and -60 weeks).	The clinical and functional outcomes evaluated using Leppilahti Score and PF strength did not differ between the rehabilitation approaches.
Costa et al. (2006)	To evaluate the effect of postoperative rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) or early weightbearing (EWB+LLE) in the clinical and functional parameters.	**n (Men/Women):** LWB+LLE: 22/3 EWB+LLE: 18/4 **Age (years):** LWB+LLE: 42 (29 to 69) EWB+LLE: 42 (28 to 61) **BMI (Kg/m²):** NR	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery.	Re-rupture, major, and minor complications occurrence; time to return to work and sport; loss of PF and DF range of motion (post-24 weeks); PF strength (post-24 weeks); deficit in calf circumference (post-24 weeks).	There were no differences between rehabilitation approaches in time to return to activities and clinical and functional outcomes.
Kangas et al. (2007)	To evaluate the effect of postoperative rehabilitation programs based on LWB+LLE and LWB+ELE in the Achilles tendon elongation and clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 24/1 LWB+ELE: 22/3 **Age (years):** LWB+LLE: 37 (23 to 53) LWB+ELE: 35 (21 to 55) **BMI (Kg/m²):** LWB+LLE: 26 (20 to 38) LWB+ELE: 26 (20 to 31)	**Injury mechanism:** SP/NSP: 48/2 **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with Kessler suture technique	Leppilahti Score (post-60 weeks); injured Achilles tendon elongation (post-1, -3, -6, 24, and -60 weeks).	No between-group differences were found in clinical and functional outcomes. Although Achilles tendon elongation occurred significantly in both groups, it was somewhat less marked in the early than late rehabilitation group at short-term.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Suchak et al. (2008)	To evaluate the effect of postoperative rehabilitation programs based on LWB+ELE and EWB+ELE in the clinical and functional outcomes.	**n (Men/Women):** LWB+ELE: 46/9 EWB+ELE: 47/8 **Age (years):** LWB+ELE: 38.1 ± 9.0 EWB+ELE: 40.6 ± 9.5 **BMI (Kg/m²):** LWB+ELE: 27.1 ± 3.1 EWB+ELE: 28.5 ± 7.6	**Injury mechanism:** SP/NSP: 102/8 **Time to surgery:** <2 weeks after injury. **Treatment Approach:** Open surgery.	Re-rupture, major, and minor complications occurrence; time to return to work and sport.	There was not found any difference between the rehabilitation approaches in outcomes of interest.
Schepull and Aspenberg (2013)	To evaluate the effect of early weightbearing combined with late lower limb exercises (EWB+LLE) or early tensional loading (EWB+ELE) during the first 7 weeks postoperatively in the clinical and functional outcomes.	**n (Men/Women):** EWB+LLE: 15/2 EWB+ELE: 15/3 **Age (years):** EWB+LLE: 43.8 EWB+ELE: 38.2 **BMI (Kg/m²):** NR	**Injury mechanism:** SP/NSP: 35/0 **Time to surgery:** <5 days after injury. **Treatment Approach:** Open surgery with single-loop, modified Kessler suture technique.	Re-rupture, and major complications occurrence; Achilles Tendon Rupture Score (post-48 weeks); number and height during heel-rise test (post-48 weeks).	No were found any difference between late lower limb exercises and early tensional loading in clinical and functional outcomes.
Groetelaers et al. (2014)	To evaluate the effect of LWB+LLE and EWB+ELE approach during the postoperative rehabilitation on clinical and functional outcomes after ATR surgery.	**n (Men/Women):** Overall: 46/14 LWB+LLE: 26 EWB+ELE: 26 **Age (years):** Overall: 43 (10 to 65) **BMI (Kg/m²):** NR	**Injury mechanism:** SP/NSP: 44/16 **Time to surgery:** <2 days after injury. **Treatment Approach:** Minimally invasive surgery with modified Bunnel suture technique.	Re-rupture, major, and minor complications occurrence; time to return to work and sports; Leppilahti Score (post-12, -24, and -48 weeks); deficit of PF strength (post-12, -24, and -48 weeks).	No between-group difference was found for time to return to activities, Leppilahti Score, and deficit of PF strength.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Lantto et al. (2015)	To evaluate the effect of postoperative rehabilitation programs based on LWB+LLE and LWB+ELE in the long-term clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 17/1 LWB+ELE: 17/2 **Age (years):** LWB+LLE: 34 ± 7 LWB+ELE: 36 ± 9 **BMI (Kg/m²):** LWB+LLE: 26 ± 4.2 LWB+ELE: 26 ± 2.8	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with Kessler suture technique.	Leppilahti Score (post-11 years); deficit of PF strength (post-11 years).	There was not found any difference for long-term clinical and functional outcomes evaluated using Leppilahti Score, as well no differences for deficit of PF strength after 11 years of surgery.
Porter and Shadbolt (2015)	To evaluate the effect of postoperative rehabilitation programs based on LWB+ELE and EWB+ELE in the clinical and functional outcomes.	**n (Men/Women):** LWB+ELE: 20/5 EWB+ELE: 22/4 **Age (years):** LWB+ELE: 32.2 (19 to 45) EWB+ELE: 36.2 (19 to 46) **BMI (Kg/m²):** NR	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <10 days after injury. **Treatment Approach:** Open surgery with locking Krackow suture technique.	Time to return sport; Achilles Tendon Rupture Score (post-48 weeks); deficit of height during the heel-rise test (post-48 weeks).	No between-group difference was found for Achilles Tendon Rupture Score. A smaller deficit of heel-rise height was found in early than late weightbearing group, as well the participants in the early weightbearing group returned sooner to running.
De la Fuente et al. (2016a)	To evaluate the effect of LWB+LLE and EWB+ELE during the postoperative rehabilitation on clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 19/0 EWB+ELE: 20/0 **Age (years):** LWB+LLE: 41.7 ± 10.7 EWB+ELE: 41.4 ± 8.3 **BMI (Kg/m²):** LWB+LLE: 30.2 ± 4.1 EWB+ELE: 28.6 ± 3.4	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <10 days after injury. **Treatment Approach:** Percutaneous repair using Dresden instrument.	Re-rupture, and major complications occurrence; time to return to work; Achilles Tendon Rupture Score (post-4, -8, and -12 weeks); DF range of motion on injured side (post-4, -8, and -12 weeks); heel-rise number (post-12 weeks); difference of calf circumference (post-4, -8, and -12 weeks).	Less time to return to work and better outcomes in Achilles Tendon Rupture Score was found in the early than late rehabilitation group. Moreover, the participants in early rehabilitation group presented smaller deficit of repetitions during the heel-rise test than those in late rehabilitation group. No differences were found for calf circumference.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
De la Fuente et al. (2016b)	To evaluate the effect of postoperative rehabilitation based on LWB+LLE and EWB+ELE in the plantar flexion function.	**n (Men/Women):** LWB+LLE: 13/0 EWB+ELE: 13/0 **Age (years):** LWB+LLE: 41.8 ± 11.5 EWB+ELE: 42.7 ± 7.8 **BMI (Kg/m²):** LWB+LLE: 30.8 ± 4.4 EWB+ELE: 28.2 ± 3.3	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <10 days after injury (6.8 ± 3 days). **Treatment Approach:** Percutaneous repair using Dresden instrument.	Re-rupture, and major complications occurrence; Achilles Tendon Rupture Score (post-4, -8, and -12 weeks); isometric PF strength on injured side (post-4, -8, and -12 weeks).	The outcomes in Achilles Tendon Rupture Score were better in early than late rehabilitation group at post-4 and -8 weeks of surgery, but not at post-12 weeks of surgery. The PF strength was higher at post-4 weeks of surgery in early than late rehabilitation group, whereas no differences were found at post-8 and -12 weeks.
Valkering et al. (2017)	To evaluate the effect LWB+LLE and EWB+ELE during the postoperative rehabilitation on Achilles tendon properties, and clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 24/3 EWB+ELE: 26/3 **Age (years):** LWB+LLE: 40.8 ± 6.0 EWB+ELE: 39.5 ± 8.7 **BMI (Kg/m²):** LWB+ELE: 24.9 ± 2.0 EWB+ELE: 25.6 ± 3.1	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with modified Kessler suture technique.	Re-rupture occurrence, DF range of motion on injured side (post-2 weeks), height and work during heel-rise test (post-24 and -48 weeks).	Higher DF range of motion was found in early than late rehabilitation group. No between-group difference was found for height and number during the heel-rise test.
Agres et al. (2018)	To evaluate the effect of postoperative rehabilitation based on LWB+ELE and EWB+ELE in the Achilles tendon length and plantar flexion function.	**n (Men/Women):** LWB+ELE: 7/1 EWB+ELE: 5/0 **Age (years):** Overall: 43.5 ± 11 **BMI (Kg/m²):** Overall: 27.3 ± 3.4	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <10 days after surgery. **Treatment Approach:** Percutaneous repair using Dresden instrument.	Isometric PF strength on both sides (post-8 and -12 weeks); tendon length on both sides (post-8 and -12 weeks).	Both groups presented similar PF strength deficits at post-8 and -12 weeks of surgery. The degree of tendon elongation on injured, compared to uninjured side, did not differ between the rehabilitation groups.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Eliasson et al. (2018)	To evaluate the effect of distinct strategies to conduct the postoperative rehabilitation based on LWB+LLE, LWB+ELE, and EWB+ELE in the myotendinous properties, and clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 19/6 LWB+ELE: 19/6 EWB+ELE: 22/3 **Age (years):** LWB+LLE: 36.9 ± 11.0 LWB+ELE: 36.0 ± 7.5 EWB+ELE: 38.8 ± 5.5 **BMI (Kg/m²):** LWB+LLE: 23.9 ± 2.5 LWB+ELE: 24.8 ± 3.0 EWB+ELE: 26.0 ± 4.0	**Injury mechanism:** SP/NSP: 73/2 **Time to surgery:** <4 days of injury. **Treatment Approach:** Open surgery with Kessler suture technique.	Re-rupture, major, and minor complications occurrence; time to return to work and sport; Achilles Tendon Rupture Score (post-12, -26, and -52 weeks); DF range of motion deficit (post-26 and -52 weeks); height and work during heel-rise test (post-26 and -52 weeks); isometric PF strength deficit (post-26 and -52 weeks); cross-sectional area of triceps surae muscles (post-6, -26, and -52 weeks); tendon elongation (post-6, -12, -26, and -52 weeks).	No groups differences were found in any comparison for time to return to activities, Achilles Tendon Rupture Score, heel-rise performance, PF strength, and DF range of motion. The cross-sectional area of triceps surae muscles did not differ among the rehabilitation approaches, as well for the tendon elongation.
Aufwerber et al. (2020a)	To evaluate the effect of LWB+LLE and EWB+ELE during the postoperative rehabilitation on the triceps surae myotendinous structure, and clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 21/10 EWB+ELE:45/10 **Age (years):** LWB+LLE: 39.0 ± 8.0 EWB+ELE: 39.5 ± 8.4 **BMI (Kg/m²):** LWB+LLE: 24.6 ± 2.8 EWB+ELE: 25.2 ± 2.6	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with modified Kessler suture technique.	Re-rupture major, and minor complications occurrence; Achilles Tendon Rupture Score (post-24 and -48 weeks); deficit of work and height during heel-rise test (post-24 and -48 weeks); cross-sectional area of medial and lateral gastrocnemius, and muscle thickness of soleus (post-2, -6, 24 and -52 weeks); injured Achilles tendon elongation (post-2, -6, 24 and -52 weeks).	Better outcomes in Achilles Tendon Rupture Score were found in the early than late rehabilitation approach at post-24 weeks, there was no between-group difference at post-48 weeks of surgery. The deficits in heel-rise test and triceps surae muscle structure were not influenced by the rehabilitation approach. The Achilles tendon elongation was more pronounced in early than late rehabilitation approach only at post-2 weeks of surgery, while no between-group difference was found over time.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Continued)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Aufwerber et al. (2020b)	To evaluate the effect of LWB+LLE and EWB+ELE in the postoperative rehabilitation on the deep venous thrombosis occurrence.	**n (Men/Women):** LWB+LLE: 40/11 EWB+ELE: 75/23 **Age (years):** LWB+LLE: 40.2 ± 8.3 EWB+ELE: 39.2 ± 8.1 **BMI (Kg/m²):** LWB+LLE: 25.0 ± 2.6 EWB+ELE: 25.1 ± 2.8	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after surgery **Treatment Approach:** Open surgery with modified Kessler suture technique.	Re-rupture, major, and minor complications occurrence.	The deep venous thrombosis occurrence in patients with lower limb immobilization did not reduce using an early rehabilitation approach.
Aufwerber et al. (2020c)	To evaluate the effect of postoperative rehabilitation based on LWB+LLE and EWB+ELE in the clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 35/11 EWB+ELE: 67/22 **Age (years):** LWB+LLE: 39.7 ± 8.0 EWB+ELE: 39.4 ± 8.1 **BMI (Kg/m²):** LWB+LLE: 25.0 ± 2.5 EWB+ELE: 24.9 ± 2.6	**Injury mechanism:** SP/NSP: 128/7 **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with modified Kessler suture technique.	Re-rupture and major complications occurrence; Achilles Tendon Rupture Score (post-24 and -48 weeks); deficit of height, number, work during heel-rise test (post-24 and 48 weeks).	Any groups differences were found in clinical and functional outcomes evaluated by Achilles Tendon Rupture Score outcomes and heel-rise performance.
Okoroha et al. (2020)	To evaluate the effect of postoperative rehabilitation programs based on late lower limb exercises with late (LWB+LLE) or early (EWB+LLE) weightbearing on the Achilles tendon elongation and clinical and functional outcomes.	**n (Men/Women):** LWB+LLE: 7/1 EWB+LLE: 9/1 **Age (years):** LWB+LLE: 36.0 ± 11.9 EWB+LLE: 37.8 ± 12.7 **BMI (Kg/m²):** LWB+LLE: 27.3 EWB+LLE: 29.3	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <10 days of injury. **Treatment Approach:** Open surgery with Krackow suture technique.	Re-rupture and major complications occurrence; Achilles Tendon Rupture Score (post-12); PF and DF range of motion on injured side (post-12 weeks); injured Achilles tendon elongation (post-0, -2, -6, and -12 weeks).	The clinical and functional outcomes did not differ either using a late or an early rehabilitation approach. The degree of Achilles tendon elongation was similar in both groups.

Table 1. Characteristics of studies and summary of findings of interest outcomes. *(Ended)*

Study	Context	Sample Characteristics	Injury and Treatment Characteristics	Outcomes (Follow-up)	Summary of Findings
Aufwerber et al. (2022)	To evaluate the effect of postoperative rehabilitation based on LWB+LLE and EWB+ELE in the plantar flexion range of motion during heel-rise.	**n (Men/Women):** LWB+LLE: 12/6 EWB+ELE: 23/6 **Age (years):** LWB+LLE: 40.5 ± 7.0 EWB+ELE: 37.6 ± 7.4 **BMI (Kg/m²):** LWB+LLE: 24.7 ± 2.6 EWB+ELE: 25.7 ± 2.9	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <1 week after injury. **Treatment Approach:** Open surgery with modified Kessler suture technique.	PF range of motion during heel-rise movement (post-8 and -12 weeks).	The deficit of PF range of motion during heel-rise was not affected by the rehabilitation approach.
Deng et al. (2022)	To evaluate the effect of postoperative rehabilitation based on LWB+ELE and EWB+ELE in the clinical and functional outcomes.	**n (Men/Women):** LWB+ELE: 28/6 EWB+ELE: 30/4 **Age (years):** LWB+ELE: 37.4 ± 6.8 EWB+ELE: 36.1 ± 7.1 **BMI (Kg/m²):** LWB+ELE: 24.6 ± 2.1 EWB+ELE: 24.8 ± 2.6	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <2 weeks after injury. **Treatment Approach:** Minimally invasive surgery with Krackow suture technique.	Major complications occurrence; time to return to work and sport; American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Scale (post-0, -12, -24, and -48 weeks); Achilles Tendon Rupture Score (post-0, -12, -24, and -48 weeks).	The group with early weightbearing returned sooner to work, whereas no between-group difference was found for the time to return to sport. At post-12 weeks of surgery, the outcomes in Ankle Society Ankle-Hindfoot Scale and Achilles Tendon Rupture Score were better in early than late weightbearing group, while no between-group differences were found at post-24 and -48 weeks of surgery.
Hoefner et al. (2024)	To evaluate the effect of LWB+LLE and EWB+ELE during the postoperative rehabilitation on the triceps surae myotendinous structure, and clinical and functional outcomes.	**n (Men/Women):** LWB+ELE: 18/6 EWB+ELE: 17/7 **Age (years):** LWB+ELE: 36.0 ± 10.0 EWB+ELE: 37.0 ± 9.0 **BMI (Kg/m²):** LWB+ELE: 25.0 ± 3.0 EWB+ELE: 26.0 ± 3.0	**Injury mechanism:** SP/NSP: NR **Time to surgery:** <2 weeks after injury. **Treatment Approach:** Open surgery with Kessler suture technique.	Re-rupture and major complication occurrence; Achilles Tenon Rupture Score (post-52 weeks); deficit of height, number, and work during heel-rise test (post-26 and -52 weeks); isometric PF strength deficit (post-52 weeks); cross-sectional area of lateral gastrocnemius and soleus, and muscle thickness of medial gastrocnemius (post-1, -12, -26, and -52 weeks); length of injured gastrocnemius tendon and soleus tendon (post-1, -12, -26, and -52 weeks).	The clinical and functional outcomes evaluated by Achilles Tendon Rupture Score, heel-rise performance, and isometric PF deficit did not differ either using later or early weightbearing in the rehabilitation approach. There were no groups differences in the triceps surae muscle structure. Similarly, the degree of gastrocnemius and soleus tendon elongation was similar in both rehabilitation approaches.

BMI: body mass index; LLE: late lower limb exercises; ELE: early lower limb exercises; LWB: late weightbearing; EWB: early weightbearing; EP: equinus position; PWB: partial weightbearing; FWB: full weightbearing; SP: sports practice; NSP: non-sports practice; PF: plantar flexion; DF: dorsiflexion.

The sample size of included studies ranged from 5 (Agres et al., 2018) to 98 (Aufwerber et al., 2020c) participants per group. Thirteen studies reported a priori sample size calculation (Aufwerber et al., 2020b; Costa et al., 2006; De la Fuente et al., 2016a; De la Fuente et al., 2016b; Deng et al., 2022; Eliasson et al., 2018; Groetelaers et al., 2014; Hoeffner et al., 2024; Okoroha et al., 2020; Porter and Shadbolt, 2015; Schepull and Aspenberg, 2013; Suchak et al., 2008; Valkering et al., 2017). The participant's characteristics were relatively homogeneous across studies. The sample of included studies were predominantly composed by a larger proportion of men than women, with the mean age ranging between 32 (Porter and Shadbolt, 2015) and 44 (Schepull and Aspenberg, 2013) years, and mean body mass index between 24 (Eliasson et al., 2018) to 31 (De la Fuente et al., 2016b) Kg/m².

Across the studies that presented the injury context, all studies reported that ATR occurred primarily during sports practice (Aufwerber et al., 2020c; Deng et al., 2022; Eliasson et al., 2018; Groetelaers et al., 2014; Kangas et al., 2007; Kangas et al., 2003; Schepull and Aspenberg, 2013). Clinical evaluation and a positive Thompson test were the most common methods of injury diagnosis (Costa et al., 2006; De la Fuente et al., 2016a; Deng et al., 2022; Kangas et al., 2007; Kangas et al., 2003; Suchak et al., 2008). In all studies reported that the time between injury diagnostic and surgery was less than 14 days. The surgical approach reported by the included studies were open (75%) (Aufwerber et al., 2020a; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; Costa et al., 2006; Eliasson et al., 2018; Hoeffner et al., 2024; Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015; Okoroha et al., 2020; Porter and Shadbolt, 2015; Schepull and Aspenberg, 2013; Suchak et al., 2008; Valkering et al., 2017), percutaneous (15%) (Agres et al., 2018; De la Fuente et al., 2016a; De la Fuente et al., 2016b), and minimally invasive (10%) (Deng et al., 2022; Groetelaers et al., 2014). The studies that reported the suture technique used Kessler (73.3%) (Aufwerber et al., 2020a; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024; Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015; Schepull and Aspenberg, 2013; Valkering et al., 2017), Krackow (20.0%) (Deng et al., 2022; Okoroha et al., 2020; Porter and Shadbolt, 2015), and modified Bunnell (6.7%) (Groetelaers et al., 2014).

The methodological quality rated according PEDro scores was fair in 7 studies (Agres et al., 2018; Aufwerber et al., 2020a; Aufwerber et al., 2020b; De la Fuente et al., 2016a; De la Fuente et al., 2016b; Porter and Shadbolt, 2015; Schepull and Aspenberg, 2013), and good in 13 studies (Aufwerber et al., 2020c; Aufwerber et al., 2022; Costa et al., 2006; Deng et al., 2022; Eliasson et al., 2018; Groetelaers et al., 2014; Hoeffner et al., 2024; Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015; Okoroha et al., 2020; Suchak et al., 2008; Valkering et al., 2017) (Table 2).

Table 2. Methodological quality of included studies rated according Physiotherapy Evidence Database (PEDro) scale. *(Continued)*

Study	PEDro Items											
	Eligibility Criteria	Random Allocation	Concealed Allocation	Baseline Comparability	Blinding of Therapists	Blinding of Assessors	Blinding of Therapists	Follow-up	Intention-to-treat Analysis	Statistical Comparisons	Point Measures and Variability	Score
Kangas et al. (2003)	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	6/10
Costa et al. (2006)	N	Y	Y	N	N	N	Y	Y	Y	Y	Y	7/10
Kangas et al. (2007)	Y	Y	Y	Y	N	N	N	Y	N	Y	Y	6/10
Suchak et al. (2008)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8/10
Schepull and Aspenberg (2013)	Y	Y	Y	N	N	N	N	Y	N	Y	Y	5/10
Groetelaers et al. (2014)	Y	Y	Y	N	N	N	N	Y	Y	Y	Y	6/10
Lantto et al. (2015)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	7/10
Porter and Shadbolt (2015)	Y	Y	N	N	N	N	N	Y	N	Y	Y	4/10
De la Fuente et al. (2016a)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
De la Fuente et al. (2016b)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
Valkering et al. (2017)	Y	Y	N	Y	N	N	N	Y	Y	Y	Y	6/10
Agres et al. (2018)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	5/10
Eliasson et al. (2018)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7/10
Aufwerber et al. (2020a)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8/10
Aufwerber et al. (2020b)	N	Y	Y	Y	N	N	N	Y	N	Y	Y	6/10

Table 2. Methodological quality of included studies rated according Physiotherapy Evidence Database (PEDro) scale. *(Ended)*

Study	PEDro Items											
	Eligibility Criteria	Random Allocation	Concealed Allocation	Baseline Comparability	Blinding of Therapists	Blinding of Assessors	Blinding of Therapists	Follow-up	Intention-to-treat Analysis	Statistical Comparisons	Point Measures and Variability	Score
Aufwerber et al. (2020c)	N	Y	N	Y	N	N	N	N	N	Y	Y	4/10
Okoroha et al. (2020)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7/10
Aufwerber et al. (2022)	N	Y	N	Y	N	N	N	N	N	Y	Y	4/10
Deng et al. (2022)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8/10
Hoefner et al. (2024)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	7/10

Y: yes; N: no.

Most of the studies were rated with some concerns about the outcomes risk of bias (Figure 2), mainly due to problems with the randomization process and deviations from the intended interventions. A detailed reporting of the risk of bias considering each study's outcome was presented in Appendix 2F.

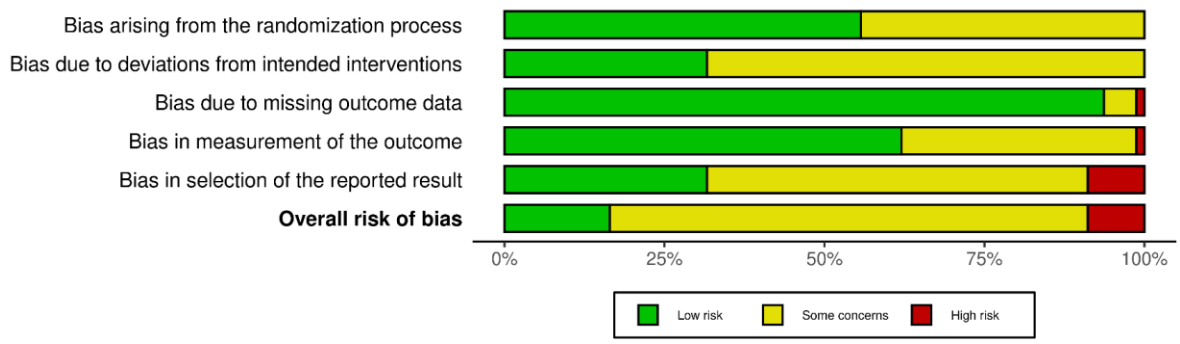


Figure 2. Overview of risk of bias in study outcomes.

3.4. Rehabilitation Characteristics

Most of the rehabilitation programs of the included studies were poorly described (Table 3), making it difficult to apply their rationale or rehabilitation programs in clinical practice and to replicate them in future studies. Although two studies (Agres et al., 2018; Schepull and Aspenberg, 2013) presented a detailed description of each exercise to enable replication, all other studies lacked these information. Only four studies (De la Fuente et al., 2016b; Kangas et al., 2007; Kangas et al., 2003; Schepull and Aspenberg, 2013) presented a detailed description of the exercise intervention including, but not limited to, number of exercise repetitions/sets/sessions, session duration, intervention/program duration. All other studies lacked important information for implementation and/or replication of these interventions.

Table 3. Appraisal of rehabilitation programs reporting according Consensus on Exercise Reporting Template (CERT) checklist.

Study	**CERT Items**																			**Y/N/NA**
	1	**2**	**3**	**4**	**5**	**6**	**7a**	**7b**	**8**	**9**	**10**	**11**	**12**	**13**	**14a**	**14b**	**15**	**16a**	**16b**	
Kangas et al. (2003)	Y	N	Y	Y	N	N	N	Y	N	N	N	N	Y	Y	Y	NA	N	N	N	7/11/1
Costa et al. (2006)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Kangas et al. (2007)	Y	N	N	Y	N	N	N	Y	N	N	N	N	N	Y	Y	NA	N	N	N	5/13/1
Suchak et al. (2008)	Y	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	NA	N	N	N	2/16/1
Schepull and Aspenberg (2013)	Y	N	N	N	N	N	Y	Y	Y	N	N	N	N	Y	N	NA	N	N	Y	6/12/1
Groetelaers et al. (2014)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Lantto et al. (2015)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Porter and Shadbolt (2015)	N	N	N	Y	N	N	N	Y	N	N	N	N	N	N	Y	NA	N	N	N	3/15/1
De la Fuente et al. (2016a)	Y	N	N	Y	N	N	N	Y	N	N	N	N	N	N	Y	NA	N	N	N	4/14/1
De la Fuente et al. (2016b)	Y	N	N	Y	N	N	N	Y	N	N	Y	N	N	Y	Y	NA	N	N	N	6/12/1
Valkering et al. (2017)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Agres et al. (2018)	Y	N	N	Y	N	N	N	N	Y	N	N	N	Y	N	Y	NA	N	N	N	5/13/1
Eliasson et al. (2018)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Aufwerber et al. (2020a)	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	NA	N	N	N	2/16/1
Aufwerber et al. (2020b)	Y	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	NA	N	N	N	2/16/1
Aufwerber et al. (2020c)	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	1/17/1
Okoroha et al. (2020)	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	NA	N	N	N	2/16/1
Aufwerber et al. (2022)	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	1/17/1
Deng et al. (2022)	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	0/18/1
Hoefner et al. (2024)	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	NA	N	N	N	1/17/1

1: Detailed description of the type of exercise equipment (e.g. weights, exercise equipment such as machines, treadmill, bicycle ergometer etc); **2:** Detailed description of the qualifications, teaching/supervising expertise, and/or training undertaken by the exercise instructor; **3:** Describe whether exercises are performed individually or in a group; **4:** Describe whether exercises are supervised or unsupervised and how they are delivered; **5:** Detailed description of how adherence to exercise is measured and reported; **6:** Detailed description of motivation strategies; **7a:** Detailed description of the decision rule(s) for determining exercise progression; **7b:** Detailed description of how the exercise program was progressed; **8:** Detailed description of each exercise to enable replication (e.g. photographs, illustrations, video etc); **9:** Detailed description of any home program component (e.g. other exercises, stretching etc); **10:** Describe whether there are any non-exercise components (e.g. education, cognitive behavioural therapy, massage etc); **11:** Describe the type and number of adverse events that occurred during exercise; **12:** Describe the setting in which the exercises are performed; **13:** Detailed description of the exercise intervention including, but not limited to, number of exercise repetitions/sets/sessions, session duration, intervention/program duration etc; **14a:** Describe whether the exercises are generic (one size fits all) or tailored to the individual; **14b:** Detailed description of how exercises are tailored to the individual; **15:** Describe the decision rule for determining the starting level at which people commence an exercise program (such as beginner, intermediate, advanced etc); **16a:** Describe how adherence or fidelity to the exercise intervention is assessed/measured; **16b:** Describe the extent to which the intervention was delivered as planned; **Y:** yes; **N:** no; **NA:** not applicable; **Y/N/NA:** number of yes, not, and not applicable in checklist.

Table 4 presents detailed information of rehabilitation approaches used in the included studies. The rehabilitation comparison based on late lower limb exercises and weight bearing versus early lower limb exercises and weight bearing (LWB+LLE versus EWB+ELE) were reported by 9 studies (Aufwerber et al., 2020a; Aufwerber et al., 2020b; Aufwerber et al., 2020c; Aufwerber et al., 2022; De la Fuente et al., 2016a; De la Fuente et al., 2016b; Eliasson et al., 2018; Groetelaers et al., 2014; Valkering et al., 2017). Six studies presented rehabilitation comparison based on early lower limb exercises and late weight bearing versus early lower limb exercises and weight bearing (LWB+ELE versus EWB+ELE) (Agres et al., 2018; Deng et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024; Porter and Shadbolt, 2015; Suchak et al., 2008). Rehabilitation comparison based on late lower limb exercises and weight bearing versus early lower limb exercises and late weight bearing (LWB+LLE versus EWB+ELE) were reported by 4 studies (Eliasson et al., 2018; Kangas et al., 2007; Kangas et al., 2003; Lantto et al., 2015). Two studies reported rehabilitation comparison based on late lower limb exercises and weight bearing versus late lower limb exercises and early weight bearing (LWB+LLE versus EWB+LLE) (Costa et al., 2006; Okoroha et al., 2020). One study presented the rehabilitation comparison based on late lower limb exercises and early weight bearing versus early lower limb exercises and weight bearing (EWB+LLE versus EWB+ELE) (Schepull and Aspenberg, 2013).

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Continued)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
Kangas et al. (2003)[1]	**LWB+LLE:** below-knee plaster cast (0º DF) during 6 weeks. **LWB+ELE:** modified below-knee plaster cast for allowing plantar flexion and restricted dorsiflexion at 0º DF during 6 weeks.	**LWB+LLE:** FWB as tolerated at post-3 weeks of surgery. **LWB+ELE:** FWB as tolerated at post-3 weeks of surgery.	**LWB+LLE:** - *week 0-6:* toes flexion-extension, isometric PF, knee flexion-extension, and hip extension exercises. - *week 6-9:* PF and DF exercises (with manual help), ankle circumduction movements, standing on the toes and heels, concentric PF using rubber bands, toes and ankle muscle's stretching exercises. - *week 9:* isometric heel-rise, isometric knee flexion, concentric PF/DF/ankle in-eversors using rubber bands, and PF stretching exercises. **LWB+ELE:** - *week 0-6:* toes flexion-extension, concentric PF and DF, knee flexion-extension, and hip extension exercises. - *week 6-9:* as week 6-9 of group LWB+LLE.
Costa et al. (2006)	**LWB+LLE:** below-knee plaster cast (EP) during 8 weeks. **EWB+LLE:** carbon orthosis with 3 heel wedges (-1 wedge at each 2 weeks) during 8 weeks.	**LWB+LLE:** FWB as tolerated at post-3 weeks of surgery. **EWB+LLE:** FWB as tolerated immediately after surgery.	**LWB+LLE:** not applicable/reported. **EWB+LLE:** not applicable/reported.
Suchak et al. (2008)	**LWB+ELE:** - *0-2 week:* below-knee plaster cast. - *2-6 week:* fixed-angle orthosis (-20º to 0º DF; gradually move the fixed-angle hinge to 0º DF at each 2-3 weeks). **EWB+ELE:** - *0-2 week:* below-knee plaster cast. - *2-6 week:* fixed-angle orthosis (-20º to 0º DF; gradually move the fixed-angle hinge to 0º DF at each 2-3 weeks).	**LWB+ELE:** FWB at post-6 weeks of surgery. **EWB+ELE:** FWB as tolerated immediately after surgery.	**LWB+ELE:** - *week 2-6:* DF range of motion exercises without orthosis. **EWB+ELE:** - *week 2-6:* DF range of motion exercises without orthosis.

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Continued)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
Schepull and Aspenberg (2013)	**EWB+LLE:** - *week 0-3.5*: below-knee plaster cast (EP). - *week 3.5-7:* below-knee plaster cast (0º DF). **EWB+ELE:** - *week 0-2*: below-knee plaster cast (EP). - *week 2-7:* orthosis with 3 heel wedges (-1 wedge at each 1 week).	**EWB+LLE:** FWB as tolerated immediately after surgery. **EWB+ELE:** FWB as tolerated immediately after surgery.	**EWB+LLE:** not applicable/reported. **EWB+ELE:** - *week 2-7:* progressive PF resistance exercises using a pedal device.
Groetelaers et al. (2014)	**LWB+LLE:** - *week 0-3:* below-knee plaster cast (10º PF). - *week 4-6:* below-knee plaster cast (0º DF). **EWB+ELE:** - *week 0-2:* below-knee plaster cast (10º PF). - *week 3-6:* flexible brace with free ankle motion.	**LWB+LLE:** FWB at post-4 weeks of surgery. **EWB+ELE:** FWB at post-2 weeks of surgery.	**LWB+LLE:** not applicable/reported. **EWB+ELE:** - *week 3-6:* standardized exercise programs (no more additional information were reported).
Porter and Shadbolt (2015)	**LWB+ELE:** - *week 0-1.5:* below-knee plaster cast (EP). - *week 1.5-4:* fixed-angle orthosis (20-30º PF). **EWB+ELE:** - *week 0-1.5:* heavy crepe bandage. - *week 1.5-4*: removable orthosis with 10-mm wedges (-1 wedge at each 2 weeks until the ankle was held in 0º DF).	**LWB+ELE:** FWB as tolerated at post-6 weeks of surgery. **EWB+ELE:** PWB as tolerated at post-2 weeks of surgery, progressing to FWB as tolerated.	**LWB+ELE:** - *week 10-12:* resistance strengthening and passive stretching (started at week 12) exercises. **EWB+ELE:** - *week 0-6:* active ankle range of motion exercises (from neutral to free PF) as tolerated. - *week 6-12:* resistance strengthening and passive stretching (started at week 12) exercises.

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Continued)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
De la Fuente et al. (2016a)[2]	**LWB+LLE:** removable orthosis during 12 weeks. **EWB+ELE:** removable orthosis during 12 weeks.	**LWB+LLE:** FWB at post-4 weeks of surgery. **EWB+ELE:** PWB immediately after surgery, progressing to FWB at post-3 weeks of surgery.	**LWB+LLE:** - *week 4-8:* PF contractions using rubber band (free PF to -15º DF), deep PF muscle contractions using ultrasound-mediated feedback, balance, bilateral heel-rise, and PF stretching exercises. - *week 8-10:* PF contractions using rubber band (free PF to -15º DF), deep PF muscle contractions using ultrasound-mediated feedback, balance, bilateral heel-rise, PF stretching, and plyometric bilateral heel-rise exercises. *week 10-12:* PF contractions using rubber band (free PF to -15º DF), deep PF muscle contractions using ultrasound-mediated feedback, balance, bilateral heel-rise, PF stretching, plyometric bilateral heel-rise, take-off, and controlled running exercises. **EWB+ELE:** - *week 0-2:* PF contractions using rubber band (free PF to -15º DF), deep PF muscle contractions using ultrasound-mediated feedback, and balance exercises. - *week 2-4* PF contractions using rubber band (free PF to -15º DF), deep PF muscle contractions using ultrasound-mediated feedback, balance, bilateral heel-rise exercises. - *week 4-12:* as week 4-12 of group LWB+LLE.
Valkering et al. (2017)	**LWB+LLE:** - *week 0-2:* below-knee plaster cast (EP). - *week 2-6:* removable orthosis with 3 heel wedges (-1 wedge at each 1 week). **EWB+ELE:** - *week 0-2:* adjustable orthosis (15-30º PF). - *week 2-6:* adjustable orthosis (5-30º PF).	**LWB+LLE:** FWB at post-2 weeks of surgery. **EWB+ELE:** FWB immediately after surgery.	**LWB+LLE:** - *week 0-2:* ankle immobilization. - *week 2-6:* range of motion exercises. **EWB+ELE:** - *week 0-6:* range of motion exercises.

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Continued)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
Agres et al. (2018)	**LWB+ELE:** - *week 0-6:* adjustable orthosis (30º PF). - *week 6-12:* adjustable orthosis (-10º PF at each 1 week). **EWB+ELE:** - *week 0-6:* adjustable orthosis (30º PF); - *week 6-12:* adjustable orthosis (-10º PF at each 1 week).	**LWB+LLE:** PWB immediately after surgery, progressing to FWB at post-6 weeks of surgery. **EWB+ELE:** PWB immediately after surgery, progressing to FWB at post-2 weeks of surgery.	**LWB+LLE:** - *week 2-4:* isometric PF contractions. - *week 4-6:* concentric PF contractions using rubber band loads. **EWB+ELE:** - *week 2-4:* isometric PF contractions and balance exercises. - *week 4-6:* concentric PF contractions using weights on thighs and balance exercises. - *week 6-12:* eccentric PF contractions and two-legged hopping (started at week 12) exercises.
Eliasson et al. (2018)	**LWB+LLE:** orthosis with 3 heel wedges (-1 wedge per week starting at week 5) during 7 weeks. **LWB+ELE:** orthosis with 3 heel wedges (-1 wedge per week starting at week 5) during 7 weeks. **EWB+ELE:** orthosis with 3 heel wedges (-1 wedge per week starting at week 5) during 7 weeks.	**LWB+LLE:** PWB at post-6 weeks of surgery, progressing to FWB at post-9 weeks of surgery. **LWB+ELE:** PWB at post-6 weeks of surgery, progressing to FWB at post-9 weeks of surgery. **EWB+ELE:** PWB immediately after surgery, progressing to FWB at post-4 weeks of surgery.	**LWB+LLE:** - *week 7-22:* range of motion exercises (starting at week 7), bike and swimming exercises (starting at week 9), stair climbing (starting at week 14), heel-rise and stretching exercise (starting at week 16), jogging (starting at week 22), return to sport (starting week 32). **LWB+ELE:** - *week 3-7:* ankle joint mobilization exercises without any load. - *week 7-32:* as week 7-32 of LWB+LLE group. **EWB+ELE:** - *week 3-7:* ankle joint mobilization exercises without any load. - *week 7-32:* as week 7-32 of LWB+LLE group.

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Continued)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
Aufwerber et al. (2020b)[3]	**LWB+LLE:** - *week 0-2:* below-knee plaster cast (30º PF). - *week 2-6:* removable orthosis with 3 heel wedges (-1 wedge at each 1 week). **EWB+ELE:** - *week 0-2:* adjustable orthosis (15-30º PF). - *week 2-6:* adjustable orthosis (5-30º PF).	**LWB+LLE:** FWB at post-2 weeks of surgery. **EWB+ELE:** FWB immediately after surgery.	**LWB+LLE:** - *week 0-2:* ankle immobilization. - *week 2-6:* PF range of motion exercises and stationary bike (starting at week 4). **EWB+ELE:** - *week 0-6:* PF range of motion exercises and stationary bike (starting at week 4).
Okoroha et al. (2020)	**LWB+LLE:** - *week 0-2:* below-knee plaster cast (20º PF). - *week 2-4:* orthosis with 2 heel wedges. - *week 4-6:* orthosis with 1 heel wedge. **EWB+LLE:** - *week 0-2:* adjustable orthosis (15-30º PF). - *week 2-6:* adjustable orthosis (5-30º PF).	**LWB+LLE:** FWB at post-6 weeks of surgery. **EWB+LLE:** FWB as tolerated at post-2 weeks of surgery.	**Both groups started identical exercises at week 6:** - *week 6-12:* physical therapy for strengthening. - *week 12-16:* range of motion and stretching exercises, gait and proprioception exercises, ankle exercises using rubber bands, bilateral leg press, leg press heel raises (starting bilateral, progressing to unilateral), two-legged heel raises, biking exercises. - *week 16-20:* progress previous exercises, PF/DF isokinetic exercises, progressive jump (leg press, mini-trampoline, and ground) and light plyometric exercises; single legged heel raises. - *week 35-42:* jogging and running when hopping is performed with good technique, sport-specific drills for appropriate patients.
Deng et al. (2022)	**LWB+ELE:** immobilization was not used/reported. Heel pads were used in the bandage at post-2 weeks of surgery (12 layers, 36mm; -1 pad at each 3 days) during 45 days. **EWB+ELE:** immobilization was not used/reported. Heel pads were used in the bandage at post-2 weeks of surgery (12 layers, 36mm; -1 pad at each 3 days) during 45 days.	**LWB+ELE:** FWB as tolerated (using the heel pads) at post-2 weeks of surgery. **EWB+ELE:** FWB as tolerated (using the heel pads) at post-3 days of surgery.	**LWB+ELE:** - *day 3-45:* active dorsiflexion exercises. **EWB+ELE:** - *day 3-45:* active dorsiflexion exercises.

Table 4. Summary of postoperative rehabilitation approaches reported by included studies. *(Ended)*

Study	Immobilization Approach	Time to Weightbearing	Therapeutic Approach
Hoefner et al. (2024)	**LWB+ELE:** - *week 0-2:* below-knee plaster cast (30º PF). - *week 2-12:* adjustable orthosis with 3 heel wedges (-1 wedge at each 2 weeks, from week 6). **EWB+ELE:** - *week 0-2:* below-knee plaster cast (30º PF). - *week 2-6:* walker orthosis with 3 heel wedges (-1 wedge at each 1 week, from week 4).	**LWB+ELE:** PWB at post-6 weeks of surgery, progressing to FWB at post-12 weeks of surgery. **EWB+ELE:** PWB at post-2 weeks of surgery, progressing to FWB at post-6 weeks of surgery.	**LWB+ELE:** - *week 3-15:* range of motion (starting at week 3), bike and swimming (starting at week 13 and 15, respectively), standing heel-rise (starting at week 21) exercises. Jogging and return to sport (starting at week 32 and 48, respectively). **EWB+ELE:** - *week 3-15:* range of motion (starting at week 3), bike and swimming (starting at week 9), standing heel-rise (starting at week 15) exercises. Jogging and return to sport (starting at week 24 and 32, respectively).

LLE: late lower limb exercises; ELE: early lower limb exercises; LWB: late weightbearing; EWB: early weightbearing; EP: equinus position; PWB: partial weightbearing; FWB: full weightbearing; PF: plantar flexion; DF: dorsiflexion; 1: Kangas et al. (2007) and Lantto et al. (2015) reported the same rehabilitation approaches; 2: De la Fuente et al. (2016b) reported the same rehabilitation approaches; 3: Aufwerber et al. (2020b), Aufwerber et al. (2020c) and Aufwerber et al. (2022) reported the same rehabilitation approaches.

3.5. Clinical and Functional Outcomes

3.5.1. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

3.5.1.1. Complications

Similar occurrence of re-ruptures (Aufwerber et al., 2020b; De la Fuente et al., 2016a; Eliasson et al., 2018; Groetelaers et al., 2014; Valkering et al., 2017), major complications (Aufwerber et al., 2020b; De la Fuente et al., 2016a; Groetelaers et al., 2014), and minor complications (Aufwerber et al., 2020b; Groetelaers et al., 2014) were found in LWB+LLE and EWB+ELE rehabilitation approaches.

To avoid sample overlap, only one outcome reporting from a single study was selected as representative when multiple publications used the same sample. The representative study was chosen on the basis of a larger sample size and/or a greater degree of detail in the information reported. Therefore, the sample of De la Fuente et al. (2016a) was considered representative of another study (De la Fuente et al., 2016b). Similarly, the sample of Aufwerber et al. (2020b) was considered representative of other studies (Aufwerber et al., 2020a; Aufwerber et al., 2020c; Aufwerber et al., 2022). Meta-analyses indicated no differences for re-rupture (Figure 3A), major complications (Figure 3B) and minor complications (Figure 3C) occurrence with LWB+LLE and EWB+ELE rehabilitation approaches.

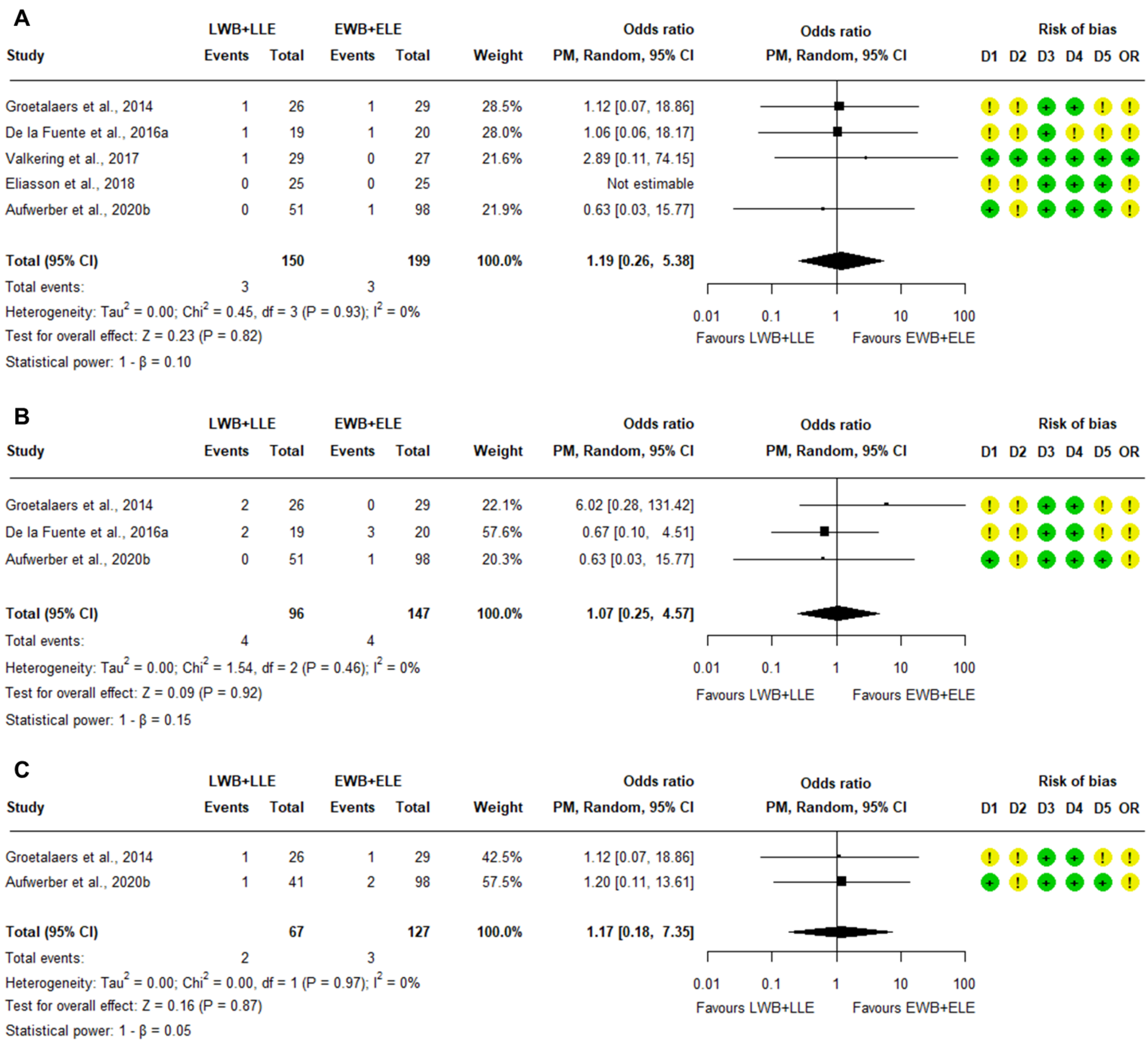


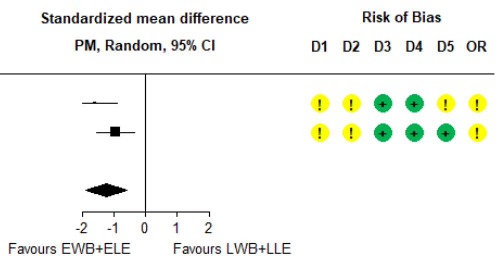
Figure 3. Re-rupture (A), major complication (B), and minor complication (C) events in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns.

Studies reporting outcomes on calf's muscle mass (Aufwerber et al., 2020a; De la Fuente et al., 2016a; Eliasson et al., 2018) found no differences between the rehabilitation approaches at short-, mid-, long-term assessment. Tendon elongation was presented by two studies (Aufwerber et al., 2020a; Eliasson et al., 2018). Eliasson et al. (2018) found no between-group differences for tendon elongation at 6, 12, 26, and 52 weeks postoperatively. On the other hand, Aufwerber et al. (2020a) found higher tendon elongation (injured-contralateral difference of tendon length) in EWB+ELE than LWB+LLE, at 2 and 6 weeks of surgery, and no between-group differences were reported at 24 and 52 weeks postoperatively.

3.5.1.2. *Return to Pre-Injury Activities*

Time to return to work was presented by three studies (De la Fuente et al., 2016b; Eliasson et al., 2018; Groetelaers et al., 2014). De la Fuente et al. (2016a) found an earlier return to work with EWB+ELE than LWB+LLE. On the other hand, Groetelaers et al. (2014) and Eliasson et al. (2018) reported no differences between rehabilitation approaches for time to return to work. One study presented the time to return to sport (Eliasson et al., 2018) and found no between-group differences. Meta-analysis indicated a very high effect size of the EWB+ELE in reducing the time to return to work compared to the LWB+LLE (Figure 4).

Study	LWB+LLE Mean	LWB+LLE SD	LWB+LLE n	EWB+ELE Mean	EWB+ELE SD	EWB+ELE n	Weight	Standardized mean difference PM, Random, 95% CI
De la Fuente et al., 2016a	11.1	2.1	19	6.2	3.6	20	45.4%	-1.62 [-2.34, -0.89]
Eliasson et al., 2018	46	11	25	37	7	22	54.6%	-0.95 [-1.55, -0.34]
Total (95% CI)			**44**			**42**	**100.0%**	**-1.25 [-1.91, -0.60]**



Heterogeneity: $Tau^2 = 0.11$; $Chi^2 = 1.95$, df = 1 (P = 0.16); $I^2 = 49\%$
Test for overall effect: Z = -3.74 (P < 0.01)
Statistical power: $1 - \beta = 0.72$

Figure 4. Time to return to work (in days) in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!):

3.5.1.3. *Multi-Item Scoring Scales*

Three studies presented Achilles Tendon Rupture Score outcomes (Aufwerber et al., 2020c; De la Fuente et al., 2016a; Eliasson et al., 2018). De la Fuente et al. (2016a) found better outcomes in Achilles Tendon Rupture Score with EWB+ELE than LWB+LLE at short-term. Eliasson et al. (2018) and Aufwerber et al. (2020c) found no differences between the rehabilitation approaches in Achilles Tendon Rupture Score at short-term (Eliasson et al., 2018), mid-term, and long-term (Aufwerber et al., 2020c; Eliasson et al., 2018). One study reported the outcomes of

Leppilahti Score (Groetelaers et al., 2014) and found that the proportion of excellent/good rating in both groups were similar at short-, mid-, and long-term with both rehabilitation approaches. Meta-analysis indicated better outcomes in Achilles Tendon Rupture Score with EWB+ELE than LWB+LLE at short-term (high effect size; Figure 5A) and mid-term (small effect size; Figure 5B). No differences were found at long-term (Figure 5C).

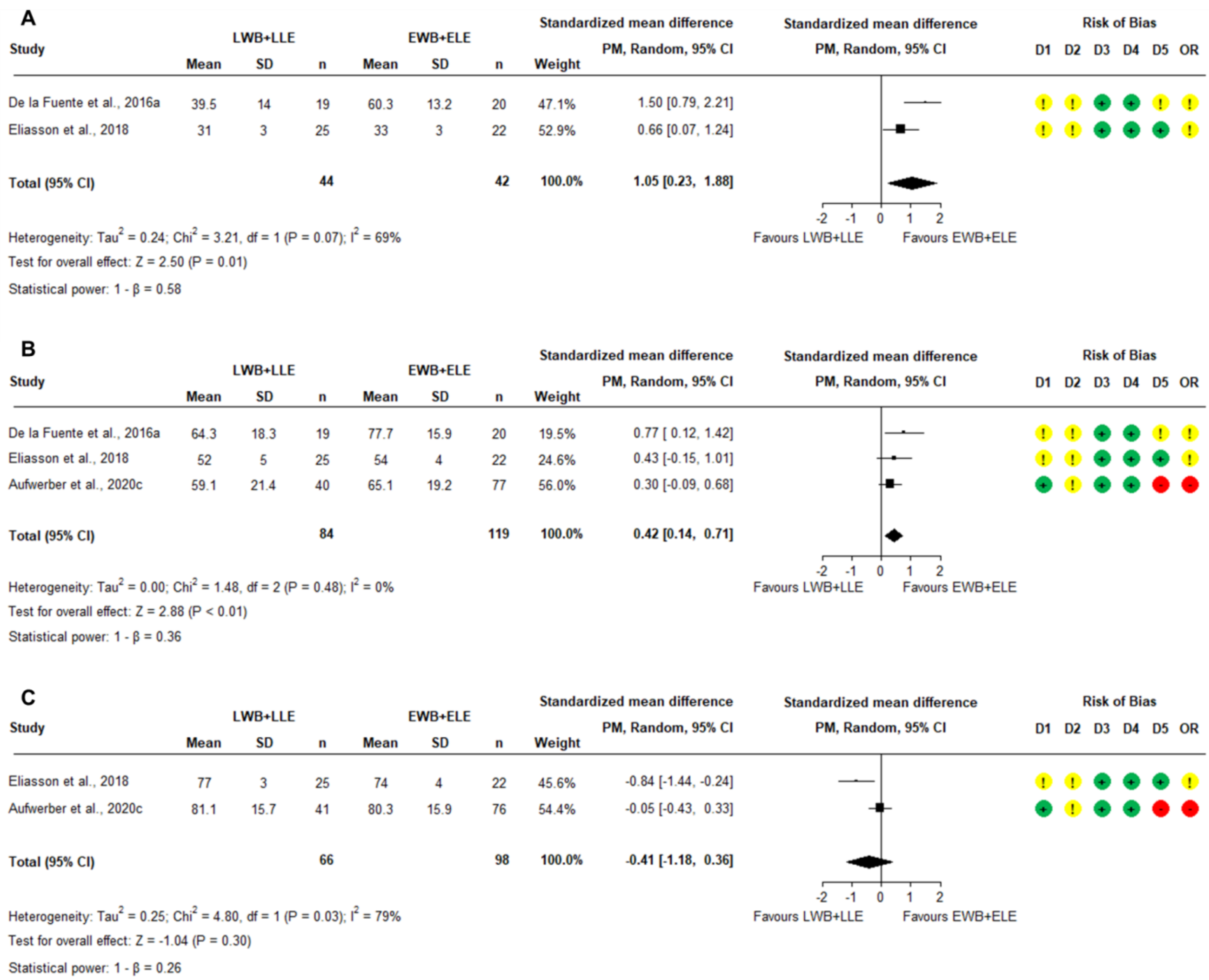


Figure 5. Achilles Tendon Ruptures Score at ≤12 weeks (A), 12-48 weeks (B), and ≥48 weeks (C) postoperatively in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns; (-): high.

3.5.1.4. Ankle Range of Motion

Dorsiflexion range of motion was presented by two studies (De la Fuente et al., 2016a; Eliasson et al., 2018). De la Fuente et al. (2016a) found no groups differences for dorsiflexion range of motion on injured side at 4 weeks postoperatively, while higher dorsiflexion range of motion were found on injured side of EWB+ELE than EWB+LLE group at 8 and 12 weeks after surgery. Eliasson et al. (2018) found no differences between rehabilitation approaches for limb symmetry index of dorsiflexion range of motion during weight bearing lunge test at 26 and 52 weeks postoperatively. One study reported plantar flexion range of motion (Aufwerber et al., 2022). The authors evaluated the maximal plantar flexion range of motion during bilateral and unilateral heel-raises, and found no between-group differences at 8, 24, and 48 weeks postoperatively.

3.5.1.5. Plantar Flexion Strength

Isometric plantar flexion strength was presented by three studies (De la Fuente et al., 2016b; Eliasson et al., 2018; Groetelaers et al., 2014). Groetelaers et al. (2014) found no differences between rehabilitation approaches for limb symmetry index of isometric plantar flexion (0º of dorsiflexion) at 12, 24, and 48 weeks after surgical repair. De la Fuente et al. (2016b) found higher isometric plantar flexion strength on injured side in EWB+ELE than LWB+LLE group at 4 weeks postoperatively, and similar outcomes at 8 and 12 weeks after surgery. Eliasson et al. (2018) found no differences between rehabilitation approaches for limb symmetry index of isometric plantar flexion strength at 26 and 52 weeks postoperatively.

3.5.1.6. Heel-Rise Performance

Heel-rise height was presented by two studies (Aufwerber et al., 2020c; Eliasson et al., 2018). Eliasson et al. (2018) and Aufwerber et al. (2020c) reported no differences between rehabilitation approaches for limb symmetry index of heel-rise height at mid- and long-term. Similarly, meta-analysis models indicated no differences between EWB+ELE and LWB+LLE for height during heel-rise test, at mid-term (Figure 6A) and long-term (Figure 6B).

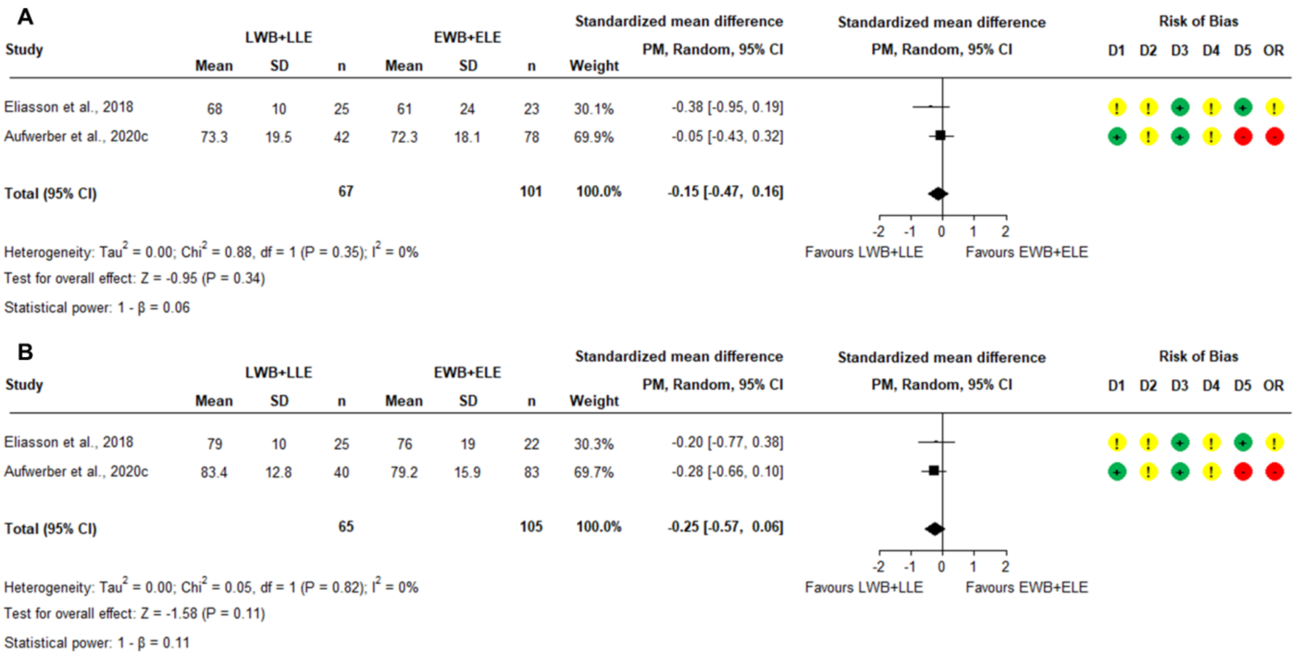


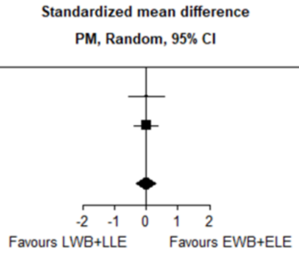
Figure 6. Limb symmetry index of height during heel-rise test at 12-48 weeks (A), and ≥48 weeks (B) postoperatively in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns; (-): high.

Two studies presented the repetitions during the heel-rise test (Aufwerber et al., 2020c; De la Fuente et al., 2016a). De la Fuente et al. (2016a) reported smaller repetitions deficit in EWB+ELE than LWB+LLE groups at 12 weeks after surgery. Aufwerber et al. (2020c) found no between-group differences for limb symmetry index of heel-rise repetitions at 24 and 48 weeks postoperatively.

Total work during the heel-rise test was presented by two studies (Aufwerber et al., 2020c; Eliasson et al., 2018), which reported no between-group differences for limb symmetry index of heel-rise work at mid- and long-term assessment. Meta-analysis models indicated no differences for limb symmetry index of heel-rise work with EWB+ELE and LWB+LLE, at mid-term (Figure 7A) and long-term (Figure 7B).

A

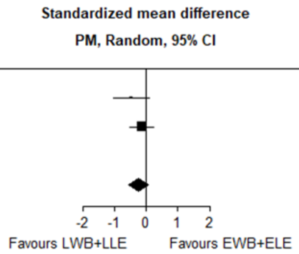
Study	LWB+LLE Mean	LWB+LLE SD	LWB+LLE n	EWB+ELE Mean	EWB+ELE SD	EWB+ELE n	Weight	Standardized mean difference PM, Random, 95% CI	D1	D2	D3	D4	D5	OR
Eliasson et al., 2018	44	10	25	44	20	22	30.0%	0.00 [-0.57, 0.57]	!	!	+	!	+	!
Aufwerber et al., 2020c	58.6	21.2	42	58.6	23	78	70.0%	0.00 [-0.38, 0.38]	+	!	+	!	-	-
Total (95% CI)			**67**			**100**	**100.0%**	**0.00 [-0.31, 0.31]**						



Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.00$, df = 1 (P = 1.00); $I^2 = 0\%$
Test for overall effect: Z = 0.00 (P = 1.00)
Statistical power: 1 - β = 0.34

B

Study	LWB+LLE Mean	LWB+LLE SD	LWB+LLE n	EWB+ELE Mean	EWB+ELE SD	EWB+ELE n	Weight	Standardized mean difference PM, Random, 95% CI	D1	D2	D3	D4	D5	OR
Eliasson et al., 2018	70	15	25	63	14	22	29.7%	-0.47 [-1.05, 0.11]	!	!	+	!	+	!
Aufwerber et al., 2020c	77.7	19.5	40	74.4	23	83	70.3%	-0.15 [-0.53, 0.23]	+	!	+	!	-	-
Total (95% CI)			**65**			**105**	**100.0%**	**-0.25 [-0.56, 0.07]**						



Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.84$, df = 1 (P = 0.36); $I^2 = 0\%$
Test for overall effect: Z = -1.52 (P = 0.13)
Statistical power: 1 - β = 0.11

Figure 7. Limb symmetry index of work during heel-rise test at 12-48 weeks (A), and ≥48 weeks (B) postoperatively in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns; (-): high.

3.5.1.7. Summary of Findings

A detailed narrative synthesis is presented in Table 1 of Appendix 2G. With a very low certainty in evidence, the narrative synthesis supported the following: 1) Similar occurrence of complications with postoperative approaches based on LWB+LLE and EWB+ELE; 2) Similar outcomes in calf's muscle mass were achieved with LWB+LLE and EWB+ELE at short-, mid-, and long-term; 3) Conflicting results were observed for tendon elongation at short-term, while at mid- and long-term consistent findings indicated no differences between rehabilitation approaches; 4) Contrasting findings for the time to return to pre-injury activities; 5) Divergent findings were reported for multi-item scoring scales at short-term, whereas no differences between LWB+LLE and EWB+ELE were commonly reported at mid- and long-term; 6) Better dorsiflexion range of motion were achieved with EWB+ELE than LWB+LLE at short-term, but not at mid- and long-term; 7) Similar outcomes for plantar flexion range of motion at short-, mid-, and long-term were achieved with both rehabilitation approaches; 8) Better plantar flexion strength outcomes were achieved with EWB+ELE than LWB+LLE at short-term, but not at mid- and long-term; 9) Similar outcomes in heel-rise performance were achieved with both LWB+LLE and EWB+ELE at mid- and long-term assessment.

The meta-analyses, with a very low certainty in evidence (Table 5), indicated the following: 1) There were no differences in occurrence of re-ruptures, major and minor complications with both rehabilitation approaches; 2) An earlier return to work were achieved with EWB+ELE than LWB+LLE; 3) Better outcomes in Achilles Tendon Rupture Score were found with EWB+ELE than LWB+LLE at short- and mid-term, but not a long-term assessment; 4) No differences between rehabilitation approaches were found for heel-rise performance at mid- and long-term.

Table 5. Summary of findings of rehabilitation comparisons based on LWB+LLE vs EWB+ELE.

Outcomes	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Summary effect (95% CI)	Certainty
Re-rupture	4	RCT	serious[a]	not serious	not serious	very serious[b]	OR: 1.19 (0.26 to 5.38)	⊕◯◯◯ Very low[a,b]
Major Complication	3	RCT	serious[a]	not serious	not serious	very serious[b]	OR: 1.07 (0.25 to 4.57)	⊕◯◯◯ Very low[a,b]
Minor Complication	2	RCT	serious[a]	not serious	not serious	very serious[b]	OR: 1.17 (0.18 to 7.35)	⊕◯◯◯ Very low[a,b]
Time to return to work	2	RCT	serious[a]	serious[c]	not serious	serious[d]	SMD: -1.25 (-1.91 to -0.60)	⊕◯◯◯ Very low[a,c,d]
ATRS (≤12 weeks postoperatively)	2	RCT	serious[a]	serious[c]	not serious	serious[d]	SMD: 1.05 (0.23 to 1.88)	⊕◯◯◯ Very low[a,c,d]
ATRS (12-48 weeks postoperatively)	3	RCT	very serious[e]	not serious	not serious	very serious[b]	SMD: 0.42 (0.14 to 0.71)	⊕◯◯◯ Very low[b,e]
ATRS (≥48 weeks postoperatively)	2	RCT	very serious[e]	very serious[f]	not serious	very serious[b]	SMD: -0.41 (-1.18 to 0.36)	⊕◯◯◯ Very low[b,e,f]
Heel-rise height (12-48 weeks postoperatively)	2	RCT	very serious[e]	not serious	not serious	very serious[b]	SMD: -0.15 (-0.47 to 0.16)	⊕◯◯◯ Very low[b,e]
Heel-rise height (≥48 weeks postoperatively)	2	RCT	very serious[e]	not serious	not serious	very serious[b]	SMD: -0.25 (-0.57 to 0.06)	⊕◯◯◯ Very low[b,e]
Heel-rise work (12-48 weeks postoperatively)	2	RCT	very serious[e]	not serious	not serious	very serious[b]	SMD: 0.00 (-0.31 to 0.31)	⊕◯◯◯ Very low[b,e]
Heel-rise work (≥48 weeks postoperatively)	2	RCT	very serious[e]	not serious	not serious	very serious[b]	SMD: -0.25 (-0.56 to 0.07)	⊕◯◯◯ Very low[b,e]

LLE: late lower limb exercises; ELE: early lower limb exercises; LWB: late weightbearing; EWB: early weightbearing; RCT: randomized controlled trails; CI: confidence interval; OR: odds ratio; SMD: standardized mean difference; ATRS: Achilles Tendon Rupture Score; Explanations: a: studies with potential sources of some concerns in risk of bias; b: very low statistical power achieved ($1-\beta<0.50$); c: moderate heterogeneity between/among studies (I^2=25-50%); d: low statistical power achieved ($1-\beta<0.80$); e: studies with potential sources of high risk of bias; f: high heterogeneity between/among studies (I^2>50%).

3.5.2. Late Weight Bearing and Early Lower Limb Exercises (LWB+ELE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

3.5.2.1. Complications

Re-rupture rate was reported by three studies (Eliasson et al., 2018; Hoeffner et al., 2024; Suchak et al., 2008). While Suchak et al. (2008) and Hoeffner et al. (2024) reported no re-ruptures in both groups of rehabilitation, Eliasson et al. (2018) observed two re-ruptures in LWB+ELE group only (2/23; 8.7%). Major complications occurrence was presented by three studies (Deng et al., 2022; Hoeffner et al., 2024; Suchak et al., 2008), which found a similar number of complications in both groups. One study reported the occurrence of minor complications (Suchak et al., 2008), with similar rates of complications in LWB+ELE (9/55; 16.4%) and EWB+ELE (8/55; 14.5%) group. Meta-analysis indicated no differences for major complications for occurrence with LWB+ELE and EWB+ELE (Figure 8).

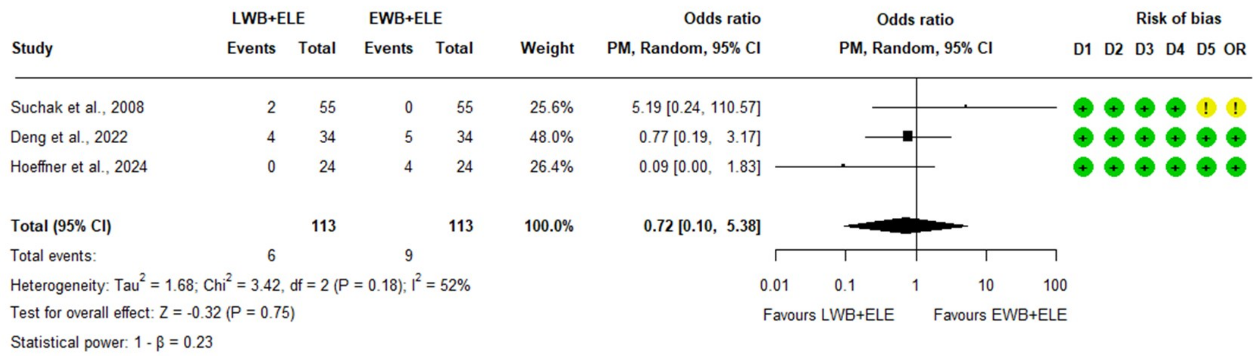


Figure 8. Major complication events in rehabilitation approaches based on early lower limb exercises with late weightbearing (EM+LWB) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns.

Two studies reporting outcomes on the calf's muscle mass (Eliasson et al., 2018; Hoeffner et al., 2024) found no differences between rehabilitation approaches for triceps surae muscle mass (soleus, gastrocnemius medialis and lateralis) at short-term (Eliasson et al., 2018), mid- and long-term (Eliasson et al., 2018; Hoeffner et al., 2024). Tendon elongation was presented by three studies (Agres et al., 2018; Eliasson et al., 2018; Hoeffner et al., 2024), which reported no differences between rehabilitation approaches for tendon elongation/length at short-term (Agres et al., 2018; Eliasson et al., 2018), mid- and long-term (Agres et al., 2018; Eliasson et al., 2018; Hoeffner et al., 2024) assessment.

3.5.2.2. Return to Pre-Injury Activities

Two studies presented the time to return to work (Deng et al., 2022; Eliasson et al., 2018). Although Eliasson et al. (2018) reported no between-group differences, Deng et al. (2022) found an earlier return to work with EWB+ELE than LWB+ELE. Meta-analysis indicated a very high effect size of the EWB+ELE rehabilitation in reducing the time to return to work compared to the LWB+ELE rehabilitation (Figure 9A). Three studies presented the time to return to sport (Deng et al., 2022; Eliasson et al., 2018; Porter and Shadbolt, 2015). While Porter and Shadbolt (2015) reported an earlier return to running with EWB+ELE than LWB+ELE, Eliasson et al. (2018) and Deng et al. (2022) found similar time to return to sport with both rehabilitation approaches. Meta-analysis indicated no differences for time to return to sport with LWB+ELE and EWB+ELE (Figure 9B).

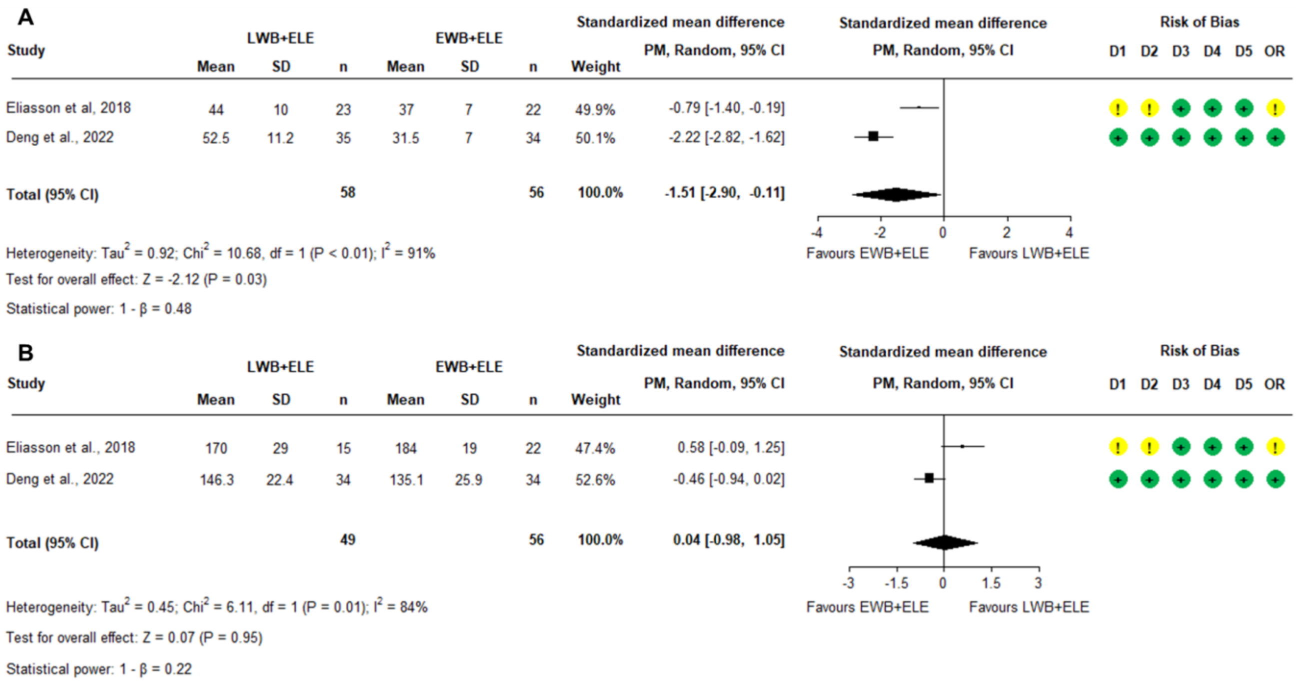


Figure 9. Time to return to work (A) and sport (B) (in days) in rehabilitation approaches based on early lower limb exercises with late weightbearing (EM+LWB) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns.

3.5.2.3. Multi-Item Scoring Scales

Achilles Tendon Rupture Score was presented by four studies (Deng et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024; Porter and Shadbolt, 2015). One study reported better outcomes with EWB+ELE than LWB+ELE only at short-term, but not at mid- and long-term (Deng et al., 2022). Three studies reported that similar outcomes in Achilles Tendon Rupture Score were achieved with both rehabilitation approaches at short-term (Eliasson et al., 2018), mid-term (Eliasson et al., 2018; Porter and Shadbolt, 2015), and long-term (Eliasson et al., 2018; Hoeffner et al., 2024) assessment. One study reporting the $AOFAS_{AHS}$ outcomes (Deng et al., 2022) found better results in EWB+ELE than LWB+ELE at 12 weeks postoperatively, while no differences were found at 24, and 48 weeks after surgery. Meta-analysis indicated that similar Achilles Tendon Rupture Score outcomes were achieved with both rehabilitation approaches at short-, mid-, long-term (Figure 10).

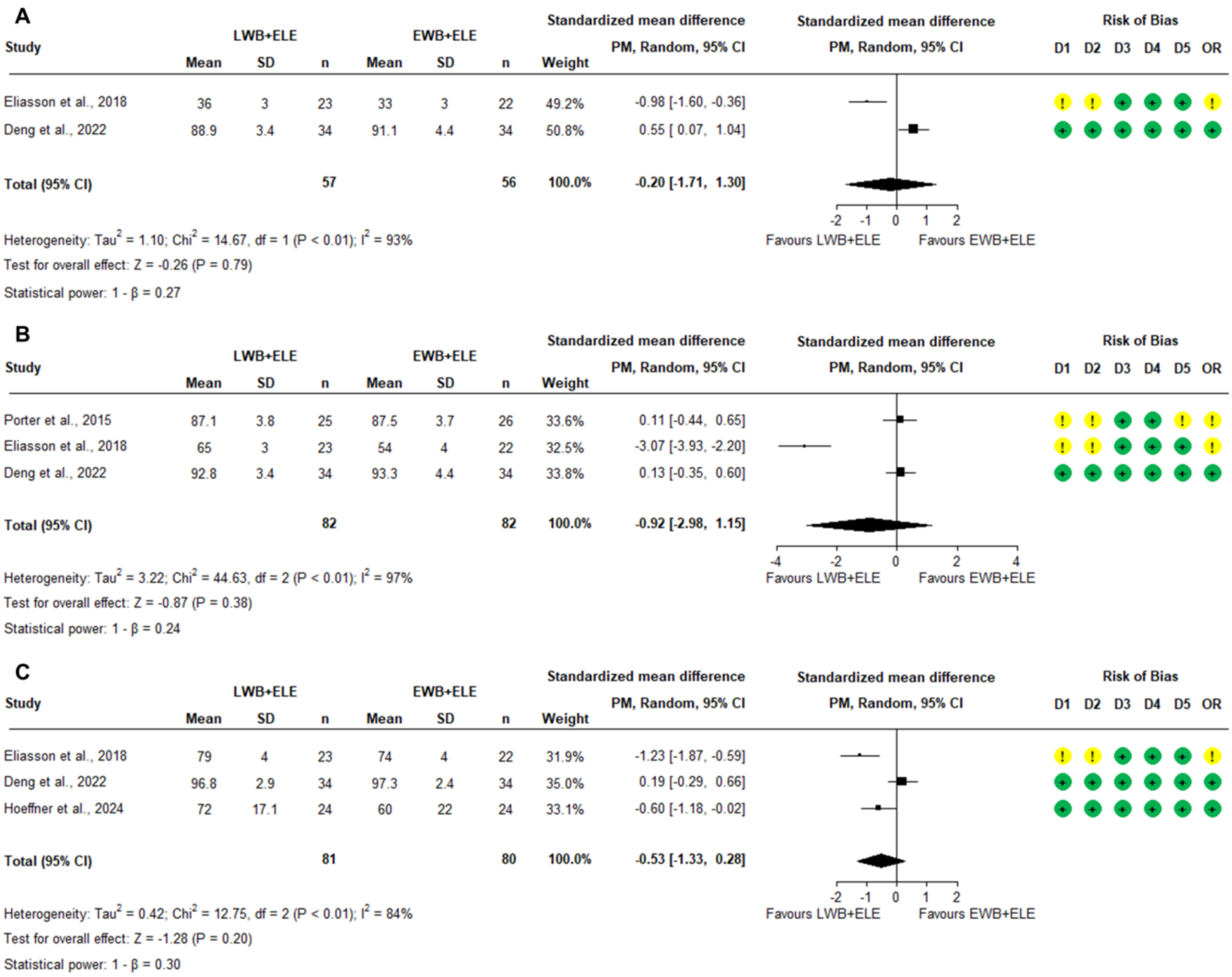


Figure 10. Achilles Tendon Ruptures Score at ≤12 weeks (A), 12-48 weeks (B), and ≥48 weeks (C) postoperatively in rehabilitation approaches based on early lower limb exercises with late weightbearing (EM+LWB) and based on early weightbearing with early lower limb exercises (EWB+ELE). 95% CI: 95% confidence interval; SD: standard deviation; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias; (+): low; (!): some concerns.

3.5.2.4. Ankle Range of Motion

One study presented the dorsiflexion range of motion (Eliasson et al., 2018) and found no group differences for limb symmetry index evaluated during weight bearing lunge test at post-26 and post-52 weeks of surgery.

3.5.2.5. Plantar Flexion Strength

Isometric plantar flexion strength was presented by three studies (Agres et al., 2018; Eliasson et al., 2018; Hoeffner et al., 2024), which reported similar outcomes with LWB+ELE and EWB+ELE at short-term (Agres et al., 2018), mid-term (Eliasson et al., 2018), and long-term (Eliasson et al., 2018; Hoeffner et al., 2024).

3.5.2.6. Heel-Rise Performance

Height during heel-rise test were presented by three studies (Eliasson et al., 2018; Hoeffner et al., 2024; Porter and Shadbolt, 2015). Porter and Shadbolt (2015) found a smaller deficit of heel-rise height in EWB+ELE than LWB+ELE, at post-48 weeks of surgery. On the other hand, Eliasson et al. (2018) and Hoeffner et al. (2024) reported no differences between rehabilitation approaches for performance of heel-rise height at 26 and 52 weeks postoperatively. One study presented the repetitions during the heel-rise test (Hoeffner et al., 2024) and found no between-group differences on both sides at 26 and 52 weeks postoperatively. Two studies presented the total work during the heel-rise test (Eliasson et al., 2018; Hoeffner et al., 2024), which reported no differences between rehabilitation approaches for work during heel-rise test at 26 and 52 weeks of surgery.

3.5.2.7. Summary of Findings

A detailed narrative synthesis of each outcome is presented in Table 2 of Appendix 2G. With very low certainty in evidence, the narrative synthesis supported the following: 1) Similar occurrence of complications with rehabilitation approaches based on LWB+ELE and EWB+ELE; 2) There were no differences for calf's muscle mass and tendon elongation with both rehabilitation approaches at short-, mid-, and long-term; 3) Contrasting findings for the time to return to pre-injury activities; 4) Conflicting results were observed for outcomes in multi-item scoring scales at short-term, while at mid- and long-term consistent findings indicated no differences between rehabilitation approaches; 5) Similar outcomes for dorsiflexion flexion range of motion at mid- and long-term with LWB+ELE and EWB+ELE; 6) There were no differences between rehabilitation approaches for plantar flexion strength outcomes at short-, mid-, and long-term; 7) Similar outcomes in heel-rise performance were achieved with both LWB+ELE and EWB+ELE at mid- and long-term.

With a very low certainty in evidence (Table 6), the meta-analysis models indicated the following: 1) There were no differences in major and minor complications occurrence with both rehabilitation approaches; 2) An earlier return to work with EWB+ELE than LWB+ELE, while similar time to return to sport were achieved with both rehabilitation approaches; 3) Similar outcomes in Achilles Tendon Rupture Score with EWB+ELE than LWB+ELE at short-, mid-, and long-term assessment.

Table 6. Summary of findings of rehabilitation comparisons based on LWB+ELE vs EWB+ELE.

Outcomes	**No. of studies**	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Summary effect (95% CI)**	**Certainty**
Major Complication	3	RCT	serious[a]	serious[b]	not serious	very serious[c]	OR: 0.72 (0.10 to 5.38)	⊕◯◯◯ Very low[a,b]
Time to return to work	2	RCT	serious[a]	very serious[b]	not serious	very serious[c]	SMD: -1.51 (-2.90 to -0.11)	⊕◯◯◯ Very low[a,c,d]
Time to return to sport	2	RCT	serious[a]	very serious[b]	not serious	very serious[c]	SMD: 0.04 (-0.98 to 1.05)	⊕◯◯◯ Very low[a,c,d]
ATRS (≤12 weeks postoperatively)	2	RCT	serious[a]	very serious[b]	not serious	very serious[c]	SMD: -0.20 (-1.71 to 1.30)	⊕◯◯◯ Very low[a,c,d]
ATRS (12-48 weeks postoperatively)	3	RCT	serious[a]	very serious[b]	not serious	very serious[c]	SMD: -0.92 (-2.98 to 1.15)	⊕◯◯◯ Very low[b,e]
ATRS (≥48 weeks postoperatively)	2	RCT	serious[a]	very serious[b]	not serious	very serious[c]	SMD: -0.53 (-1.33 to 0.28)	⊕◯◯◯ Very low[b,e,f]

ELE: early lower limb exercises; LWB: late weightbearing; EWB: early weightbearing; RCT: randomized controlled trails; CI: confidence interval; OR: odds ratio; SMD: standardized mean difference; ATRS: Achilles Tendon Rupture Score. Explanations: a: Studies with potential sources of some concerns in risk of bias; b: High heterogeneity between/among studies (I^2>50%); c: Very low statistical power achieved (1-β<0.50).

3.5.3. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Late Weight Bearing and Early Lower Limb Exercises (LWB+ELE)

3.5.3.1. Complications

Re-rupture rate was presented by two studies (Eliasson et al., 2018; Kangas et al., 2003), which reported similar occurrences of re-ruptures in LWB+LLE (0-4%) and LWB+ELE (8-9%). Meta-analysis indicated a similar occurrence of re-ruptures with both rehabilitation approaches (Figure 11).

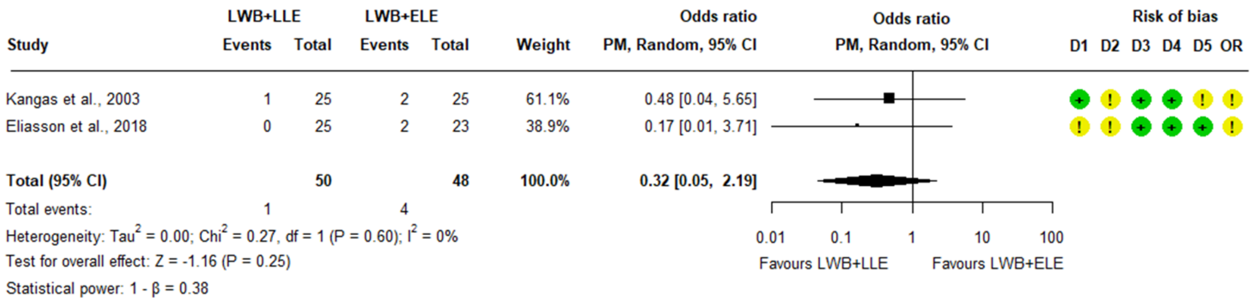


Figure 11. Re-rupture events in rehabilitation approaches based on late weightbearing with late lower limb exercises (LWB+LLE) and based on early lower limb exercises with late weightbearing (EM+LWB). 95% CI: 95% confidence interval; PM: Paule-Mandel method; D1: randomization process; D2: deviations from the intended interventions; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result; OR: overall risk of bias, (+): low; (!): some concerns.

One study reported outcomes of calf's muscle mass (Eliasson et al., 2018), which found no between-group differences on injured side cross-sectional area of gastrocnemius medialis, gastrocnemius lateralis, and soleus at 6, 25, and 52 weeks postoperatively. The injured tendon elongation was reported by two studies (Eliasson et al., 2018; Kangas et al., 2007), which found no differences between rehabilitation approaches at short-, mid-, and long-term assessment.

3.5.3.2. Return to Pre-Injury Activities

One study reported the time to return to previous activities (Eliasson et al., 2018) and found similar time to return to work and sport with LWB+LLE and LWB+ELE.

3.5.3.3. *Multi-Item Scoring Scales*

Achilles Tendon Rupture Score was presented by one study (Eliasson et al., 2018), which reported no between-group differences at post-12, post-26, and post-52 weeks of surgery. Clinical and functional outcomes evaluated using Leppilahti Score were presented by two studies (Kangas et al., 2003; Lantto et al., 2015). The authors reported no differences between rehabilitation approaches at 15 months (Kangas et al., 2003) and at 11 years (Lantto et al., 2015) after surgical repair.

3.5.3.4. *Ankle Range of Motion*

One study reporting the dorsiflexion range of motion (Eliasson et al., 2018) found no between-group differences for limb symmetry index during weight bearing lunge test at post-26 and post-52 weeks of surgery.

3.5.3.5. *Plantar Flexion Strength*

Isometric plantar flexion strength deficit was presented by three studies (Eliasson et al., 2018; Kangas et al., 2003; Lantto et al., 2015), which reported no differences between LWB+LLE and LWB+ELE for plantar flexion strength capacity at mid-term (Eliasson et al., 2018) and long-term (Eliasson et al., 2018; Kangas et al., 2003; Lantto et al., 2015).

3.5.3.6. *Heel-Rise Performance*

Height and total work during heel-rise test was reported by one study (Eliasson et al., 2018), which found no between-group differences for limb symmetry index of height and work at post-26 and post-52 weeks of surgery.

3.5.3.7. *Summary of Findings*

A detailed narrative synthesis of each outcome is presented in Table 3A of Appendix 2G. The narrative synthesis, with a very low certainty in evidence, supported the following: 1) There were no differences for calf's muscle mass and tendon elongation with both rehabilitation approaches at short-, mid-, and long-term; 2) Similar time to return to work and sport were achieved with LWB+LLE and

LWB+ELE; 3) There were no differences between rehabilitation approaches for outcomes in multi-item scoring scales, dorsiflexion range of motion, plantar flexion strength capacity, or heel-rise performance across short-, mid-, and long-term assessments. With a very low certainty in evidence (Table 6), the meta-analysis model for re-rupture indicated no differences for occurrence of re-ruptures in both LWB+LLE and LWB+ELE (Table 3B of Appendix 2G).

3.5.4. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Early Weight Bearing and Late Lower Limb Exercises (EWB+LLE)

3.5.4.1. Complications

Re-rupture rate was presented by two studies (Costa et al., 2006; Okoroha et al., 2020), which reported similar occurrences in LWB+LLE (0-4%) and EWB+LLE (0-8%). Two studies presented the major and minor complications occurrence (Costa et al., 2006; Okoroha et al., 2020). Costa et al. (2006) found similar occurrences of major complications (LWB+LLE: 8%; EWB+LLE: 4%) and minor complications (LWB+LLE: 20%; EWB+LLE: 26%) in both groups. Okoroha et al. (2020) registered no complications in either group.

Calf's muscle loss was reported by one study (Costa et al., 2006), which found no difference between LWB+LLE and EWB+LLE for injured-contralateral side difference of calf diameter at 24 weeks postoperatively. Tendon elongation was presented by one study (Okoroha et al., 2020), which reported no differences between rehabilitation approaches for injured tendon elongation at post-2, post-6, and post-12 weeks of surgery, as well as for overall tendon elongation from 0 to 12 weeks postoperatively.

3.5.4.2. Return to Pre-Injury Activities

One study reporting the time to return to work and sport (Costa et al., 2006) found no differences for time to return to work and sport with LWB+LLE and EWB+LLE.

3.5.4.3. Multi-Item Scoring Scales

Achilles Tendon Rupture Score was presented by one study (Okoroha et al., 2020), which found no differences between rehabilitation approaches at 12 weeks postoperatively.

3.5.4.4. Ankle Range of Motion

Two studies presented dorsiflexion range of motion outcomes (Costa et al., 2006; Okoroha et al., 2020). Costa et al. (2006) reported no differences between rehabilitation approaches for injured-contralateral side difference of dorsiflexion range of motion at 42 weeks postoperatively. Okoroha et al. (2020) reported no differences between LWB+LLE and EWB+LLE for dorsiflexion range of motion on the injured side after 12 weeks of surgery. Two studies reporting plantar flexion range of motion outcomes found no between-group differences for plantar flexion range of motion at post-12 (Okoroha et al., 2020) and post-24 (Costa et al., 2006) weeks of surgery.

3.5.4.5. Summary of Findings

A detailed narrative synthesis of each outcome is presented in Table 4 of Appendix 2G. With very low certainty in evidence, the narrative synthesis supported the following: 1) Similar occurrence of re-rupture, major and minor complications were found in both LWB+LLE and EWB+ELE; 2) There were no differences between rehabilitation approaches for calf’s muscle loss at mid-term, and tendon elongation at short-, mid-, and long-term; 3) Similar outcomes in multi-item scoring scales were achieved with both rehabilitation approaches at short-term; 4) There were no differences between LWB+LLE and EWB+LLE for dorsiflexion and plantar flexion range of motion at short-, and mid-term.

3.5.5. Early Weight Bearing and Late Lower Limb Exercises (EWB+LLE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

3.5.5.1. Summary of Findings

A detailed narrative synthesis of each outcome is presented in Table 5 of Appendix 2G. The narrative synthesis of a single study (Schepull and Aspenberg,

2013) (very low certainty in evidence) supported the following: 1) Similar re-ruptures and major complications in both EWB+LLE and EWB+LLE; 2) There were no differences between rehabilitation approaches for Achilles Tendon Rupture Score, as well as for height and number of movements on both sides during the heel-rise test at long-term.

4. DISCUSSION

In this study we synthetized the effects of different rehabilitation approaches following the ATR surgical repair on clinical and functional outcomes. Our findings suggest that the early approaches did not increase the occurrence of complications when compared to late approaches in the postoperative rehabilitation for ATR. Similarly, the degree of muscle mass loss and tendon elongation was not influenced by the rehabilitation approach used. On the other hand, patients treated with early lower limb exercises and weight bearing returned to work earlier than those treated with late lower limb exercises and/or late weight bearing during rehabilitation, whereas the time to return to sport was not affected by the postoperative rehabilitation. Moreover, although early approaches lead to better outcomes in multi-item scoring scales than late approaches at the short- and mid-term, these effects were comparable at the long-term. The effect of postoperative rehabilitation on functional performance was comparable in all time frames, regardless of the rehabilitation approach used.

4.1. Studies Characteristics

The included studies had methodological concerns that should be considered when interpreting their results. The PEDro scores for methodological quality were fair in 35% of studies and good in 65% of studies. Most studies of fair methodological quality did not report allocation concealment, intention-to-treat analysis, and blinding of assessors. It is important to consider that none of the studies were able to blind participants and therapists, which presents a methodological challenge inherent to the intervention process. In addition, most studies presented some concerns in risk of bias for the outcomes reported, which were mainly related to problems with the randomization process and deviations from the intended interventions. These issues of methodological quality and risk of bias in the included studies may be related to the very low certainty in evidence in our synthesis, highlighting that most of the evidence presented a low to very low certainty, and should be considered with caution when interpreting our findings.

Participants' characteristics were relatively homogenous across the included studies. The sample primarily consisted of middle-aged people of male sex, with a high proportion being overweight, who sustained ATR during sports activities. These findings align with previous systematic reviews (Massen et al., 2022; McCormack and Bovard, 2015; Suchak et al., 2006), as well as with epidemiological studies that report these characteristics as common among individuals who have suffered an ATR (Leino et al., 2022; Lemme et al., 2018). It has been discussed that this "injury profile" may be related to the increasing popularity of recreational sports activities (Ganestam et al., 2016), which are practiced by overweight individuals and possibly those with other comorbidities that may be associated with an increased risk of sustaining an ATR (Ganestam et al., 2016; Lemme et al., 2018). On the other hand, the higher incidence of ATR in people of male compared to female sex remains unclear. Hormonal and biological factors have been suggested as potential contributors, while requiring further investigation (Ganestam et al., 2016). Acute ATR (<14 days of injury), commonly diagnosed by clinical evaluation and positive Thompson test, were treated using open surgical approach and Kessler suture technique in most of studies, which are according with previous systematic reviews (Gould et al., 2021; Massen et al., 2022; McCormack and Bovard, 2015).

4.2. Rehabilitation Characteristics

Rehabilitation approaches were poorly reported, and intervention comparisons heterogeneous across included studies. Although we sought to synthesize rehabilitation approaches to facilitate their implementation in evidence-based practice, most of the trials included in our review lacked clear reporting of rehabilitation programs. Most studies failed to describe the volume and load management of the exercises. Additionally, most studies did not provide a detailed description of the exercises used during rehabilitation and how they were performed. These limitations in primary studies not only limit their applicability to clinical practice, but also limit the advancement of scientific knowledge, as most rehabilitation programs may be difficult to replicate. Our findings highlight the importance of detailed reporting of rehabilitation programs, as consistently recommended by exercise intervention reporting templates (Hoffmann et al., 2014; Slade et al., 2016).

Previous systematic reviews of postoperative rehabilitation for ATR performed their synthesis considering the comparisons in a comprehensive component of early functional rehabilitation (i.e., early weight bearing and/or lower limb exercises) versus conservative rehabilitation (i.e., late lower limb exercises and/or weight bearing) (Brumann et al., 2014; Huang et al., 2015; McCormack and Bovard, 2015; Suchak et al., 2006). Nonetheless, this approach could limit the understating of the impact of each component (i.e., lower limb exercises and weight bearing) on the clinical and functional outcomes. Therefore, we grouped the comparison into several theoretical categories, while we have endeavored to conduct an analysis considering the main structure of interventions (i.e., lower limb exercises and weight bearing). The most common comparison was the combination of late lower limb exercises with weight bearing versus early lower limb exercises with weight bearing (LWB+LLE versus EWB+ELE), followed by early lower limb exercises with late weight bearing versus early lower limb exercises with weight bearing (LWB+ELE versus EWB+ELE), and late lower limb exercises with weight bearing versus early lower limb exercises with late weight bearing (LWB+LLE versus LWB+ELE). Few studies compared the effect of other distinct strategies during the postoperative rehabilitation for ATR. Two studies investigated the effect of a late lower limb exercises with late or early weight bearing, and one study compared the effects of early weight bearing associated with late or early lower limb exercises.

4.3. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

Traditionally, rehabilitation programs following ATR surgical repair have been based on a conservative approach, avoiding early lower limb exercises and weight bearing (Suchak et al., 2006; Zellers et al., 2019). Although the rationale for rehabilitation based on a late approach was to avoid excessive loads on the healing tendon (Suchak et al., 2006; Zellers et al., 2019), our findings indicated that early approach did not increase the complications. Consistent with previous studies, it appears that early rehabilitation with EWB+ELE does not induce high loads that could compromise repair healing, leading to ruptures (Massen et al., 2022;

McCormack and Bovard, 2015) or tendon elongation (Gould et al., 2021). Conversely, it seems possible that the lower load profile of the exercises used in the EWB+ELE approach was unable to prevent calf's muscle loss after ATR compared to LWB+LLE, which is consistent with previous studies reporting similar results (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015).

Alternatively, it seems plausible to suggest that EWB+ELE could be implemented with a comparable level of safety to that of LWB+LLE, while also anticipating the return to work. In our study, we found a very large effect size for EWB+ELE in reducing the time to return to work compared to LWB+LLE, which contrasts with a previous study (Huang et al., 2015; McCormack and Bovard, 2015). Meta-analyses presented by Huang et al. (2015) and McCormack and Bovard (2015) indicated similar time to return to work with early and late rehabilitation approaches. Although these studies reported similar findings, it is important to consider that both exhibited high heterogeneity (I^2>90%) in data synthesis, which can affect the precision of the estimated effects (Gurevitch et al., 2018). The high heterogeneity presented in these studies (Huang et al., 2015; McCormack and Bovard, 2015) may be related to the type of rehabilitation included in their meta-analyses, which grouped rehabilitation based on early or late approach into a comprehensive component (i.e., without differentiating lower limb exercises or weight bearing components).

In contrast, we attempted to reduce the heterogeneity of the studies pooled in the meta-analysis by grouping studies with similar approaches to lower limb exercises and weight bearing. Although we observed lower heterogeneity (I^2=49%) than those studies (I^2=90%) (Huang et al., 2015; McCormack and Bovard, 2015), the heterogeneity observed in our meta-analysis could be attributed to differences in the rehabilitation approaches used in the pooled studies (De la Fuente et al., 2016a; Eliasson et al., 2018). Although De la Fuente et al. (2016a) reported a progressive approach to the implementation of weight bearing, whereas Eliasson et al. (2018) lack a clear description of their management of weight bearing. Considering that a progressive early weight bearing and ambulation promotes greater independence in daily living activities (Maffulli et al., 2003), it is plausible to speculate that these differences in rehabilitation approaches reported by the pooled studies (De la Fuente et al., 2016a; Eliasson et al., 2018) may be a source of heterogeneity.

Moreover, we found a similar return to return to sport (very low certainty in evidence) for both LWB+LLE and EWB+ELE, in contrast to previous studies

(Brumann et al., 2014; Gould et al., 2021). These previous findings were reported through a narrative synthesis, similar to our study. Therefore, it is important to consider that narrative syntheses of quantitative effects are characterized by a lack of transparency, which leads to difficulties in assessing the validity of the findings (Campbell et al., 2019). On the other hand, we endeavored to present a detailed account of the narrative synthesis. Moreover, due to our methodological approach to perform the synthesis, we obtained a single study reporting the effects of LWB+LLE versus EWB+ELE, which could limit our conclusions about the effect of these approaches in the time to return to sport. Taken together, our results indicate that while there was an earlier return to work with EWB+ELE, there was a similar time to return to sport with both LWB+LLE and EWB+ELE. Although returning to work could be considered an essential aspect of daily life, returning to sport may be a matter of personal choice, given that most ATRs occurred during recreational sports practice. Considering that patients may choose not to return to sport or delay their return due to fear of reinjury (Larsson et al., 2024; Zellers et al., 2016), it is plausible to speculate that rehabilitation effects may be negligible in such cases. In addition, it is important to consider that many people are unable to return to their previous level of sports activity due to severe functional deficits (Hoeffner et al., 2022; Zellers et al., 2016).

Post-ATR impairments include poor clinical and functional outcomes in multi-item scoring scales (Gould et al., 2021), deficits in plantar flexion strength (~30%) (Hoeffner et al., 2022; Svensson et al., 2019) and ankle range of motion (~20%) (Gould et al., 2021; Silbernagel et al., 2012), which are associated with difficulties in performing a complete heel-rise (Silbernagel et al., 2012; Svensson et al., 2019). Thus, early rehabilitation has been proposed to improve recovery after ATR surgery, potentially accelerating recovery and reducing functional impairment compared to late rehabilitation approaches (Gould et al., 2021; Suchak et al., 2006). In our study, we found better outcomes in multi-item scoring scales in EWB+ELE than LWB+LLE, especially in the short-term (<3 months postoperatively). These findings are consistent with previous studies (Brumann et al., 2014; Gould et al., 2021; McCormack and Bovard, 2015), which reported better outcomes with early than late rehabilitation approaches in the short-term. Moreover, it is interesting to observe that better outcomes in Achilles Tendon Rupture Score were found in EWB+ELE than LWB+LLE at short- and mid-term assessment, while at long-term there was no difference between rehabilitation approaches. This tool is an ATR-specific patient-reported outcome measure that accounts for ten items (0-10 points) to obtain an overall score (0-100 points, where 100 represents the best condition) (Nilsson-Helander et al., 2007; Spennacchio et al., 2016). Albeit speculative, it is possible that the better results in the short- and mid-term could be related to an improved ability to perform daily activities as well as an improved pain tolerance, given that 50% of the total score was related to walking ability (20%), limitation of work/daily activities (20%), and pain outcomes (10%). Previous studies have reported a greater number of steps (Suchak et al., 2008), earlier return to work (De la Fuente et al., 2016a), and improved pain tolerance (De la Fuente et al., 2016a) with early than late approaches during the postoperative rehabilitation for ATR.

Moreover, although any heterogeneity was found in the meta-analysis for Achilles Tendon Rupture Score at mid-term, at short-term and long-term there was a high heterogeneity. The rehabilitation programs described by Eliasson et al. (2018) involved a lower load profile compared to those reported by De la Fuente et al. (2016a). This difference may affect participants' recovery and potentially contribute to the heterogeneity observed in the short-term effect model. However, the high heterogeneity in long-term outcomes may be related to the different approaches to lower limb exercises and weight bearing used in the studies (Aufwerber et al., 2020c; Eliasson et al., 2018). While Eliasson et al. (2018) reported rehabilitation programs that were distinctly different between LWB+LLE and EWB+ELE, Aufwerber et al. (2020c) presented rehabilitation programs that were very similar. This difference in rehabilitation approaches may have contributed to the observed heterogeneity in the long-term meta-analysis results. Taken together, these findings suggest that EWB+ELE may accelerate recovery compared to LWB+LLE, resulting in better outcomes on multi-item scoring scales at the short- and mid-term. However, in the long-term, clinical and functional outcomes were comparable between these rehabilitation approaches, corroborating previous studies (Gould et al., 2021; Suchak et al., 2006).

Additionally, it is important to consider that the multi-item scoring scales were often composed of subjective and objective outcomes (Pearsall et al., 2023), especially the Achilles Tendon Rupture Score, which is a patient-reported outcome tool. It is possible that the better outcomes in these tools were related to a better subjective sense of recovery rather than to better functional performance in objective measures. These findings may suggest that postoperative exercises may not induce substantial and long-lasting adaptations, as most exercises used in these rehabilitation protocols focused on ankle range of motion and weight bearing exercises (i.e., low load profile) (Zellers et al., 2019), which may be associated with similar functional performance in both rehabilitation approaches. Previous studies reported similar functional performance using either late or early rehabilitation approaches (Brumann et al., 2014; Gould et al., 2021), with no differences found for plantar flexion strength, ankle range of motion, and heel-rise performance. Similarly, in our study, supported that plantarflexion strength and ankle range of motion capacity were similar after LWB+LLE and EWB+ELE, regardless of the timeframe of the assessment (very low certainty in evidence). Moreover, meta-analyses, with very low certainty in evidence, indicated no differences in heel-rise performance with LWB+LLE and EWB+ELE at mid- and long-term assessment. Taken together, these findings indicate that exercises applied during postoperative rehabilitation for ATR may not fully prevent functional deficits. Nevertheless, it is interesting to note that the rehabilitation programs with a higher load profile appear to have produced better responses in terms of clinical and functional outcomes (De la Fuente et al., 2016a; De la Fuente et al., 2016b). Therefore, it is reasonable to suggest that rehabilitation programs could incorporate strength-focused exercises into postoperative management (Christensen et al., 2024; Christensen et al., 2020), along with complementary strategies following rehabilitation (e.g., strength training) to support long-term recovery.

4.4. Early Weight Bearing and Late Lower Limb Exercises (EWB+LLE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

Considering that similar clinical and functional outcomes were achieved using LWB+LLE and EWB+ELE, studies have been investigated the effect of progressive early weight bearing with late lower limb exercises (i.e., EWB+LLE) compared to the early rehabilitation approach (i.e., EWB+ELE). The rationale is that EWB+LLE could lead to more progressive myotendinous loading, improving tendon healing while avoiding re-ruptures and/or excessive tendon elongation (Hoeffner et al., 2024; Maffulli et al., 2022). In our study, we found that there were no differences in complications with EWB+LLE and EWB+ELE, including ruptures and tendon elongation. Therefore, it is possible to suggest that the late lower limb exercises was not able to prevent the tendon elongation, which is opposite with the rationale of using EWB+LLE over EWB+ELE. Some degree of elongation is a biological response in the healing process (Hiramatsu et al., 2018; Kangas et al., 2007), which is attributed to the deposition of scar tissue at the injury site (Hiramatsu et al., 2018). However, it is unlikely that the repair was compromised by the low loads applied in rehabilitation based on the EWB+ELE approach, as well as to attenuate calf's muscle loss after ATR.

Alternatively, although comparable complications with both rehabilitation approaches, we found a very large effect size of EWB+ELE in reducing the time to return to work compared to EWB+LLE. However, it is important to consider that this result was obtained from a meta-analysis with a very low certainty in evidence and high heterogeneity. The heterogeneity observed in our meta-analysis may be due to differences in the weight bearing management used in the pooled studies (Deng et al., 2022; Eliasson et al., 2018). Given that early ambulation promotes greater independence in activities of daily living (Maffulli et al., 2003), potentially influencing return to work. Thus, Eliasson et al. (2018) reported that the participants in EWB+ELE group were allowed to full-weight bearing at 4 weeks postoperatively, while Deng et al. (2022) allowed the participants in EWB+ELE group to perform full-weight bearing as tolerated after 3 days of surgery. It is reasonable to speculate that these differences in weight bearing approaches applied by these studies (Deng et al., 2022; Eliasson et al., 2018) may be related to the high heterogeneity observed in our meta-analysis model.

On the other hand, a similar time to return to sport were found with both EWB+LLE and EWB+ELE. This result was provided from meta-analysis with very low certainty in evidence and high heterogeneity. The high heterogeneity observed could be related to the differences in rehabilitation programs used by these studies Eliasson et al. (2018) and started weight bearing immediately after surgery, while Porter and Shadbolt (2015) allowed weight bearing only at post-2 weeks. Moreover, the programs reported by Eliasson et al. (2018) did not include strength exercises, while Porter and Shadbolt (2015) reported the use of resistance strengthening at 6 weeks in the EWB+ELE group. Thus, it is possible that these differences in rehabilitation approaches could be considered a potential source of heterogeneity. Furthermore, it is interesting to observe that the program reported by Porter and

Shadbolt (2015) combined early weight bearing with strength exercises achieved better results in return to sport than the program presented by Eliasson et al. (2018). These results may highlight the positive effect of strength exercises as a component of postoperative rehabilitation, potentially attenuating functional impairments after ATR.

In our study, meta-analyses with very low certainty in evidence indicated that similar Achilles Tendon Rupture Score achieved with EWB+LLE and LWB+ELE at short-, mid-, and long-term assessment. The studies pooled in the short-term meta-analysis (Deng et al., 2022; Eliasson et al., 2018) resulted in high heterogeneity. Eliasson et al. (2018) allowed full weight bearing in the EWB+ELE group at 4 weeks postoperatively, while Deng et al. (2022) allowed full weight bearing as tolerated in the EWB+ELE group 3 days after surgery. These differences in weight bearing approaches may be related to the high heterogeneity. Moreover, the studies pooled in the mid-term meta-analysis (Deng et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024) resulted in high heterogeneity. Sensitivity analyses indicate that the study of Eliasson et al. (2018) accounted for the high heterogeneity, while removing this study does not alter the results. Moreover, the high heterogeneity could be associate with rehabilitation approaches conducted by each study. As previously mentioned, the load profile in the rehabilitation approaches used by Eliasson et al. (2018) were lower than that in other studies (Deng et al., 2022; Porter and Shadbolt, 2015). Taken together, these findings may indicate that approaches based on early weight bearing with late or early lower limb exercises have comparable effects on clinical and functional outcomes. These results could be due to the similarity of the rehabilitation programs, which, despite differences in the timing of application, do not differ significantly in terms of the stimuli applied.

Finally, we found no differences between rehabilitation approaches based on EWB+LLE and EWB+ELE on functional performance at short-, mid-, and long-term. Moreover, there were no differences between rehabilitation approaches for dorsiflexion flexion range of motion and plantar flexion strength outcomes (very low certainty in evidence). Similarly, comparable functional performance was observed during the heel-rise test. These findings indicate that both EWB+LLE and EWB+ELE may not fully prevent functional impairments. This may indicate that, beyond the timing of lower limb exercises and/or weight bearing, the exercises used in rehabilitation should be further explored. Taken together, these results may suggest that rehabilitation approaches based on EWB+ELE may be superior to those based on EWB+LLE, particularly in reducing time to return to work, while comparable clinical and functional outcomes were achieved with both rehabilitation approaches.

4.5. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Late Weight Bearing and Early Lower Limb Exercises (LWB+ELE)

In this study, we found that the occurrence of re-ruptures and complications were similar in both LWB+LLE and LWB+ELE, as well as similar tendon elongation and calf's muscle mass outcomes. As mentioned above, it is reasonable to assume that these approaches based on late weight bearing with early or late lower limb exercises do not result in distinct complications, nor do they seem to be able to attenuate the post-ATR calf's muscle loss. Similarly, these approaches result in a comparable time to return to work and sport, as well as similar clinical and functional outcomes.

Therefore, it is plausible to suggest that the combination of early lower limb exercises and weight bearing may have therapeutic potential precisely because of its combination of components. Given the characteristically low profile of the loads used during rehabilitation exercises, isolating these components through late application can further reduce the stimuli, which can be as effective as the natural recovery from injury.

4.6. Late Weight Bearing and Lower Limb Exercises (LWB+LLE) versus Early Weight Bearing and Late Lower Limb Exercises (EWB+LLE)

The occurrence of re-ruptures and complications was similar in both LWB+LLE and EWB+LLE rehabilitation approaches. Moreover, no differences were found for calf's muscle mass (Costa et al., 2006) and tendon elongation (Eliasson et al., 2018) outcomes with LWB+LLE and EWB+LLE. Similarly, the time to return to work and sport did not differ using rehabilitation approaches based on a late or early weightbearing (Costa et al., 2006). Similar findings were found in clinical and functional outcomes, with both rehabilitation approaches leading comparable to the outcomes in Achilles Tendon Rupture Score, ankle range of motion. As already mentioned, rehabilitation based on early weight bearing does not seem to alter complications, even when combined with late lower limb exercises, while its effect on functional performance is negligible. These results could both be due to the low mechanical loads used in these approaches. Although the low profile of the loads used in the exercises may not lead to increased complications, it may also be sufficient to promote the positive adaptations that could attenuate the functional deficits.

4.7. Early Weight Bearing and Late Lower Limb Exercises (EWB+LLE) versus Early Weight Bearing and Lower Limb Exercises (EWB+ELE)

Schepull and Aspenberg (2013) compared the effects of a rehabilitation approach based on early weightbearing associated with late or early lower limb exercises. The occurrence of re-rupture and complications was similar in both groups. Although the authors applied a progressive strength training for plantar flexors, similar outcomes were found in Achilles Tendon Rupture Score and heel-rise performance at long-term. These results suggest that strength training with higher load profiles may not fully prevent long-term functional deficits. It is plausible to suggest that the effects of rehabilitation may play an important role in the short-term, but its effects may not be sustained in the long-term. Thus, complementary strategies following rehabilitation should be further explored to support long-term recovery.

4.8. Concluding Remarks: Limitations, Strengths, and Future Perspectives

Our study has some aspects that could limit our findings and should be considered to interpret the results. The evidence synthetized in our review was mostly presented by studies of fair methodological quality. In addition, there were some concerns in the risk of bias assessments for the outcomes of the majority of studies. These methodological limitations in primary studies reduce the certainty in evidence of our findings. In our study, the meta-analysis results indicated a very low certainty in evidence, which could be associated with the methodological limitations of the primary studies, as well as the high heterogeneity and low statistical power of the meta-analysis models. Although we endeavored to perform meta-analyses that were as homogeneous as possible, considering the comparison of rehabilitation and the assessments timeframe, this approach implied meta-analyses with few studies. The small number of studies in the meta-analysis models limited our ability to explore the sources of heterogeneity, restricting our approach to speculative discussion of the possible sources. Moreover, the degree of certainty in the models is also reduced by low statistical power. As would be expected, the small number of studies produced underpowered meta-analysis. Nonetheless, we have chosen to present these models while being explicit about their limitations. Moreover, due to heterogeneity of assessment methods and timeframe, meta-analysis models were not performed for some outcomes. On another hand, we are striving to provide a detailed narrative synthesis of the interest outcomes, which presented a very low certainty in evidence and should be considered in the interpretation of our results.

To the best of our knowledge, our study is the first study to perform a systematic review considering a detailed comparison of the main components/approaches applied during the postoperative rehabilitation for ATR. Taken together, our findings can provide important information for evidence-based practice and scientific development in the field. Considering that most of the intervention studies lack detailed reporting of rehabilitation programs, our comprehensive review could provide a basis for management decisions tailored to the specific needs of each patient, as we investigate the effects of distinct approaches used in the postoperative rehabilitation for ATR. Moreover, the effect of early versus late approaches has been constantly and extensively investigated. However, the available evidence indicated that the early application of loads does not cause an increase in complications, although it is ineffective in attenuating functional deficits. Therefore, it seems plausible to consider exploring different strategies beyond the time period for starting lower limb exercises and/or weight bearing, especially in relation to the exercises used in rehabilitation programs. Recent studies have already attempted to explore the effect of these strategies by investigating the use (Christensen et al., 2020) and feasibility (Christensen et al., 2024) of strength exercises during rehabilitation for ATR. Moreover, complementary strategies following rehabilitation to support long-term recovery should be further explored. Finally, the reinforcement of detailed reporting of exercise programs by intervention studies should be consistently recommended. Inadequate reporting not only limits applicability to clinical practice, but also limits the advancement of scientific knowledge, as most exercise interventions may be difficult to replicate (Hoffmann et al., 2014; Slade et al., 2016).

5. CONCLUSION

Rehabilitation approaches based on early lower limb exercises and weight bearing are safe and could reduce the time to return to work. Although these approaches lead to better outcomes on multi-item scoring scales in the short and mid-term, while similar outcomes were found in the long-term. Furthermore, the different postoperative rehabilitation approaches do not appear to attenuate the post-ATR functional deficits of ankle range of motion, plantar flexion strength, and heel-rise ability. Further research is needed to explore and identify strategies to attenuate the clinical and functional impairments following ATR.

ADDITIONAL INFORMATION

Felipe Gidiel Machado received a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, from Brazil (88887.798480/2022-00), and expressed his acknowledgement for the support. However, this financial support does not imply any conflicts of interest, as well as there are no other potential conflicts of interest. To minimize the impact of cross-cultural language adaptation, the text grammar and concordance were checked using artificial intelligence translation tools from DeepL Translate Software (https://deepl.com) and OpenAI's ChatGPT (https://openai.com/chatgpt).

CHAPTER III

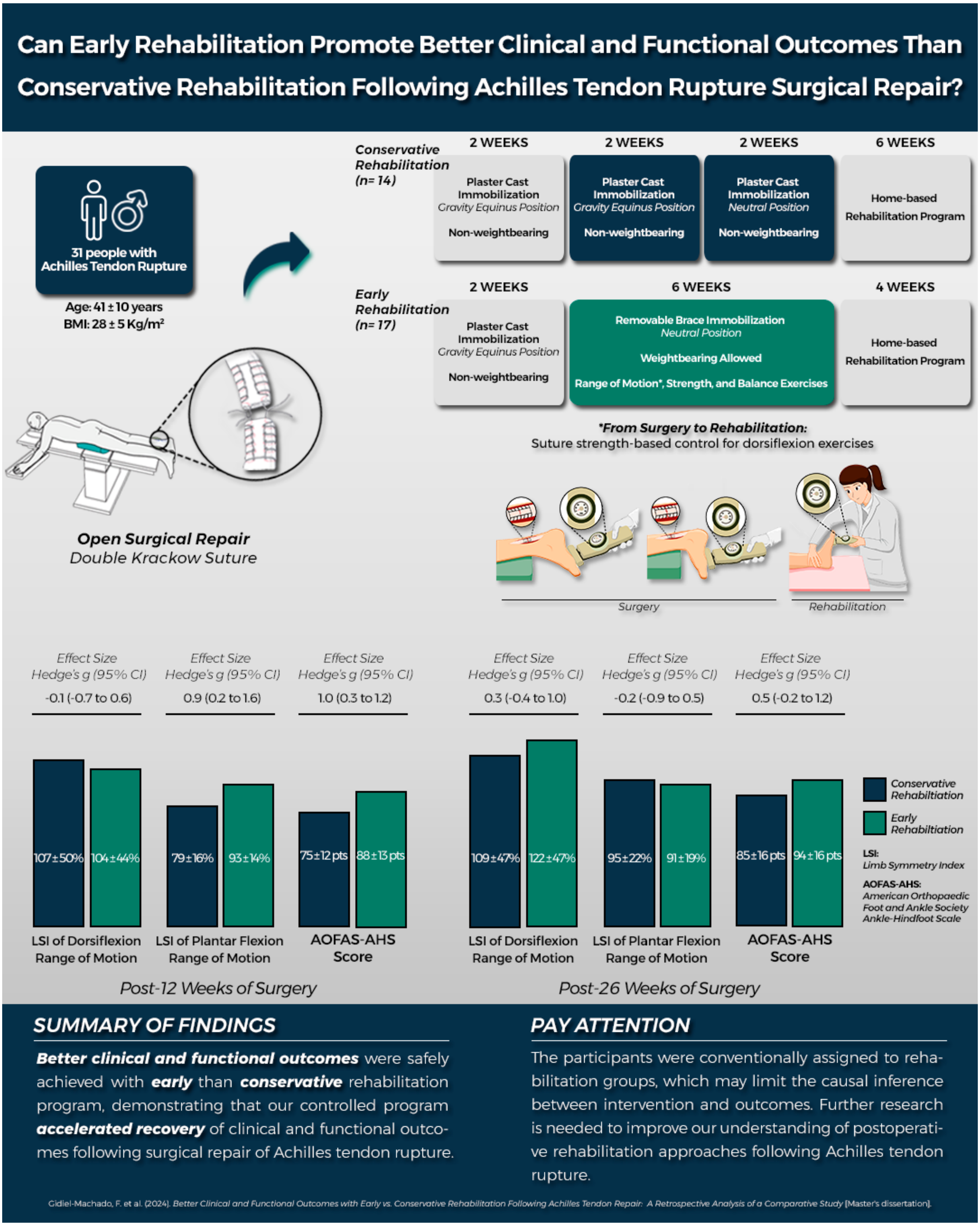
Better Clinical and Functional Outcomes with Early vs. Conservative Rehabilitation Following Achilles Tendon Repair: A Retrospective Analysis of a Comparative Study

ABSTRACT

Background: Achilles tendon rupture (ATR) is a disabling injury. Contrasting findings have been reported using conservative rehabilitation (CR) and early rehabilitation (ER) after surgical repair of ATR. Furthermore, most studies lack clear intervention descriptions, which limits both clinical applicability and scientific advancement. **Purpose:** To describe a detailed report and controlled ER program; and to compare the clinical and functional outcomes between CR and ER following ATR surgical repair. **Methods:** Thirty-one male participants underwent either twelve weeks of conservative rehabilitation (CR; n=14) or early rehabilitation (ER; n=17) following open surgical repair of ATR. The participants were evaluated at the surgery admission for anthropometrics and injury characteristics, post-2 (P2), post-12 (P12), and post-26 (P26) weeks of surgery for limb symmetry index of active plantarflexion (PF) and dorsiflexion (DF) ROM, and American Orthopaedic Foot and Ankle Society Score, Ankle-Hindfoot Scale ($AOFAS_{AHS}$) (evaluated at P12 and P26 only). **Results:** No between-group differences were found in anthropometrics and injury characteristics, as well as for ankle ROM at P2. At P12, compared to CR, the ER group presented a higher limb symmetry index of PF_{ROM} and better outcomes in $AOFAS_{AHS}$, while no group differences were found for limb symmetry index of DF_{ROM}. At P26, no between-group differences were found for limb symmetry index of PF_{ROM} and DF_{ROM}, as well for $AOFAS_{AHS}$ outcomes. No re-rupture occurred during the follow-up. **Conclusion:** At the end of rehabilitation (P12), better clinical and functional outcomes without tendon re-ruptures were achieved with ER than CR program, demonstrating that our controlled ER program can safely accelerate the recovery of clinical and functional outcomes following the ATR surgical repair.

Keywords: Tendon tears; Accelerated Rehabilitation; Early Mobilization.

GRAPHICAL ABSTRACT



1. INTRODUCTION

Achilles tendon rupture (ATR) is a common and disabling injury (Leino et al., 2022; Lemme et al., 2018; Zellers et al., 2016). ATR leads to absence from work and sports practice (McCormack and Bovard, 2015; Zellers et al., 2016), also causing severe impairments (Hoeffner et al., 2022; Svensson et al., 2019). While the optimal treatment remains controversial, surgical approaches have been reported as a viable option (Meulenkamp et al., 2018; Ochen et al., 2019). Postoperative management can be performed by a conservative rehabilitation (CR) or an early rehabilitation (ER) approach. While CR involves non-weight bearing and ankle immobilization (Massen et al., 2022; Zellers et al., 2019), ER is based on early-applied (i.e., <2 weeks postoperatively) weight bearing and lower limb exercises (Massen et al., 2022; Zellers et al., 2019).

Although CR has been used to protect the surgical repair and prevent tendon re-ruptures (McCormack and Bovard, 2015), it can intensify the disuse period caused by absence from activities (Eliasson et al., 2018; Schepull and Aspenberg, 2013). A disuse period can lead to muscle mass loss and tendon degeneration (Narici and Maganaris, 2007). These adaptations have been associated with post-ATR clinical and functional limitations (Hoeffner et al., 2022; Svensson et al., 2019). Therefore, ER programs have been proposed as an alternative to CR, aiming to attenuate the impact of disuse and improve the patient's recovery (Massen et al., 2022; Schepull and Aspenberg, 2013; Zellers et al., 2019).

Compared to CR, ER approaches can promote greater personal satisfaction (McCormack and Bovard, 2015), potentially resulting in a shorter time to return to pre-injury activities (Gould et al., 2021; McCormack and Bovard, 2015), anticipating the patient's recovery without increasing the risk of re-ruptures (Massen et al., 2022). However, divergent results were reported in clinical and functional outcomes. While some studies reported better ankle range of motion (ROM) using ER (Buchgraber and Pässler, 1997; Cetti et al., 1994), others reported no differences between CR and ER (Kim et al., 2017; Okoroha et al., 2020). Similarly, divergent findings have been found in American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Score ($AOFAS_{AHS}$). Some studies found better clinical and functional outcomes in $AOFAS_{AHS}$ using ER (Deng et al., 2022; Kim et al., 2017), whereas others reported similar responses with CR and ER (Mosconi et al., 2022; Nam et al., 2019). These divergent findings could be related to the management and structuring of ER programs (Zellers et al., 2019).

Zellers et al. (2019) reported more than seven components used in ER programs, with the most commonly used exercises focused on gaining ankle ROM (66%). Despite significant ankle ROM deficits are reported after an ATR (~20-30%) (Agres et al., 2020; Silbernagel et al., 2010), ROM exercises were primarily used to prevent deep adhesion by tendon slippage (i.e., subtle ankle movements to protect the tendon repair) (Zellers et al., 2019). However, while wider ankle ROM exercises could be used to reduce ankle ROM deficits (Zellers et al., 2019), methods to safely control ankle ROM exercises remain unclear. Since excessive stimulation can lead to tendon re-ruptures (Pajala et al., 2002; Rettig et al., 2005), an exercise control method could ensure safety and effectiveness during the early stages of rehabilitation. In addition, most rehabilitation programs are poorly described and lack a clear reporting of structuring and application (Christensen et al., 2020). These limitations in exercise management and rehabilitation reporting present a challenge to their effective implementation in clinical practice and replication in scientific research.

Our study's purposes are (1) to describe a detailed report and controlled ER program; and (2) to compare the clinical and functional outcomes between CR and ER programs, at post-12 and post-26 weeks of surgical repair. Our hypothesis is that, by using a controlled ER program, positive results will be achieved in favor of ER over CR, safely anticipating the participant's recovery.

2. METHODS

2.1. Participants

Our study was conducted according to the Declaration of Helsinki and was approved by the ethics and research committee (protocols 07/04008 and 2007879; Appendix 3A). The study's sample was drawn from the database of a previous trial. Thus, a post hoc power analysis was performed. The inclusion criteria were aged between 18 to 60 years; and primary, unilateral, and total ATR diagnosed (i.e., positive Thompson test) with at least 15 days of the injury event. The exclusion criteria were arterial insufficiency (Svedman et al., 2020), diabetes (Claessen et al., 2014), autoimmune diseases (Claessen et al., 2014), systemic use of quinolones/corticoids (Claessen et al., 2014), contraindication to dynamometry tests (>12 weeks postoperatively), and >3 absences in ER sessions. All 38 participants that met the inclusion criteria, were informed about the study and signed written consent form to participate. Seven participants were lost to follow-up (CR: n=5; ER: n=2). Thirty-one participants were included in the study analysis (Figure 1).

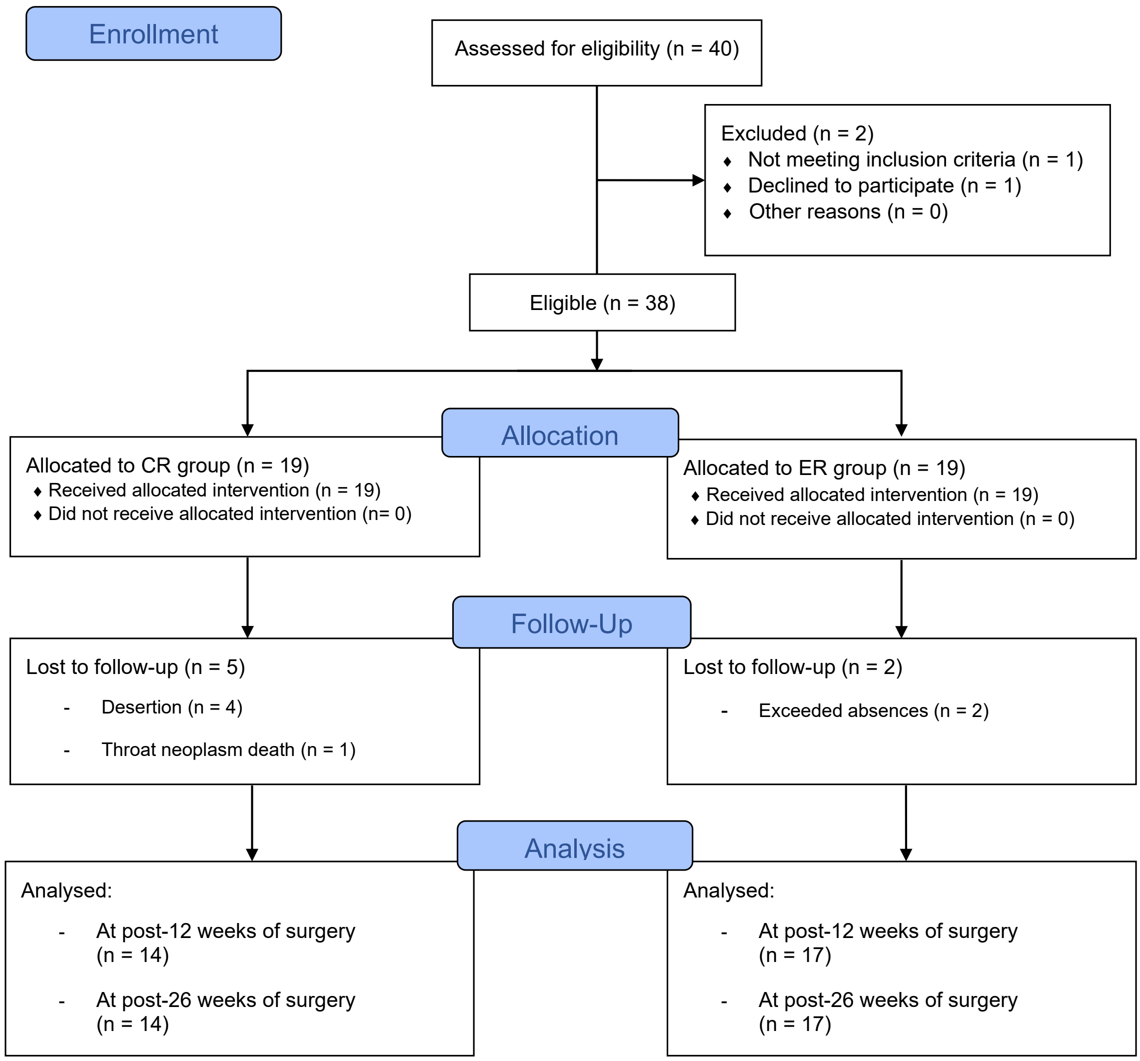


Figure 1. Flow chart of the study. CR: conservative rehabilitation. ER: early rehabilitation.

2.2. Experimental design

Eligible participants were surgically treated. Postoperatively, the participants were conveniently allocated into CR or ER groups in a 1:1 ratio for rehabilitation (parallel non-randomized design). To facilitate participation in the study, people who lived closest to the rehabilitation clinic were enrolled in the ER group (n=17), while the remainder were enrolled in the CR group (n=14). Clinical rehabilitation sessions were conducted by experienced physiotherapists. Neither the participants nor the professionals could be blinded to intervention allocation. At the end of rehabilitation, all participants received instructions to perform the same home-based rehabilitation protocol.

At pre-operative, the participant's anthropometrics (age, body mass, and height) and injury characteristics (time between injury and surgery, injury mechanism, and injury side) were obtained. During the surgery, the strength of the tendon repair was obtained. Ankle ROM and $AOFAS_{AHS}$ were evaluated through the same experimental outline: First, the limb symmetry index of active plantarflexion ROM (PF_{ROM}) and dorsiflexion ROM (DF_{ROM}) were evaluated, at post-2 (P2), post-12 (P12), and post-26 (P26) weeks of surgery. Finally, at P12 and P26, $AOFAS_{AHS}$ outcomes were obtained. The outcome assessor and data analyst were not blinded to the intervention allocation.

2.3. Surgical Procedures

Surgery was performed by the same experienced surgeon using the same approach. With the participant in the prone position, an incision was made directly to the hematoma area, preserving the paratendon whenever possible. After identifying injury, tendinous stumps were sutured using Double Krackow suture technique with Vicryl 2.0. A posterior compartment fasciotomy was performed to facilitate closure. The repair was then tensioned to the same degree of gravitational equinus as the contralateral side and the strength of the repair was tested using a handheld dynamometer (Baseline Hydraulic push-pull dynamometer, NY, USA). The surgeon applied force on the plantar foot region with the dynamometer (Figure 2A) to induce dorsiflexion until tension at the suture was observed without visible separation of tendon stumps (Figure 2B). At this moment, the dynamometer's force value was recorded (Figure 2B) and used as a limit for conducting passive dorsiflexion exercises in ER (Figure 2C). For wound closure, the paratendon and subcutaneous plane were repaired with Vicryl 2.0, and the skin was sutured with Mononylon 3.0. No repair reinforcement was used. Participants were discharged 24 hours postoperatively.

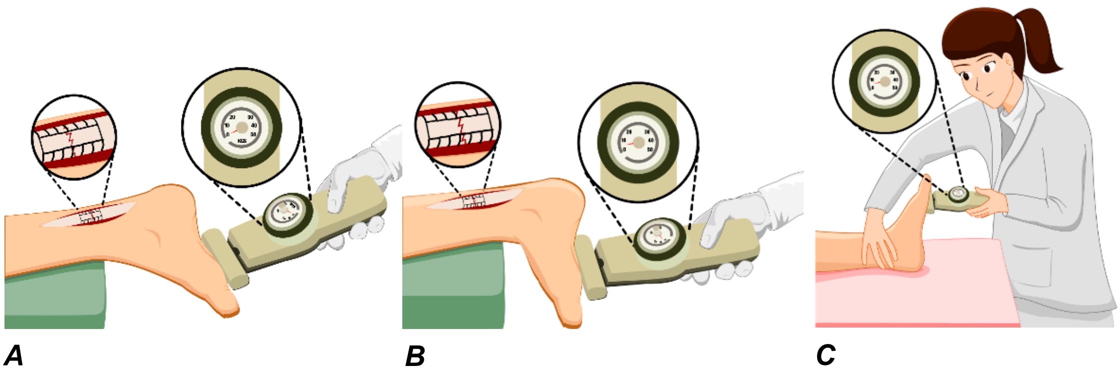


Figure 2. Repair strength test conducted after surgical repair. (A) The surgeon applied force to the plantar foot region to induce dorsiflexion. (B) Critical point of repair resistance, which was observed without visible separation of tendon stumps. (C) Passive dorsiflexion exercises conducted with submaximal forces obtained during the tendon repair's strength test.

2.4. Rehabilitation Programs

Rehabilitation programs were presented according to The Consensus on Exercise Reporting Template (Slade et al., 2016). The strength exercises were reported according to Toigo & Boutellier exercise descriptors (Toigo and Boutellier, 2006). Postoperatively, participants were divided into two groups for rehabilitation (CR or ER), conducted according to Geremia et al. (2015). Detailed information on the interventions structure and exercise descriptors is provided in Appendices 3B and 3C, respectively.

Conservative rehabilitation: From postoperatively to the fourth week, participants had the injured side immobilized in a gravity equinus position for four weeks using a plaster cast no weight bearing being allowed. From the fourth to the sixth week, the plaster cast was repositioned with the ankle in a neutral position (ankle angle 90°, considering the tibia perpendicular to the foot sole), and partial to total weight bearing as tolerated was allowed. At the end of the sixth week, the plaster cast was removed, and participants received a home-based rehabilitation program.

Early rehabilitation: From postoperatively to the second week, participants had the injured side immobilized in gravity equinus position with a plaster cast without weight bearing. From the second to the eighth week, physiotherapists conducted and supervised one-hour individualized rehabilitation sessions, three times a week (≥48 hours between sessions), for six weeks (see Appendix 3B for more details). During the ER, participants used a removable brace with ankle in neutral position (ROBOFOOT® SalvaPé, São Paulo, Brazil). To increase the engagement in sessions and treatment, verbal feedback strategies were employed. Rehabilitation adherence was not monitored. Interventions were performed in a physical therapy clinic and consisted of weight bearing, ankle ROM, and lower limb strength exercises (all performed bilaterally) (refer to Appendix 3C for more details). To avoid damage to the tendon repair, passive dorsiflexion ROM exercises were controlled using the tendon repair's strength test during the surgery (Figure 2). With the participant in the supine position and with the knee and hip fully extended (180°), using a handheld dynamometer positioned on the plantar foot region, force was applied to induce dorsiflexion until the repair's strength limit that was registered during surgery was achieved (Figure 2C). No adverse events occurred during the interventions. After the eighth week post-surgery, participants received a home-based rehabilitation program.

Home-based rehabilitation: The home-based rehabilitation program was focused on lower limb strength exercises. All participants were instructed to perform the exercises bilaterally seven days a week for six weeks in CR group, and for four weeks in the ER group.

2.5. Ankle Range of Motion

Ankle ROM was evaluated using a handheld goniometer with the patient in supine position and the knee and hip fully extended (180°). The goniometer's center of rotation was aligned with the lateral malleolus, the proximal arm was aligned with the midline of the fibula, and the distal arm parallel to the fifth metatarsal (Silbernagel et al., 2012). Maximal active ROM was determined from the neutral ankle position during three attempts in each test. A 30-second interval was allowed between each trial and test. First, DF_{ROM} was measured, then PF_{ROM}. The highest ROM value was used to calculate the limb symmetry index (quotient of injured by uninjured limb, multiplied by one hundred).

2.6. Clinical and Functional Outcomes

Clinical and functional outcomes were summarized using $AOFAS_{AHS}$ (Kitaoka et al., 1994). This tool includes scores in three domains: pain (0-40 points), function (0-50 points), and alignment (0-10 points). The sum of scores was used for analysis (100 points representing the best condition). Due to technical issues with database extraction, different sample sizes were analyzed at P12 (CR: n=12; ER: n=14) and P26 (CR: n=11; ER: n=13).

2.7. Data Analysis

Descriptive statistics were used for reporting the results. A generalized linear model fitted by restricted maximum likelihood with binomial distribution and logit link function was applied to verify the relationship between group allocation (predictor: CR and ER) and injury characteristics [dependent variables: injury context (sports or non-sports practice) and side (right or left)]. A generalized linear model fitted by restricted maximum likelihood with group (CR and ER) as a predictor was applied to verify groups differences in participants' anthropometrics (age, body mass, and height), injury characteristics (time between injury and surgery, and repair strength test), limb symmetry index of ankle ROM, and $AOFAS_{AHS}$. Although our study was not randomized, we calculated the propensity score and used it as a covariate in the ankle ROM and $AOFAS_{AHS}$ analysis (D'Agostino Jr, 1998; Friedrich and Friede, 2020). The propensity score was calculated using participants' baseline characteristics as predictors, with group allocation as the dependent variable in a generalized linear model fitted by restricted maximum likelihood method, applying a binomial distribution and a logit link function.

We conducted statistical modeling under different distributions to assess the suitability of models for our data (Jiang and Nguyen, 2007). Due to the continuous variables' nature and by distribution analysis (i.e., skewness, kurtosis, and graphical analysis), gaussian and gamma distributions were explored. The goodness of fit was assessed through graphical residuals analysis and fit metrics (Akaike information criterion) (Jiang and Nguyen, 2007). The residuals analysis of each model is presented in Appendix 3D. Finally, a generalized linear model was applied using gaussian distribution for body mass, tendon's repair strength test DF_{ROM} (P12),

PF_{ROM} (P2 and P26), and $AOFAS_{AHS}$ (P12 and P26); and gamma distribution for age, height, time between injury and surgery, DF_{ROM} (P2 and P26), and PF_{ROM} (P12).

A post hoc power analysis was performed using GLIMMPSE software (https://glimmpse.samplesizeshop.org, version 3.1.0), considering ankle ROM and $AOFAS_{AHS}$ (main outcomes). The statistical test was set to the Hotelling-Lawley Trace test, and the type I error rate was set at 0.05. Group was defined as the fixed predictor, and the effects available for consideration were set at group. The statistical power calculated was 0.593. Given the relatively low statistical power, pairwise comparisons (reference: ER-CR) were explored using the models' estimated marginal means by mean difference (MD) and effect size (ES), Hedges' g, with their respective 95% confidence intervals (95% CI). The ES was categorized as trivial (≤0.20), small (0.20 to 0.49), moderate (0.50 to 0.79), large (0.80 to 1.29) or very large (>1.29) (Fritz et al., 2012). All statistical tests were performed using Jamovi Software (The Jamovi Project, version 2.5.6, https:// jamovi.org), at a significance level of 5% (alpha≤0.05).

3. RESULTS

There were no between-group differences for baseline characteristics (Table 1). Participation of rehabilitation groups (CR or ER) was not influenced by injury context (sports or non-sports practice) (χ^2_1=0.522; p=0.470). In the CR group, 71% of injuries were sports-related [soccer: direct tendon trauma (n=1), during sprints (n=6), during jumps (n=2); running: during push-off phase (n=1)] and 29% occurred during daily activities [wrong step: sidewalk (n=3), getting off a truck (n=1); climbing onto a sofa (n=1)]. In the ER group, 82% of injuries were sports-related [soccer: during sprints (n=9), change of direction (n=2); volleyball: during jumps (n=1); running: during push-off phase (n=1), wrong step (n=1)] and 18% occurred during daily activities [wrong step (n=2), during stair climb (n=1)]. The injured side had no influence on participation of rehabilitation groups (CR, right=6; and ER, right=9) (χ^2_1=0.313; p=0.576). No tendon re-ruptures were registered.

Table 1. Anthropometrics, injury characteristics, and limb symmetry index (LSI) of active range of motion (ROM) during plantarflexion (PF_{ROM}) and dorsiflexion (DF_{ROM}) movements obtained at post-2 (P2) weeks of surgery in conservative rehabilitation (CR) and early rehabilitation (ER) groups.

Baseline Characteristics	Mean ± SD (95% CI)		Group Effect
	CR	ER	
Age (years)	41.4 ± 8.2 (36.7 – 46.2)	39.5 ± 9.6 (34.6 – 44.5)	χ^2_1=0.339; p=0.561
Body Mass (Kg)	81.4 ± 8.5 (76.4 – 86.3)	85.6 ± 10.7 (80.1 – 91.1)	χ^2_1=1.45; p=0.229
Height (cm)	171.8 ± 5.6 (168.6 – 175.0)	173.5 ± 5.2 (170.9 – 176.2)	χ^2_1=0.809; p=0.368
Injury-Surgery Time (days)	7.4 ± 2.4 (6.0 – 8.8)	7.6 ± 4.2 (5.4 – 9.7)	χ^2_1=0.034; p=0.853
Repair's Strength Test (kgf)	4.6 ± 1.2 (3.9 – 5.4)	5.1 ± 1.3 (4.4 – 5.8)	χ^2_1=1.03; p=0.311
PF_{ROM} (%LSI) ^{P2}	68.5 ± 20.7 (56.5 – 80.5)	68.2 ± 15.0 (60.5 – 75.9)	χ^2_1=0.002; p=0.967
DF_{ROM} (%LSI) ^{P2}	34.6 ± 23.0 (21.3 – 47.8)	46.6 ± 37.2 (27.5 – 65.8)	χ^2_1=1.24; p=0.266

At P12, ER group presented higher limb symmetry index of PF_{ROM} than CR group [MD= 14.0%, ES (95% CI)= 0.87 (0.15 – 1.59)]. No between-group differences were found in limb symmetry index of DF_{ROM} [MD= -2.6%, ES (95% CI)= -0.06 (-0.75 – 0.63)] (Table 2). Larger scores on $AOFAS_{AHS}$ were found in ER than CR group [MD= 13.0 points, ES (95% CI)= 1.08 (0.34 – 1.82)].

Table 2. Statistical results and estimated marginal means of limb symmetry index (LSI) of active range of motion (ROM) during plantarflexion (PF_{ROM}) and dorsiflexion (DF_{ROM}) movements, and American Orthopaedic Foot and Ankle Society Ankle-Hindfoot Score ($AOFAS_{AHS}$) of conservative rehabilitation (CR) and early rehabilitation (ER) groups.

Outcomes	Mean ± SD (95% CI)		Group Effect
	CR	ER	
Post-12 Weeks of Surgery			
PF_{ROM} (%LSI)	79.0 ± 15.3 (71.0 – 87.0)	93.0 ± 16.0 (84.6 – 101.4)	χ^2_1=5.35; p=0.021
DF_{ROM} (%LSI)	107.0 ± 49.8 (79.4 – 134.0)	104.0 ± 44.9 (79.5 – 129.0)	χ^2_1 =0.02; p=0.888
$AOFAS_{AHS}$ (Score)	75.2 ± 12.2 (68.4 – 81.9)	88.1 ± 11.2 (81.9 – 94.3)	χ^2_1=7.94; p=0.005
Post-26 Weeks of Surgery			
PF_{ROM} (LSI%)	95.9 ± 22.3 (84.8 – 107.0)	91.2 ± 20.1 (81.2 – 101.0)	χ^2_1=0.392; p=0.531
DF_{ROM} (LSI%)	109.0 ± 47.4 (86.8 – 132.0)	122.0 ± 47.0 (99.3 – 144.0)	χ^2_1=0.527; p=0.468
$AOFAS_{AHS}$ (Score)	85.4 ± 16.2 (77.2 – 93.6)	93.7 ± 14.9 (86.2 – 101.2)	χ^2_1=2.29; p=0.130

At P26, no group differences were found in limb symmetry index of PF_{ROM} [MD= -4.7%, ES (95% CI)= -0.22 (-0.91 – 0.47)] and DF_{ROM} [MD= 12.3%, ES (95% CI)= 0.27 (-0.42 – 0.96)] (Table 2). There were no between-group differences on $AOFAS_{AHS}$ [MD= 8.3 points, ES (95% CI)= 0.52 (-0.18 – 1.22)].

4. DISCUSSION

The main purpose of our study was to describe a detailed report on a postoperative ER program and evaluate its effects compared to a CR program. Our findings indicated that positive and safe results were achieved with ER than CR at the end of intervention (P12): higher limb symmetry index of PF_{ROM} and better clinical and functional outcomes in $AOFAS_{AHS}$, without tendon re-ruptures. Participants who received the CR program continued to have worse outcomes than those who received the ER program even 14 weeks after the end of rehabilitation. These results support our study's hypothesis, demonstrating that a controlled ER program can safely accelerate recovery of clinical and functional outcomes compared to a CR program.

People who suffer an ATR present deficits of plantarflexion ROM (~30%) (Agres et al., 2020; Silbernagel et al., 2010). Similarly, at P12, we found deficits in CR (-21%) and ER (-8%) groups, which could be related to post-ATR myotendinous adaptations. The ruptured Achilles tendon elongates as an inherent adaptation of the healing process (Kangas et al., 2007), reducing the myotendinous capacity of transmitting tension to the calcaneus bone. This increased tendon length affects the force generating and transmitting capacity of the plantar flexor muscles throughout the entire ankle joint ROM (Mullaney et al., 2006; Stäudle et al., 2021). Muscle remodeling is hypothesized to reduce increased tendon slack length by shortening the plantar flexor's fascicle length (Stäudle et al., 2021). Nevertheless, a combination of tendon elongation and fascicle shortening may be a reasonable explanation for the impaired functional ankle range of motion (Zellers et al., 2021). The plantar flexors work in the ascending limb of the force-length relation (Maganaris, 2003), which means that maximal force production occurs at the longest muscle length. With a longer Achilles tendon, the plantar flexor muscles are unable to produce force at their optimal (i.e., longest) length due to a change in their excursion. Moreover, fascicle shortening after ATR may limit muscle excursion during contraction, especially affecting functional tasks requiring end-range plantar flexion (Zellers et al., 2021).

In our study, higher limb symmetry for PF_{ROM} was found in ER than CR group at P12, while there were no between-group differences at P26. Although speculative, it is plausible that the mechanisms of these results may be related to structural adaptations in the triceps surae muscle architecture. It has been established in animal models that changes in muscle-tendon tension results in serial sarcomeres subtraction, as induced by tendon elongation (Hoeffner et al., 2023) or immobilization (Williams and Goldspink, 1978). Remodeling of parallel sarcomeres within a muscle fiber are consistently associated to changes in muscle fascicle length (Blazevich and Sharp, 2005; Lieber and Fridén, 2001), affecting the movement excursion (Agres et al., 2020; Lieber and Fridén, 2001). Although the reduction in myotendinous tension induced by tendon elongation is inherent adaptation of healing process (Kangas et al., 2007), this immobilization-related effect could be attenuated. Therefore, it is plausible that while our ER program may have attenuated the disuse effect in the short-term (<3 months postoperatively), it was not able to provide long-term (>12 months postoperatively) adaptations compared to the CR program.

Our findings align with previous studies, which found better plantarflexion ROM using ER than CR programs, at short-term postoperatively. However, contrasting findings were found by other studies (Kim et al., 2017; Okoroha et al., 2020), which reported similar results between CR and ER. These divergent findings may be related to the structure and management of rehabilitation programs. Similar to Cetti et al. (1994) and Buchgraber and Pässler (1997), our ER focused on early weight bearing and lower limb exercises, which may have attenuated the disuse effects. However, the ER applied by Okoroha et al. (2020) and Kim et al. (2017) focused in progressive weight bearing with late-applied (>4 weeks postoperatively) lower limb exercises, which may have not been sufficient to attenuate the disuse effects. Taken together, these findings suggest that the timing, duration, and progressive loading of the mechanical load applied to the muscle-tendon unit play an important role in rehabilitation and its effectiveness. Nonetheless, although the focus of ER in these studies (Buchgraber and Pässler, 1997; Cetti et al., 1994; Kim et al., 2017; Okoroha et al., 2020) were similar to ours (i.e., early weight bearing and lower limb exercises), the lack of detailed information on exercise management and progression makes it difficult to critically compare the interventions, as well as applying them in a clinical context.

Although better PF_{ROM} was achieved with ER than CR, we found no between-group differences in DF_{ROM}. Previous studies have reported that the post-ATR impairments for dorsiflexion movements were smaller than for plantarflexion (Agres et al., 2020; Mayer et al., 2010; Silbernagel et al., 2012). Although plantarflexion function is significantly impaired after an ATR (Mullaney et al., 2006), the dorsiflexors were not directly affected by the injury, leaving their function less affected. Therefore, considering the small effect of ATR on dorsiflexion movements, it is possible that our rehabilitation may have not resulted in a significant effect in DF_{ROM}. Nonetheless, our findings are consistent with those from previous studies. De la Fuente et al. (2016a) and Okoroha et al. (2020) found similar ROM of dorsiflexion using CR and ER, despite that both studies employed different approaches during ER. De la Fuente et al. (2016a) started ROM exercises at post-4 weeks of surgery, while Okoroha et al. (2020) began them only at 6 weeks postoperatively. Despite these timing differences in the beginning of rehabilitation exercises, similar results were observed in both studies (De la Fuente et al., 2016a; Okoroha et al., 2020). Although we also achieved similar results in DF_{ROM}, we started ROM exercises earlier (at 2 weeks postoperatively) than in those studies (De la Fuente et al., 2016a; Okoroha et al., 2020). This was implemented using our control method based on the tendon repair's strength test during surgery, which provided safety and confidence in the therapeutic process, potentially leading to better clinical and functional outcomes.

In our study, better clinical and functional outcomes in $AOFAS_{AHS}$ were achieved with ER than CR at P12. Considering that the $AOFAS_{AHS}$ are largely composed of pain scores (40%), albeit speculative, our findings may be related to an improved pain tolerance in ER than CR group, which has been reported by a previous study (De la Fuente et al., 2016a). Moreover, the better PF_{ROM} could be associated with better outcomes in the functional domain of $AOFAS_{AHS}$, which could be related to the better outcomes achieved with ER over CR at the end of the intervention (after 12 weeks of surgery). However, there was no between-group differences after 26 weeks of surgery, although the scores achieved with ER were 9.8 points higher (moderate effect size) than those achieved with CR. These results could suggest that the participants in CR group continued to have poorer outcomes than those in the ER group even after 14 weeks of rehabilitation, partially corroborating previous studies.

Although Kim et al. (2017) found better outcomes in $AOFAS_{AHS}$ with ER at P12, Nam et al. (2019) did not find differences between CR and ER approaches at the same time. It is plausible that these contrasting findings may be related to different rehabilitation approaches. Kim et al. (2017) started the ER two weeks post-surgery, applying weight bearing, ankle ROM, and heel-rise exercises. Similar to Kim et al. (2017) we started the ER sessions at two weeks postoperatively, using exercises with progressive load. This approach may explain our better outcomes achieved with ER than CR. On the other hand, Nam et al. (2019) described low-load and very similar rehabilitation programs applied to both groups, focusing primarily on weight bearing. The ER group began weight bearing at one week postoperatively, while the CR group started weight bearing four weeks after surgery. Exercises for ROM and strength were introduced in both groups only at four weeks postoperatively. Therefore, it may be that the low-load profile of ER and its similarity to CR did not induce different adaptations in this study (Nam et al., 2019).

Our study has some limitations. Firstly, the participants were conventionally allocated into rehabilitation groups. However, despite a non-randomized allocation, no between-group differences were found in participants and injury characteristics. In addition, we adopted the propensity score approach, which incorporates a potential source of sampling variability into our analysis to try to take account for the effect of non-randomized allocation. Secondly, during rehabilitation, we did not control the cadence and rest time between sets and exercises. This may have influenced both the time under tension in strength exercises, which impact on muscle adaptation (Toigo and Boutellier, 2006), and the participant’s relative effort, which may not have been uniform as the interval was based on subjective perception of recovery. Nevertheless, during the ER sessions, physiotherapists provided clear instructions and guidance to participants on the correct execution of the exercises. Thus, the participants received instructions not only in the execution of the exercises but also in the speed of execution. Moreover, although the time between sets and exercises was not systematically controlled, the physiotherapists adjusted the intervals according to each patient's feedback. In general, these intervals ranged from 30 to 60 seconds between sets and approximately 60 seconds between exercises.

5. CONCLUSION

Our proposed suture strength-based within a controlled ER program provided safe and positive results. People who received ER had better clinical and functional outcomes compared to those who received CR, without increasing tendon re-ruptures. In addition, it appears that the patients that received CR continued to have worse outcomes than those who received ER even after the end of rehabilitation.

ADDITIONAL INFORMATION

Felipe Gidiel Machado received a scholarship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, from Brazil (88887.798480/2022-00), and expressed his acknowledgement for the support. However, this financial support does not imply any conflicts of interest, as well as there are no other potential conflicts of interest. To minimize the impact of cross-cultural language adaptation, the text grammar and concordance were checked using artificial intelligence translation tools from DeepL Translate Software (https://deepl.com) and OpenAI's ChatGPT (https://openai.com/chatgpt).

FINAL CONSIDERATIONS

Our purpose with this dissertation was to evaluate current knowledge, identify gaps, and propose strategies to improve the understanding and clinical management of postoperative rehabilitation for ATR. To accomplish these purposes, we conducted three studies: (1) a systematic review of systematic reviews on postoperative rehabilitation for ATR, (2) a systematic review of randomized controlled trials investigating rehabilitation approaches after ATR surgical repair, and (3) a controlled trial comparing the effects of a controlled early rehabilitation program with a conservative rehabilitation program.

In the systematic review of systematic reviews, we critically reviewed evidence from systematic reviews on postoperative rehabilitation for ATR. Our main findings indicate that early rehabilitation (ER) can be safely implemented after surgical repair, providing higher satisfaction than conservative rehabilitation (CR). However, limited evidence suggests that ER may not effectively reduce post-ATR clinical and functional deficits compared to CR. Nevertheless, these findings are based on studies with potential methodological concerns that limit the interpretation of their results. Therefore, we conducted a systematic review of randomized controlled trials to address the limitations identified in previous studies.

In the systematic review of randomized controlled trials, our main findings indicate that: 1) Early approaches are safe and could reduce the time to return to work; 2) Although early approaches lead to better outcomes on multi-item scoring scales in the short and mid-term than late approaches, similar outcomes were found at long-term; 3) Different postoperative rehabilitation approaches do not appear to attenuate the post-ATR muscle loss and functional deficits; 4) Most studies lack clear intervention descriptions, which limits both clinical applicability and scientific advancement, as most rehabilitation programs are difficult to implement and replicate.

Therefore, in the controlled trial, we aimed to provide a detailed description of a controlled ER program and to evaluate clinical and functional outcomes comparing CR and ER following the ATR surgical repair. At the end of rehabilitation, better clinical and functional outcomes without tendon rupture were achieved with ER than CR, demonstrating that our controlled rehabilitation program can safely accelerate the recovery of clinical and functional outcomes after surgical repair of ATR.

Taken together, our findings can provide important information for evidence-based practice and scientific development in the field, highlighting the need for detailed reporting of exercise interventions and complementary strategies to support long-term recovery. Examining the results of previous systematic reviews allows a critical overview of the evidence that could be useful for clinical practice. In addition, this review allowed the identification of methodological and theoretical aspects that were addressed in study 2 of this dissertation (i.e., systematic review of intervention studies). In this study, however, we have attempted to contribute to a critical and up-to-date synthesis of the evidence, while striving to conduct this study with a high level of methodological rigor. Additionally, we have highlighted a number of aspects that need to be better explored, particularly in relation to the reporting of interventions. This aspect was the aim of our intervention study, in which, in addition to investigating the effects of a controlled rehabilitation program, we attempted to describe the program according to relevant guidelines.

In conclusion, these findings may highlight the need for well-controlled studies to identify effective rehabilitation strategies following ATR surgical repair. Investigation of different strategies beyond the period of initiation of lower limb exercises and/or weight bearing, particularly in relation to the exercises used in rehabilitation programs, as well as complementary post-rehabilitation strategies (e.g., strength training) to support long-term recovery should be further explored.

RESEARCH, TEACHING, AND OUTREACH ACTIVITIES

Summary published in proceedings of conferences

- Gidiel-Machado et al., A New and Safe Method for Conducting Early Rehabilitation After Achilles Tendon Surgical Repair: Short-Term Results on Calf Muscle Structure and Ankle Range of Motion. (XII Simpósio em Neuromecânica Aplicada; FACAT; 2022; Conference Award).

- Gidiel-Machado et al., From Surgery to Rehabilitation: A Control Method for Conducting Early-Applied Exercises Following Achilles Tendon Repair. (XV Salão Internacional de Ensino, Pesquisa e Extensão; UNIPAMPA; 2023; Nominated for a Conference Award).

- Löbel et al., Effects of Different Foam Rolling Protocols on the Achilles Tendon Properties: A Randomized Crossover Clinical Trial. (XII Simpósio em Neuromecânica Aplicada; UFSC; 2024).

- Lima et al., Efeitos Agudos de Diferentes Protocolos de Aplicação do Foam Rolling Sobre a Arquitetura Muscular de Flexores Plantares: Ensaio Clínico Randomizado Crossover. (XII Simpósio em Neuromecânica Aplicada; UFSC; 2024).

Research projects

- Löbell et al., Effects of Different Foam Rolling Protocols on Plantar Flexors Musculotendinous Properties and Functional Performance: Randomised Crossover Trial; (2023).

- Roos et al., Tendon's Morphological, Mechanical, and Material Adaptive Responses to Early Functional Rehabilitation Versus Traditional Rehabilitation After Achilles Tendon Rupture; (2023).

- Gidiel-Machado et al., Biopsychosocial Model for Understanding Rookie Injuries in the National Basketball Association; (2024).

- Prates et al., Epidemiological Profile of Achilles Tendon Ruptures: A Systematic Review and Meta-Analysis of Observational Studies; (2024).

- Ziemann et al., Foam Rolling's Acute Effects on Flexibility and Joint Range of Motion: An Umbrella Review; (2024).

Teaching and outreach activities

- Supervised teaching: Estudos Anátomo-Funcionais: Cinesiologia (Undergraduate Program in Physical Education; UFRGS).

- Public lecture: Adaptações estruturais após a ruptura do tendão de Aquiles (GPBiC; Subgrupo tendão de Aquiles).

- Public lecture: Métodos de pesquisa em rupturas do tendão de Aquiles: possibilidades e tendências (GPBiC; Subgrupo tendão de Aquiles).

- Organizing committee: II Escola de Inverno em Biomecânica Musculoesquelética (UFRGS; 2023).

- Organizing committee: National Biomechanics Day: Science is for everyone. (UFRGS; 2023).

- Study Group Organization: Grupo de Estudos sobre Tendão de Aquiles (GPBiC; UFRGS; 2022 – 2023).

Article produced during the Master's period

Original article

Early Rehabilitation versus Conservative Rehabilitation Following Achilles Tendon Repair: Short-Term Effects on Ankle Function and Muscle Structure

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ABSTRACT

Background: Compared to conservative rehabilitation (CR), early rehabilitation (ER) approaches may have therapeutic potential by attenuating the disuse period after surgical repair of Achilles tendon rupture (ATR). However, the postoperative rehabilitation effects on short-term adaptations (i.e., <8 weeks postoperatively) remain poorly documented. The aim of our study was to investigate the short-term effects of CR versus ER on ankle range of motion (ROM) and gastrocnemius medialis (GM) muscle architecture in ATR patients.

Methods: Twenty-five male participants underwent either CR (n=12) or ER (n=13) after the open surgical repair of ATR. Participants' anthropometrics and injury characteristics were recorded at enrolment. Plantar flexion (PF_{ROM}) and dorsiflexion (DF_{ROM}) ROM during active movements were obtained on both sides, at post-2 (P2) and post-6 (P6) weeks of surgery. Muscle architecture [gastrocnemius medialis fascicle length (GM_{FL}), pennation angle (GM_{PA}), and muscle thickness (GM_{MT})] was measured on both the uninjured and injured sides, at P6.

Results: Groups were similar for anthropometrics and injury characteristics. The injured side, in both groups, presented smaller GM_{FL} and GM_{MT} than uninjured side. The GM_{PA} was similar in both groups. At P2, PF_{ROM} and DF_{ROM} deficits were found on both groups. At P6, while both groups presented PF_{ROM} and DF_{ROM} deficits, smaller deficits were found in ER than CR group. No tendon re-ruptures were recorded.

Conclusion: Although both approaches lead to similar responses in muscle architecture, ER safely attenuated the ankle ROM deficits following ATR repair.

KEYWORDS: Tendon rupture; Accelerated rehabilitation; Muscle architecture; Ankle functionality.

APPENDICES

Chapter I – Rehabilitation Following Surgical Repair of Achilles Tendon Rupture: A Systematic Review of Systematic Reviews

Appendix 1A

PRISMA 2020 Main Checklist

Topic	No.	Item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	pag. 17
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	App. 1B
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	pag. 19-20
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	pag. 19-20
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	pag. 21/24
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	pag. 20-21
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	pag. 20-21
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	pag. 21-22
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	pag. 21-22
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	pag. 21-22/24
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	pag. 21-22/24

Topic	No.	Item	Location where item is reported
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	pag. 22-23
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	pag. 24
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item 5)).	pag. 24
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	pag. 24
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	pag. 24
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	pag. 26
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	pag. 26
Study characteristics	17	Cite each included study and present its characteristics.	pag. 26
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	pag. 31
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	pag. 28-29/ 34-35
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	pag. 27/31
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA

Topic	No.	Item	Location where item is reported
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	pag. 40
	23b	Discuss any limitations of the evidence included in the review.	pag. 45
	23c	Discuss any limitations of the review processes used.	pag. 45
	23d	Discuss implications of the results for practice, policy, and future research.	pag. 45
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	pag. 20
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	pag. 20
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	pag. 20/ App. 1C
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	pag. 46
Competing interests	26	Declare any competing interests of review authors.	pag. 46
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. MetaArXiv. 2020, September 14. DOI: 10.31222/osf.io/v7gm2. For more information, visit: www.prisma-statement.org

Appendix 1B

PRISMA Abstract Checklist

Topic	No.	Item	Reported?
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesize results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	No
Registration	12	Provide the register name and registration number.	Yes

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. MetaArXiv. 2020, September 14. DOI: 10.31222/osf.io/v7gm2. For more information, visit: www.prisma-statement.org

Appendix 1C

PROSPERO Protocol Deviations

Item Number 16 (Searches)

In our previous search strategy, we used specific terms (i.e., Medical Subject Headings for MEDLINE and Cochrane Library, and Emtree terms for Embase) to search for systematic reviews. Following the recommendations for search terms applicable to systematic reviews of reviews proposed by Hennessy et al. (2019), we added these recommended terms to our search strategy in addition to the database-specific terms. This adjustment aims to optimize the search process.

Item Number 20 and 21 (Intervention and Comparator)

In the previous version of our protocol, the PICOS strategy defined the intervention as “Early rehabilitation approaches (i.e., immediately to 2 weeks post-surgery)” and the control as “Conservative rehabilitation approaches (i.e., more than 2 weeks post-surgery)”. However, we have revised the PICOS strategy to define the intervention as “Postoperative rehabilitation following ATR repair” and the comparator as “At least two different types of rehabilitation after surgical treatment”. These adjustments were designed to better align the PICOS strategy with our research question.

Item Number 23 (Context)

Given the adaptations on the PICOS strategy, we revised the eligibility criteria from “Systematic reviews considering early rehabilitation (i.e., weight bearing and/or lower limb exercises immediately to post-2 weeks of surgery) and conservative rehabilitation (i.e., weight bearing and/or lower limb exercises over than post-2 weeks of surgery) postoperative approaches will be included” to “Systematic reviews were eligible for inclusion if they reported at least one outcome of interest comparing two or more postoperative rehabilitation approaches in the population of interest”. This adaptation is intended to improve the clarity of the description.

Item Number 28 (Data Synthesis)

In the original protocol, a narrative data synthesis was planned, although we did not report that content analysis would be used. We conducted the content analysis to provide a reproducible and less biased synthesis.

REFERENCES

Hennessy, E. A.; Johnson, B. T.; Keenan, C. Best practice guidelines and essential methodological steps to conduct rigorous and systematic meta-reviews. **Applied Psychology: Health and Well-Being**, 11, n. 3, p. 353-381, 2019.

Appendix 1D

Search strategy used for each database.

PubMed	Cochrane CENTRAL	EMBASE
#1 "Achilles Tendon"[Mesh] OR "Achilles Tendon" OR "Tendon, Achilles" OR "Calcaneal Tendon" OR "Calcaneal Tendons" OR "Tendon, Calcaneal" OR "Tendons, Calcaneal" OR "Tendo Calcaneus" **#2** "Rupture"[Mesh] OR "Rupture" OR "Tendon Injuries"[Mesh] OR "Tendon Injuries" OR "Injuries, Tendon" OR "Injury, Tendon" OR "Tendon Injury" **#3** "Rehabilitation" OR "early functional rehabilitation" OR "early rehabilitation" OR "early mobilization" **#4** "Systematic Reviews as Topic"[Mesh] OR "Systematic Review as Topic" OR "Reviews Systematic as Topic" OR "Systematic Review"[All Fields] OR "systematic review*" OR "systematic map*" OR "systematic overview*" OR "systematically review*" OR "systematized review" OR "systematic literature mapping" OR "systematic search" OR "meta-synthesis" OR "meta analy*" OR "meta-analysis" OR "metaanaly*" OR "systematic review and synthesis" **#5** #1 AND #2 AND #3 AND #4	**#1** MeSH descriptor: [Achilles Tendon] explode all trees **#2** MeSH descriptor: [Tendon Injuries] explode all trees **#3** MeSH descriptor: [Rehabilitation] explode all trees **#4** 1# AND #2 AND #3	**#1** ('achilles tendon rupture'/exp OR 'achilles tendon rupture' OR 'tendo achillis rupture') **#2** ('functional readaptation' OR 'medical rehabilitation' OR 'readaption' OR 'readjustment' OR 'rehabilitation concept' OR 'rehabilitation engineering' OR 'rehabilitation potential' OR 'rehabilitation process' OR 'rehabilitation program' OR 'rehabilitation programme' OR 'rehabilitation, medical' OR 'rehabilitative treatment' OR 'resocialisation' OR 'resocialisation therapy' OR 'resocialization' OR 'resocialization therapy' OR 'revalidation' OR 'rehabilitation') **#3** ('systematic review'/exp OR ‘review, systematic’ OR ‘systematic review’ OR ‘systematic map*’ OR ‘systematic overview*’ OR ‘systematically review*’ OR ‘systematized review’ OR ‘systematic literature mapping’ OR ‘systematic search’ OR ‘meta-synthesis’ OR ‘meta analy*’ OR ‘meta-analysis’ OR ‘metaanaly*’ OR ‘systematic review and synthesis’) **#4** #1 AND #2 AND #3

Appendix 1E

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies		Systematic Reviews					
	PEDro Score	Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
Cetti, R. (1988). Ruptured Achilles Tendon--Preliminary Results Of A New Treatment. British Journal of Sports Medicine, 22(1), 6-8.	1/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: No; 8: No; 9: No; 10: No; 11: No]					X	
Cetti, R., Henriksen, L. O., & Jacobsen, K. S. (1994). A New Treatment Of Ruptured Achilles Tendons A Prospective Randomized Study. Clinical Orthopaedics And Related Research (1976-2007), 308, 155-165.	4/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]	X	X	X	X		X
Buchgraber, A., & Pässler, H. H. (1997). Percutaneous Repair Of Achilles Tendon Rupture; Immobilization Versus Functional Postoperative Treatment. Clinical Orthopaedics And Related Research (1976-2007), 341, 113-122.	2/10 [1: Yes; 2: No; 3: No; 4: No; 5: No; 6: No; 7: No; 8: No; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	
Mortensen, N. H. M., Skov, O., & Jensen, P. E. (1999). Early Motion Of The Ankle After Operative Treatment Of A Rupture Of The Achilles Tendon. A Prospective, Randomized Clinical And Radiographic Study. JBJS, 81(7), 983-990.	4/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]	X	X	X	X	X	X
Kauranen, K., Kangas, J., & Leppilahti, J. (2002). Recovering Motor Performance Of The Foot After Achilles Rupture Repair: A Randomized Clinical Study About Early Functional Treatment Vs. Early Immobilization Of Achilles Tendon In Tension. Foot & Ankle International, 23(7), 600-605.	4/10 [1: Yes; 2: Yes; 3: Yes; 4: No; 5: No; 6: No; 7: No; 8: No; 9: No; 10: Yes; 11: Yes]		X			X	X
Kerkhoffs, G., Struijs, P., Raaymakers, E., & Marti, R. (2002). Functional Treatment	4/10 [1: No; 2: No; 3: No; 4: Yes; 5: No; 6:		X	X	X	X	X

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies	**PEDro Score**	**Systematic Reviews** Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
After Surgical Repair Of Acute Achilles Tendon Rupture: Wrap Vs Walking Cast. Archives Of Orthopaedic And Trauma Surgery, 122, 102-105.	No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]						
Costa, M., Shepstone, L., Darrah, C., Marshall, T., & Donell, S. (2003). Immediate Full-Weight-Bearing Mobilisation For Repaired Achilles Tendon Ruptures: A Pilot Study. Injury, 34(11), 874-876.	5/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: Yes; 8: No; 9: Yes; 10: Yes; 11: Yes]	X	X	X	X	X	X
Kangas, J., Pajala, A., Siira, P., Hämäläinen, M., & Leppilahti, J. (2003). Early Functional Treatment Versus Early Immobilization In Tension Of The Musculotendinous Unit After Achilles Rupture Repair: A Prospective, Randomized, Clinical Study. Journal Of Trauma And Acute Care Surgery, 54(6), 1171-1180.	6/10 [1: Yes; 2: Yes; 3: Yes; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]	X	X	X	X	X	X
Maffulli, N., Tallon, C., Wong, J., Lim, K. P., & Bleakney, R. (2003). No Adverse Effect Of Early Weight Bearing Following Open Repair Of Acute Tears Of The Achilles Tendon. Journal Of Sports Medicine And Physical Fitness, 43(3), 367.	3/10 [1: No; 2: No; 3: No; 4: No; 5: No; 6: No; 7: Yes; 8: No; 9: No; 10: Yes; 11: Yes]	X	X	X	X	X	X
Maffulli, N., Tallon, C., Wong, J., Peng Lim, K., & Bleakney, R. (2003). Early Weight Bearing And Ankle Mobilization After Open Repair Of Acute Midsubstance Tears Of The Achilles Tendon. The American Journal Of Sports Medicine, 31(5), 692-700.	4/10 [1: Yes; 2: No; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]	X	X	X	X	X	X
Costa, M., Macmillan, K., Halliday, D., Chester, R., Shepstone, L., Robinson, A.,	7/10 [1: Yes; 2: Yes; 3: Yes; 4: No; 5: No; 6:		X	X	X		X

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies		**Systematic Reviews**					
	PEDro Score	Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
& Donell, S. (2006). Randomised Controlled Trials Of Immediate Weight-Bearing Mobilisation For Rupture Of The Tendo Achillis. The Journal Of Bone And Joint Surgery. British, 88(1), 69-77.	No; 7: Yes; 8: Yes; 9: Yes; 10: Yes; 11: Yes]						
Kangas, J., Pajala, A., Ohtonen, P., & Leppilahti, J. (2007). Achilles Tendon Elongation After Rupture Repair: A Randomized Comparison Of 2 Postoperative Regimens. The American Journal Of Sports Medicine, 35(1), 59-64.	6/10 [1: Yes; 2: Yes; 3: Yes; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]		X	X	X	X	X
Majewski, M., Schaeren, S., Kohlhaas, U., & Ochsner, P. (2008). Postoperative Rehabilitation After Percutaneous Achilles Tendon Repair: Early Functional Therapy Versus Cast Immobilization. Disability And Rehabilitation, 30(20-22), 1726-1732.	3/10 [1: Yes; 2: No; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: No; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	
Suchak, A. A., Bostick, G. P., Beaupré, L. A., D'Arcy, C. D., & Jomha, N. M. (2008). The Influence Of Early Weight-Bearing Compared With Non-Weight-Bearing After Surgical Repair Of The Achilles Tendon. JBJS, 90(9), 1876-1883.	7/10 [1: Yes; 2: Yes; 3: Yes; 4: Yes; 5: No; 6: No; 7: Yes; 8: Yes; 9: No; 10: Yes; 11: Yes] *Rated by authors		X		X	X	X
Saxena, A., Ewen, B., & Maffulli, N. (2011). Rehabilitation Of The Operated Achilles Tendon: Parameters For Predicting Return To Activity. The Journal Of Foot And Ankle Surgery, 50(1), 37-40.	4/10 [1: Yes; 2: No; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	
Schepull, T., & Aspenberg, P. (2013). Early Controlled Tension Improves The Material Properties Of Healing Human Achilles Tendons After Ruptures: A Randomized Trial. The American Journal Of Sports Medicine, 41(11), 2550-2557.	5/10 [1: Yes; 2: Yes; 3: Yes; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]		X			X	X

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies	**PEDro Score**	**Systematic Reviews** Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
Groetelaers, R. P., Janssen, L., Van Der Velden, J., Wieland, A. W., Amendt, A. G., Geelen, P. H., & Janzing, H. M. (2014). Functional Treatment Or Cast Immobilization After Minimally Invasive Repair Of An Acute Achilles Tendon Rupture: Prospective, Randomized Trial. Foot & Ankle International, 35(8), 771-778.	5/10 [1: No; 2: Yes; 3: Yes; 4: No; 5: No; 6: No; 7: No; 8: No; 9: Yes; 10: Yes; 11: Yes]				X	X	X
Geremia, J. M., Bobbert, M. F., Nova, M. C., Ott, R. D., De Aguiar Lemos, F., De Oliveira Lupion, R., Frasson, V. B., & Vaz, M. A. (2015). The Structural And Mechanical Properties Of The Achilles Tendon 2 Years After Surgical Repair. Clinical Biomechanics, 30(5), 485-492.	3/10 [1: Yes; 2: No; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: Yes; 10: Yes; 11: Yes] *Rated by authors					X	
Lantto, I., Heikkinen, J., Flinkkila, T., Ohtonen, P., Kangas, J., Siira, P., & Leppilahti, J. (2015). Early Functional Treatment Versus Cast Immobilization In Tension After Achilles Rupture Repair: Results Of A Prospective Randomized Trial With 10 Or More Years Of Follow-Up. The American Journal Of Sports Medicine, 43(9), 2302-2309.	6/10 [1: Yes; 2: Yes; 3: Yes; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	X
Porter, M. D., & Shadbolt, B. (2015). Randomized Controlled Trial Of Accelerated Rehabilitation Versus Standard Protocol Following Surgical Repair Of Ruptured A Chilles Tendon. ANZ Journal Of Surgery, 85(5), 373-377.	4/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	X
De La Fuente, C., Y Lillo, R. P., Carreño, G., & Marambio, H. (2016). Prospective Randomized Clinical Trial Of Aggressive Rehabilitation After Acute Achilles Tendon	5/10 [1: No; 2: Yes; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]					X	X

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies		**Systematic Reviews**					
	PEDro Score	Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
Ruptures Repaired With Dresden Technique. The Foot, 26, 15-22.							
De La Fuente, C. I., Lillo, R. P. Y., Ramirez-Campillo, R., Ortega-Auriol, P., Delgado, M., Alvarez-Ruf, J., & Carreno, G. (2016). Medial Gastrocnemius Myotendinous Junction Displacement And Plantar-Flexion Strength In Patients Treated With Immediate Rehabilitation After Achilles Tendon Repair. Journal Of Athletic Training, 51(12), 1013-1021.	4/10 [1: Yes; 2: Yes; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: No; 9: No; 10: Yes; 11: Yes]					X	X
Valkering, K. P., Aufwerber, S., Ranuccio, F., Lunini, E., Edman, G., & Ackermann, P. W. (2017). Functional Weight-Bearing Mobilization After Achilles Tendon Rupture Enhances Early Healing Response: A Single-Blinded Randomized Controlled Trial. Knee Surgery, Sports Traumatology, Arthroscopy, 25(6), 1807-1816.	6/10 [1: Yes; 2: Yes; 3: No; 4: Yes; 5: No; 6: No; 7: No; 8: Yes; 9: Yes; 10: Yes; 11: Yes] *Rated by authors					X	X
Vitomskyi, V., Lazarieva, O., & Vitomska, M. (2017). Restoration Of Ankle Joint, Quality Of Life Dynamics And Assessment Of Achilles Tendon Rupture Consequences. Pedagogics, Psychology, Medical-Biological Problems Of Physical Training And Sports(6), 308-314.	4/10 [1: Yes; 2: No; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: Yes; 10: Yes; 11: Yes] *Rated by authors					X	
Kim, U., Choi, Y. S., Jang, G. C., & Choi, Y. R. (2017). Early Rehabilitation After Open Repair For Patients With A Rupture Of The Achilles Tendon. Injury, 48(7), 1710-1713.	5/10 [1: No; 2: Yes; 3: No; 4: No; 5: No; 6: No; 7: Yes; 8: Yes; 9: No; 10: Yes; 11: Yes] *Rated by authors					X	X
Agres, A. N., Gehlen, T. J., Arampatzis, A., Taylor, W. R., Duda, G. N., &	6/10 [1: Yes; 2: Yes; 3: No; 4: No; 5: No; 6: No;					X	X

Methodological quality rated using PEDro (Physiotherapy Evidence Database) Scale and overlap of primary studies included in the systematic reviews.

Primary Studies	**PEDro Score**	**Systematic Reviews** Suchak et al. (2006)	Brumann et al. (2014)	Huang et al. (2014)	McCormack & Bovard (2015)	Gould et al. (2021)	Massen et al. (2022)
Manegold, S. (2018). Short-Term Functional Assessment Of Gait, Plantarflexor Strength, And Tendon Properties After Achilles Tendon Rupture. Gait & Posture, 62, 179-185.	7: Yes; 8: Yes; 9: Yes; 10: Yes; 11: Yes]						
Eliasson, P., Agergaard, A.-S., Couppe, C., Svensson, R., Hoeffner, R., Warming, S., Warming, N., Holm, C., Jensen, M. H., & Krogsgaard, M. (2018). The Ruptured Achilles Tendon Elongates For 6 Months After Surgical Repair Regardless Of Early Or Late Weight Bearing In Combination With Ankle Mobilization: A Randomized Clinical Trial. The American Journal Of Sports Medicine, 46(10), 2492-2502.	3/10 [1: No; 2: No; 3: No; 4: No; 5: No; 6: No; 7: No; 8: Yes; 9: No; 10: Yes; 11: Yes]					X	

X: Included in the systematic review.

Appendix 1F

Categories	Study: Suchak et al. (2006) Results Coded	Conclusions Coded
Complications	***Re-rupture*** ***2006, Suchak.*** The rerupture rate in the early functional treatment group was not different to that in the immobilized group (2.5% versus 3.8% respectively) (Fig 2). Ten reruptures occurred in 315 patients. ***Complications*** ***2006, Suchak.*** Other complications, including scar adhesions and tran- sient sural nerve deficits, occurred less frequently (p 0.01) (Fig 4) in the early functional treatment group (5.8%) than in the immobilized group (13.5%). ***Complications*** ***2006, Suchak.*** No differences in superficial and deep infections oc- curred in the early functional treatment group (four infec- tions) and immobilized group (six infections) during their postoperative rehabilitation (Fig 3). The average incisional infection rate was 2.6% in the early functional treatment group and 3.9% in the immobilized group. ***Calf Muscle Loss*** ***2006, Suchak.*** Only one study2 found fewer (p 0.02) patients with calf atrophy with an average of 0.7 cm larger (p 0.02) calf circumference and better (p 0.0006) plantar flexion strength in the early functional treatment group compared with the immobilized group. All other studies3,7,10–12 showed no difference between their groups.	***Complications*** ***2006, Suchak.*** An early functional rehabilitation protocol for Achilles tendon ruptures improves patient satisfaction with reduc- tion in minor complications and no increase in rerupture rate or infection rate.
Participant's Satisfaction	***Participant's Satisfaction*** ***2006, Suchak.*** Early functional treatment protocols led to more ($p < 0.0001$) excellent subjective responses when compared with postoperative immobilization (88% versus 62%, re-spectively) (Fig 1).	***Participant's Satisfaction*** ***2006, Suchak.*** An early functional rehabilitation protocol for Achilles tendon ruptures improves patient satisfaction with reduc- tion in minor complications and no increase in rerupture rate or infection rate

Categories	Study: Suchak et al. (2006) Results Coded	Conclusions Coded
Clinical and Functional Outcomes	***Ankle Range of Motion*** ***2006, Suchak.*** Only one study2 found a difference ($p < 0.00001$) in the degree of ROM in the early functional treatment group, with these patients having a 25º greater range after 6 weeks. ***Ankle Range of Motion*** ***2006, Suchak.*** The ankle ROM in both groups was comparable at 1 year. The increased ROM at 6 weeks in the mobile cast group2 is likely related to early timing of the measurement. Unfortunately, insufficient data for differences in ROM at 1 year postoperatively were provided in this study. ***Plantarflexion Strength*** ***2006, Suchak.*** Only one study2 found fewer (p 0.02) patients with calf atrophy with an average of 0.7 cm larger (p 0.02) calf circumference and better (p 0.0006) plantar flexion strength in the early functional treatment group compared with the immobilized group. All other studies3,7,10–12 showed no difference between their groups.	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
Complications	***Re-rupture*** ***2014, Brumann.*** In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15], calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. Two reruptures were observed for FWB within 12 months, while one paraesthesiae and ATR of the contralateral side was observed for NWB. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.*** Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or sports. No rerupture occurred in either group. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.*** Costa et al. demonstrated in 2003, that patients treated with FWB	***Re-rupture*** ***2014, Brumann.*** In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture rate or tendon lengthening. Therefore, the patients should be allowed to bear full weight immediately after the operation. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.*** In conclusion, EM is superior to IM as it shortens time to work and sports significantly. Moreover, EM does not increase the rerupture rate. Based on these findings, free plantar flexion with restriction of dorsiflexion at 0º should be allowed latest after three weeks. ***Early mobilization vs Late mobilization*** ***Re-rupture*** ***2014, Brumann.*** Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates,the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both. ***Early Clinical functional rehabilitation vs Late mobilization***

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	return to sports two months earlier [13]. Furthermore, calf muscle strength measured by the Kincom system and range of motion were increased non-significantly when compared to NWB. In both groups no reruptures were observed. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.*** In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15], calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. Two reruptures were observed for FWB within 12 months, while one paraesthesiae and ATR of the contralateral side was observed for NWB. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.*** Kerkhoffs et al. treated all patients with a BKC for one week followed by either partial weight bearing or NWB [19]. Patients allowed to bear weight had a significantly shorter hospital stay and time to return to sports. No significant differences were found for the Rupp Score evaluating pain and patient satisfaction. One rerupture was reported in the non weight bearing group. ***Early weight bearing vs Late weight bearing*** ***Re-rupture*** ***2014, Brumann.***	 ***Tendon Elongation*** ***2014, Brumann.*** In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture rate or tendon lengthening. Therefore, the patients should be allowed to bear full weight immediately after the operation. ***Early weight bearing vs Late weight bearing*** ***Tendon Elongation*** ***2014, Brumann.*** Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates,the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both. ***Early Clinical functional rehabilitation vs Late mobilization***

Study: Brumann et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	Kangas et al. present the same patient collective two times, evaluating different outcome measures when comparing EM to IM [20,21]. Consequently, in the following the two studies will be treated as one. FWB was allowed after three weeks in both groups. No significant differences could be detected for isokinetic and isometric calf muscle function, tendon elongation or pain level assessed by the visual analogue scale – although all in favour of EM [22]. The Achilles Rupture Performance Score did not reveal differences between both groups. One rerupture occurred for EM and two for IM. ***Early mobilization vs Late mobilization*** ***Re-rupture*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. There were two reruptures following IM and one rerupture following EM. ***Early mobilization vs Late mobilization*** ***Re-rupture*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. Further- more, the time to return to work was significantly prolonged for IM (53.4 days) compared to 20.2 days for CFT. One rerupture was noted for CFT and two for IM. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Re-rupture*** ***2014, Brumann.*** One patient in the CFT group suffered a rerupture (Shepull [27]). ***Early Clinical functional rehabilitation vs Late mobilization*** ***Complications*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. ***Early mobilization vs Late mobilization*** ***Complications*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at– 208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems.	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	Early Clinical functional rehabilitation vs Late mobilization ***Tendon Elongation*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Tendon Elongation*** ***2014, Brumann.*** Tendon elongation was assessed by implantation of tantalum markers and was increased in the IM group (Shepull [27]). ***Early Clinical functional rehabilitation vs Late mobilization*** ***Tendon Elongation*** ***2014, Brumann.*** Kangas et al. present the same patient collective two times, evaluating different outcome measures when comparing EM to IM [20,21]. Consequently, in the following the two studies will be treated as one. FWB was allowed after three weeks in both groups. No significant differences could be detected for isokinetic and isometric calf muscle function, tendon elongation or pain level assessed by the visual analogue scale – although all in favour of EM [22]. ***Early mobilization vs Late mobilization***	

Study: Brumann et al. (2014) Categories	Results Coded	Conclusions Coded
	Tendon Elongation ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. ***Early mobilization vs Late mobilization*** ***Calf Muscle Loss*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Calf Muscle Loss*** ***2014, Brumann.*** Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or sports. No rerupture occurred in either group. ***Early weight bearing vs Late weight bearing*** ***Calf Muscle Loss*** ***2014, Brumann.*** In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15], calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. ***Early weight bearing vs Late weight bearing*** ***Calf Muscle Loss*** ***2014, Brumann.*** Mafulli et al. showed that FWB significantly reduced the time with crutches, number of physiotherapy sessions and the time to return to sports [16]. In addition, FWB led to a higher patient satisfaction measured by 4 point scale introduced by Boyden et al. [17] and better results of the VISA-A [18], although these results were not significantly different. No differences were found for tendon thickness measured by high-resolution real time ultra- sound, muscle atrophy assessed by calf muscle circumference and muscle	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	function. ***Early weight bearing vs Late weight bearing*** ***Calf Muscle Loss*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. ***Early mobilization vs Late mobilization*** ***Calf Muscle Loss*** ***2014, Brumann.*** Mafulli et al. reported significantly fewer outpatient visits, less physiotherapy, higher patient satisfaction and a shorter time to return to work/sport for CFT [25]. Regarding calf circumference, isometric strength and VISA-A score the results, all in favour of the treatment group, did not reach a level of significance. ***Early Clinical functional rehabilitation vs Late mobilization***	
Participant's Satisfaction	***Participant's Satisfaction*** ***2014, Brumann.*** Mafulli et al. reported significantly fewer outpatient visits, less physiotherapy, higher patient satisfaction and a shorter time to return to work/sport for CFT [25]. ***Early Clinical functional rehabilitation vs Late mobilization***	***Participant's Satisfaction*** ***2014, Brumann.*** In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	Participant's Satisfaction ***2014, Brumann.*** Mafulli et al. showed that FWB significantly reduced the time with crutches, number of physiotherapy sessions and the time to return to sports [16]. In addition, FWB led to a higher patient satisfaction measured by 4 point scale introduced by Boyden et al. [17] and better results of the VISA-A [18], although these results were not significantly different. ***Early weight bearing vs Late weight bearing*** ***Participant's Satisfaction*** ***2014, Brumann.*** Kerkhoffs et al. treated all patients with a BKC for one week followed by either partial weight bearing or NWB [19]. Patients allowed to bear weight had a significantly shorter hospital stay and time to return to sports. No significant differences were found for the Rupp Score evaluating pain and patient satisfaction. ***Early weight bearing vs Late weight bearing***	rate or tendon lengthening. Therefore, the patients should be allowed to bear full weight immediately after the operation. ***Early weight bearing vs Late weight bearing*** ***Participant's Satisfaction*** ***2014, Brumann.*** Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates,the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both. ***Early Clinical functional rehabilitation vs Late mobilization***
Return to Activities	***Return to Work*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. ***Early mobilization vs Late mobilization*** ***Return to Work*** ***2014, Brumann.***	***Return to Activities*** ***2014, Brumann.*** In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture rate or tendon lengthening. Therefore, the patients should be allowed to bear full weight immediately after the operation. ***Early weight bearing vs Late weight bearing*** ***Return to Activities*** ***2014, Brumann.***

Study: Brumann et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	Mafulli et al. reported significantly fewer outpatient visits, less physiotherapy, higher patient satisfaction and a shorter time to return to work/sport for CFT [25]. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Return to Work*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. Further- more, the time to return to work was significantly prolonged for IM (53.4 days) compared to 20.2 days for CFT. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Return to Work*** ***2014, Brumann.*** Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or	In conclusion, EM is superior to IM as it shortens time to work and sports significantly. Moreover, EM does not increase the rerupture rate. Based on these findings, free plantar flexion with restriction of dorsiflexion at 08 should be allowed latest after three weeks ***Early mobilization vs Late mobilization*** ***Return to Activities*** ***2014, Brumann.*** Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates,the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both. ***Early Clinical functional rehabilitation vs Late mobilization***

Study: Brumann et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	sports. No rerupture occurred in either group. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2014, Brumann.*** Costa et al. demonstrated in 2003, that patients treated with FWB return to sports two months earlier [13]. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2014, Brumann.*** Mafulli et al. showed that FWB significantly reduced the time with crutches, number of physiotherapy sessions and the time to return to sports [16]. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2014, Brumann.*** Kerkhoffs et al. treated all patients with a BKC for one week followed by either partial weight bearing or NWB [19]. Patients allowed to bear weight had a significantly shorter hospital stay and time to return to sports. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe	

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Clinical and Functional Outcomes	***Ankle Range of Motion*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at–208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. ***Early Clinical functional rehabilitation vs Late mobilization***	***Clinical and Functional Outcomes*** ***2014, Brumann.*** In conclusion, immediate FWB leads to significant higher patient satisfaction, earlier ambulation and returns to pre-injury activity including time to return to work and sports. All functional parameters were in favour of FWB, but did not reach a level significance in any study. Furthermore, there was no evidence for increased rerupture rate or tendon lengthening. Therefore, the patients should be

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	Ankle Range of Motion ***2014, Brumann.*** Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or sports. No rerupture occurred in either group. ***Early weight bearing vs Late weight bearing*** ***Ankle Range of Motion*** ***2014, Brumann.*** Costa et al. demonstrated in 2003, that patients treated with FWB return to sports two months earlier [13]. Furthermore, calf muscle strength measured by the Kincom system and range of motion were increased non-significantly when compared to NWB. ***Early weight bearing vs Late weight bearing*** ***Ankle Range of Motion*** ***2014, Brumann.*** In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15],	allowed to bear full weight immediately after the operation. ***Early weight bearing vs Late weight bearing*** ***Clinical and Functional Outcomes*** ***2014, Brumann.*** Based on these results, combined functional treatment using immediate full weight bearing and early ankle mobilization starting in week three is most beneficial. These patients do not only show significantly higher satisfaction levels, less use of rehabilitation resources and earlier return to pre-injury activities, but also demonstrate significantly superior functional results including increased calf muscle strength, reduced calf atrophy and tendon elongation. Especially as there were no higher rerupture rates,the postoperative rehabilitation should not only include FWB or EM but should be based on the combination of both. ***Early Clinical functional rehabilitation vs Late mobilization***

Study: Brumann et al. (2014)		
Categories	Results Coded	Conclusions Coded
	calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. ***Early weight bearing vs Late weight bearing*** ***Ankle Range of Motion*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. ***Early mobilization vs Late mobilization*** ***Heel-Rise*** ***2014, Brumann.*** Cetti et al. allowed FWB and EM with restriction of dorsiflexion at– 208 immediately [26]. All patients treated by IM suffered from painful oedema whereas none in CFT group reported similar problems. The range of motion was significantly better for CFT, but only after six weeks. The ability to stand on toes showed significant differences in favour of CFT after 3 and 6 months. After one year, CFT led to significant less calf muscle atrophy, higher rate of return to pre-injury level and less tendon elongation, as detected by radiographic measurements. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Heel-Rise*** ***2014, Brumann.***	

Study: Brumann et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. ***Early mobilization vs Late mobilization*** ***Heel-Rise*** ***2014, Brumann.*** The heel raise index and Achilles Tendon Rupture Score were comparable in both groups [28]. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Plantarflexion Strength*** ***2014, Brumann.*** Suchak et al. managed all patients in a BKC in plantar flexion for two weeks NWB [11]. Thereafter, they were randomized to either FWB or NWB. Primary outcome parameter was the health-related quality-of-life score RAND-36 [12]. After six weeks all domains were significantly better in the FWB group and the median number of steps, assessed by sensor device, was significantly higher (5985 steps) compared to NWB (960 steps). After 6 months only the social functioning domain revealed significant differences in favour of FWB. No significant differences were observed for range of motion, calf circumference, calf muscle strength and return to work or sports. No rerupture occurred in either group. ***Early weight bearing vs Late weight bearing***	

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	Plantarflexion Strength ***2014, Brumann.*** Costa et al. demonstrated in 2003, that patients treated with FWB return to sports two months earlier [13]. Furthermore, calf muscle strength measured by the Kincom system and range of motion were increased non-significantly when compared to NWB. ***Early weight bearing vs Late weight bearing*** ***Plantarflexion Strength*** ***2014, Brumann.*** In 2006, Costa et al. randomized patients to either FWB bearing or NWB after patients decided on operative or non-operative treatment [14]. We included only the operatively treated patients, as this was part of our inclusion criteria. Patients with FWB returned to normal walking and stair climbing significantly earlier when compared to NWB. All other aspects, such as health scores (EQoL, E5E) [15], calf diameter, range of motion and calf muscle strength were in favour of FWB, but not significantly. ***Early weight bearing vs Late weight bearing*** ***Plantarflexion Strength*** ***2014, Brumann.*** Mafulli et al. showed that FWB significantly reduced the time with crutches, number of physiotherapy sessions and the time to return to sports [16]. In addition, FWB led to a higher patient satisfaction measured by 4 point scale introduced by Boyden et al. [17] and better results of the VISA-A [18], although these results were not significantly different. No differences were found for tendon thickness measured by high-resolution real time ultra- sound, muscle atrophy assessed by calf muscle circumference and muscle function. ***Early weight bearing vs Late weight bearing***	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	Plantarflexion Strength ***2014, Brumann.*** Kangas et al. present the same patient collective two times, evaluating different outcome measures when comparing EM to IM [20,21]. Consequently, in the following the two studies will be treated as one. FWB was allowed after three weeks in both groups. No significant differences could be detected for isokinetic and isometric calf muscle function, tendon elongation or pain level assessed by the visual analogue scale – although all in favour of EM [22]. ***Early mobilization vs Late mobilization*** ***Plantarflexion Strength*** ***2014, Brumann.*** Mortensen et al. treated the EM group with a walker allowing passive free plantar flexion and active dorsiflexion, similar to Kleinert traction, starting two weeks postoperatively [24]. FWB was allowed after four weeks for EM and after eight weeks for IM. EM resulted in a significantly earlier return to work and sports and these patients demonstrated significantly fewer and less severe adhesions. Range of motion, strength of plantar flexion (strength and heel raise index), calf muscle atrophy (circumfer- ence) and tendon elongation (radiographic markers) was comparable. ***Early mobilization vs Late mobilization*** ***Plantarflexion Strength*** ***2014, Brumann.*** Mafulli et al. reported significantly fewer outpatient visits, less physiotherapy, higher patient satisfaction and a shorter time to return to work/sport for CFT [25]. Regarding calf circumference, isometric strength and VISA-A score the results, all in favour of the	

Categories	Study: Brumann et al. (2014) Results Coded	Conclusions Coded
	treatment group, did not reach a level of significance. ***Early Clinical functional rehabilitation vs Late mobilization*** ***Multi-Item Scoring Scale*** ***2014, Brumann.*** Tendon elongation was assessed by implantation of tantalum markers and was increased in the IM group. The heel raise index and Achilles Tendon Rupture Score were comparable in both groups [28]. ***Early Clinical functional rehabilitation vs Late mobilization***	

Categories	Study: Huang et al. (2014) Results Coded	Conclusions Coded
Complications	***Re-rupture*** ***2014, Huang.*** The rerupture rate was 3.0% in the early functional group and 2.05% in the immobilized group. No significant difference existed between the 2 groups (P = .64). ***Early mobilization and weight bearing vs Late mobilization*** ***Re-rupture*** ***2014, Huang.*** No significant difference was observed between the 2 groups with regard to reruptures (P = .4) and rates of major (P = .71) and minor (P = .83) complications. ***Early mobilization and late weight bearing vs Late mobilization*** ***Complications*** ***2014, Huang.*** the patients who underwent rigid cast management had a significantly higher rate of minor complications (P = .03) (including scar adhesions, abnormal sensation, delayed wound healing, ankle stiffness, and footwear restriction). ***Early mobilization and weight bearing vs Late mobilization*** ***Complications*** ***2014, Huang.*** The rate of major complications (including wound infections, deep vein thrombosis, and wound dehiscence) was also similar in both groups (P = .44); however, the patients who underwent rigid cast management had a significantly higher rate of minor complications (P = .03) (including scar adhesions, abnormal sensation, delayed wound healing, ankle stiffness, and footwear restriction). ***Early mobilization and weight bearing vs Late mobilization***	***Re-rupture*** ***2014, Huang.*** Compared with cast immobilization, patients who under- went early weight bearing rehabilitation had similar rates of reruptures but significantly lower rates of minor complica- tions. The higher complication rate in patients with cast immobilization was mainly related to scar adhesions and abnormal sensation. ***Complications*** ***2014, Huang.*** Compared with cast immobilization, patients who under- went early weight bearing rehabilitation had similar rates of reruptures but significantly lower rates of minor complica- tions. The higher complication rate in patients with cast immobilization was mainly related to scar adhesions and abnormal sensation. ***Tendon Elongation*** ***2014, Huang.*** The present study reported that patients with early weight bearing and ankle motion rehabilitation had significantly less elongation at both 3- and 6-month follow-ups.

Categories	Study: Huang et al. (2014) Results Coded	Conclusions Coded
	Complications ***2014, Huang.*** No significant difference was observed between the 2 groups with regard to reruptures (P = .4) and rates of major (P = .71) and minor (P = .83) complications. ***Early mobilization and late weight bearing vs Late mobilization*** ***Tendon Elongation*** ***2014, Huang.*** The AT elongation distance was also sig- nificantly less in patients who began early weight bearing coupled with early motion at 3 months (P = .02) and at 1 year of follow-up (P = .006). ***Early mobilization and weight bearing vs Late mobilization*** ***Tendon Elongation*** ***2014, Huang.*** This subgroup data analysis demon- strated that only the time to return to sports (P = .0005) and tendon elongation (P \ .0001) at 1-year follow-up were significantly superior to conventional immobilization. ***Early mobilization and late weight bearing vs Late mobilization*** ***Calf Muscle Loss*** ***2014, Huang.*** Early weight bearing with ankle motion was also associated with a significantly greater number of patients with recovery of a normal calf circumfer- ence (P = .02) ***Early mobilization and weight bearing vs Late mobilization***	
Participant's Satisfaction	***Participant's Satisfaction*** ***2014, Huang.*** The data analysis demonstrated that 11 of the 15 out- come	***Participant's Satisfaction*** ***2014, Huang.*** Moreover, significantly more patients who under- went this early

Study: Huang et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	measurements were significantly better for the patients who performed early weight bearing with ankle motion exercises than for patients who received rigid cast immobilization. The subjective satisfaction rate was 93.6% in the early functional group and 77.5% in the immobilized group (P = .006). ***Early mobilization and weight bearing vs Late mobilization***	functional management were satisfied with their rehabilitation.
Return to Activities	***Return to Sport*** ***2014, Huang.*** Significantly superior results were detected with regard to the time to return to sports (P \ .0001) and the number returning to sports (P = .04), which all favored the early functional group. ***Early mobilization and weight bearing vs Late mobilization*** ***Return to Sport*** ***2014, Huang.*** This subgroup data analysis demon- strated that only the time to return to sports (P = .0005) and tendon elongation (P \ .0001) at 1-year follow-up were significantly superior to conventional immobilization. ***Early mobilization and late weight bearing vs Late mobilization***	
Clinical and Functional Outcomes	***Ankle Range of Motion*** ***2014, Huang.*** Furthermore, significantly more patients in the early functional group achieved normal ankle range of motion (P = .03). ***Early mobilization and weight bearing vs Late mobilization*** ***Heel-Rise*** ***2014, Huang.*** Early weight bearing with ankle motion was also associated with a significantly greater number of patients with recovery of a normal calf circumfer- ence (P = .02), a higher percentage of heel-raise	***Clinical and Functional Outcomes*** ***2014, Huang.*** Our results demonstrated that after the surgical treat- ment of acute AT ruptures, the patients who underwent early weight bearing combined with ankle motion exercises achieved significantly superior clinical results than those observed in patients who received conventional immobili- zation. ***Clinical and Functional Outcomes*** ***2014, Huang.*** Early weight bearing combined with early ankle motion exercises

Study: Huang et al. (2014)		
Categories	**Results Coded**	**Conclusions Coded**
	ability (P = .05) ***Early mobilization and weight bearing vs Late mobilization*** ***Plantarflexion Strength*** ***2014, Huang.*** Early weight bearing with ankle motion was also associated with a significantly greater number of patients with recovery of a normal calf circumfer- ence (P = .02), a higher percentage of heel-raise ability (P = .05), and less of a strength loss in plantar flexion at 3 months (P \ .0001) and 1 year (P \ .0001) of follow-up. ***Early mobilization and weight bearing vs Late mobilization***	achieves a superior and more rapid functional recovery than conventional immobilization after the surgi- cal repair of acute AT ruptures. Few advantages over rigid cast fixation are obtained when only early ankle motion exercises are applied.

Categories	Study: McCormack & Bovard (2015) Results Coded	Conclusions Coded
Complications	***Re-rupture*** ***2015, McCormack.*** Rerupture was an infrequent complication, occurring in fewer than 3% of patients in both groups. There was no dif- ference in the number of reruptures between bracing (n=6) and casting (n=6) (p=0.98). ***Complications*** ***2015, McCormack.*** There was no dif- ference in the incidence of major complications (figure 5) between the two groups (p=0.21; RD, −0.03; 95% CI −0.06 to 0.01). ***Tendon Elongation*** ***2015, McCormack.*** Mortensen et al15 reported slightly more tendon elongation with early mobilisation after 12 weeks (p=0.20). However, Cetti et al14 cited less elongation in the bracing group at all follow-ups and significantly lower tendon elongation after 1 year (p=0.0033). Long-term follow-up by Kangas et al22 also found less tendon elongation in the bracing group at 60 weeks postoperative (p=0.054), and noted a signifi- cant correlation between less tendon elongation and a better clinical outcome (p=0.017). Although these trials could not be pooled statistically because of inconsistent data presentation, they provide no support for increased tendon elongation with early mobilisation. **Calf Muscle Loss** **2015, McCormack.** Six articles reported on the level of calf atrophy, and all noted a significant loss of muscle mass in the injured leg compared with the uninjured leg. Although there was little or no difference between the bracing and casting groups.14 15 17 19–21	***Complications*** ***2015, McCormack.*** The benefits and convenience of bracing, without increased complication rates, has led to bracing for Achilles tendon rupture being a popular choice among both patients and physi- cians. Pooled analysis of randomised controlled trials shows higher patient satisfaction with no increase in complications. Thus, dynamic functional bracing may contribute to evidenced- based practice in the postoperative rehabilitation of acute Achilles tendon rupture.
Participants Satisfaction	***Participants Satisfaction*** ***2015, McCormack.*** results demonstrated that the bracing group had three times the	***Participants Satisfaction*** ***2015, McCormack.*** The benefits and convenience of bracing, without increased

Categories	Study: McCormack & Bovard (2015) Results Coded	Conclusions Coded
	odds of rating their satisfaction as 'good' or 'excellent' compared to the casting group (p=0.01; OR, 3.13; 95% CI 1.30 to 7.53).	complication rates, has led to bracing for Achilles tendon rupture being a popular choice among both patients and physi- cians. Pooled analysis of randomised controlled trials shows higher patient satisfaction with no increase in complications. Thus, dynamic functional bracing may contribute to evidenced- based practice in the postoperative rehabilitation of acute Achilles tendon rupture. ***Participants Satisfaction*** ***2015, McCormack.*** Compared to cast immobilisation, early functional rehabilitation after Achilles tendon repair ‣ is safe. ‣ results in higher patient satisfaction. ‣ leads to earlier return to function. ***Participants Satisfaction*** ***2015, McCormack.*** ‣ It is safe to start functional rehabilitation early following Achilles tendon repair. ‣ Early functional rehabilitation can improve patient satisfaction and facilitate earlier return to activity following Achilles tendon repair. ‣ Postoperative immobilisation is not necessary or helpful.
Return to Activities	***Return to Work*** ***2015, McCormack.*** For time to resumption, the mean difference was 1.5 weeks shorter for return to prior employment and 2.4 weeks for prior sporting level; although these results were not statistically signifi- cant (p=0.23; MD, −1.53; 95% CI −4.02 to 0.95 and p=0.48; MD, −2.38; 95% CI −8.95 to 4.19, respectively). Moreover, dif- ferences in patient demographics and employment protocols gen- erated considerable heterogeneity across the studies (I2 >80%). When analysing the studies individually, five of the six trials showed a faster return in the bracing group. Only the trial by Costa et al21 did not favour bracing, although this may be explained by a higher proportion of manual jobs in the early motion group. The time to resume walking and stair climbing, which are unaffected by occupation, were also reported by	***Return to Activities*** ***2015, McCormack.*** Compared to cast immobilisation, early functional rehabilitation after Achilles tendon repair ‣ is safe. ‣ results in higher patient satisfaction. ‣ leads to earlier return to functionReturn to Activities 2015, McCormack. ‣ It is safe to start functional rehabilitation early following Achilles tendon repair. ‣ Early functional rehabilitation can improve patient satisfaction and facilitate earlier return to activity following Achilles tendon repair. ‣ Postoperative immobilisation is not necessary or helpful.

Categories	Study: McCormack & Bovard (2015) Results Coded	Conclusions Coded
	Costa et al21 and the bracing group had a significantly faster return to normal function (p=0.027 and p=0.023, respectively). RTS 2015, McCormack. For time to resumption, the mean difference was 1.5 weeks shorter for return to prior employment and 2.4 weeks for prior sporting level; although these results were not statistically signifi- cant (p=0.23; MD, −1.53; 95% CI −4.02 to 0.95 and p=0.48; MD, −2.38; 95% CI −8.95 to 4.19, respectively). Moreover, dif- ferences in patient demographics and employment protocols gen- erated considerable heterogeneity across the studies (I2 >80%). When analysing the studies individually, five of the six trials showed a faster return in the bracing group. Only the trial by Costa et al21 did not favour bracing, although this may be explained by a higher proportion of manual jobs in the early motion group. The time to resume walking and stair climbing, which are unaffected by occupation, were also reported by Costa et al21 and the bracing group had a significantly faster return to normal function (p=0.027 and p=0.023, respectively).	
Clinical and Functional Outcomes	***Ankle Range of Motion*** ***2015, McCormack.*** Five articles measured ROM either in terms of median loss of ROM or regaining normal ROM.14 15 17 21 22 Similar to the change in strength over time, the between-group difference in ROM tended to favour bracing within the first year and diminished over time. ***Plantarflexion Strength*** ***2015, McCormack.*** Strength Ankle plantarflexion and dorsiflexion strength was assessed by nine authors.14 15 17–21 23 24 At early follow-up, ankle strength in the injured leg tended to be closer to normal for the bracing group than for patients in the casting group. Over time this difference diminished, and the overall mean deficit in strength was approximately equal in both groups by 6 months. Regarding late follow-up, Cetti et al14 found that the mean deficit was significantly different between the injured and uninjured legs in both groups at 1 year, suggesting that a return to preinjury level of ankle strength does not occur within 1 year for patients in either group.	***Clinical and Functional Outcomes*** ***2015, McCormack.*** What are the new findings? Compared to cast immobilisation, early functional rehabilitation after Achilles tendon repair ‣ is safe. ‣ results in higher patient satisfaction. ‣ leads to earlier return to function.

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
Complications	***Complications*** ***2021, Gould.*** Cetti et al21 conducted an RCT to compare post- operative casting and NWB to the application of a mobile cast with immediate weight bearing and early active ROM following AT repair. The mobile cast group that was allowed to weight bear reported less edema, faster RTW, and better active ROM at 6 weeks, as well as greater ankle mobility, stronger ankle plantarflexion, and less calf atrophy at 12 months. ***Tendon Elongation*** ***2021, Gould.*** Porter and colleagues conducted an RCT to compare a CR protocol that allowed PWB at 6 weeks and resistance strengthening at 10 weeks to an accelerated protocol that allowed PWB at 2 weeks and resistance strengthening at 6 weeks.38 This article reported less lengthening of the AT and faster return to running in the accelerated rehabilitation group, although no difference in ATRS scores was observed between groups. ***Early mobilization and weight bearing vs Late mobilization*** ***Tendon Elongation*** ***2021, Gould.*** an RCT by Agres and col- leagues compared an EFR group consisting of weightbear- ing exercise to a CR group consisting of NWB exercise; no difference was found between groups in terms of ankle kinematics, ankle kinetics, or AT properties postoperatively, though EFR was associated with faster RTP and less AT elongation postoperatively.19 ***Early mobilization and weight bearing vs Late mobilization*** ***Tendon Elongation*** ***2021, Gould.*** Mortensen et al37 compared casting versus bracing with early ROM and early weight bearing; better subjective results as well as faster RTW and RTP were reported in the brace group, though no difference was found between groups with regard to tendon	***Complications*** ***2021, Gould***. Following AT repair, early postoperative weightbear- ing with less rigid immobilization appears to facilitate accelerated functional recovery in the short-term. An aggressive rehabilitation program can be safely incorporated during the postoperative period and may offer some short- term benefits over a more conservative rehabilitation protocol. ***Overall*** ***Tendon Elongation*** ***2021, Gould.*** As a whole, the results of these studies suggest that a more accelerated rehabilitation protocol following AT repair may be incorporated safely and may offer some benefits over CR, particularly with regarding to RTW, RTP, and AT elongation. ***Early mobilization and weight bearing vs Late mobilization***

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	elongation. ***Tendon Elongation*** ***2021, Gould.*** Kangas et al28 also compared postoperative casting to early ankle ROM and reported no significant difference between groups with regard to tendon elongation, pain, stiffness, ROM, isokinetic calf muscle strength, or overall outcome.29 ***Early mobilization vs Late mobilization*** ***Tendon Elongation*** ***2021, Gould***. Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25 and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing***	
Participant's Satisfaction	***Participant's Satisfaction*** ***2021, Gould.*** Mortensen et al37 compared casting versus bracing with early ROM and early weight bearing; better subjective results as well as faster RTW and RTP were reported in the brace group, though no difference was found between groups with regard to tendon elongation. ***Participant's Satisfaction*** ***2021, Gould.*** Majewski et al36 conducted a similar prospective cohort study and reported faster RTW as well as superior patient-reported outcomes in patients who were allowed to perform early weight bearing exercise in an orthotic shoe, in contrast to rigid immobilization.	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
Return to Activities	***Return to Work*** ***2021, Gould.*** Kerkhoffs et al31 compared cast immobilization to a less restrictive wrap and reported a shorter hospital stay as well as faster RTP in the wrap group, though Rupp outcome scores were not significantly different between groups post- operatively. ***Return to Work*** ***2021, Gould.*** Mortensen et al37 compared casting versus bracing with early ROM and early weight bearing; better subjective results as well as faster RTW and RTP were reported in the brace group, though no difference was found between groups with regard to tendon elongation. ***Early mobilization vs Late mobilization*** ***Return to Work*** ***2021, Gould***. Cetti et al21 conducted an RCT to compare post- operative casting and NWB to the application of a mobile cast with immediate weight bearing and early active ROM following AT repair. The mobile cast group that was allowed to weight bear reported less edema, faster RTW, and better active ROM at 6 weeks, as well as greater ankle mobility, stronger ankle plantarflexion, and less calf atrophy at 12 months. ***Early weight bearing vs Late weight bearing*** ***Return to Work*** ***2021, Gould.*** Kim et al32 compared NWB in a cast for 4 weeks versus splinting for 2 weeks, followed by WBAT and earlier initiation of exercise. Although there was no differ- ence in the postoperative heel-raise test performance between groups, the early weight bearing group performed better in terms of RTW as well as AOFAS and ATRS outcome scores. ***Early weight bearing vs Late weight bearing***	***Return to Activities*** ***2021, Gould.*** Taken together, the results of these studies suggest that less rigid forms of immobilization with early ROM facilitate faster RTP and RTW, though this is not consistently asso- ciated with a significant difference in subjective or objective postoperative outcomes. ***Early mobilization vs Late mobilization*** ***Return to Activities*** ***2021, Gould.*** Overall, the literature pertaining to postoperative weight bearing following AT repair is characterized by het- erogeneous results. While some studies suggest a short-term benefit of early weight bearing with regard to functional outcomes, resource utilization, and RTW, it is not clear whether any of these differences in the early postoperative period have a sustained effect on long-term outcomes. ***Early weight bearing vs Late weight bearing*** ***Return to Activities*** ***2021, Gould.*** As a whole, the results of these studies suggest that a more accelerated rehabilitation protocol following AT repair may be incorporated safely and may offer some benefits over CR, particularly with regarding to RTW, RTP, and AT elongation. ***Early mobilization and weight bearing vs Late mobilization***

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	Return to Work ***2021, Gould.*** Likewise, Maffulli and colleagues con- ducted 2 prospective cohort studies comparing cast immo- bilization with immediate weight bearing and earlier exercise versus casting with delayed weight bearing.34,35 In these studies, early weight bearing was associated with decreased crutch utilization, fewer outpatient physical therapy visits, earlier discharge from physical therapy, and faster RTP and RTW postoperatively. ***Early weight bearing vs Late weight bearing*** ***Return to Work*** ***2021, Gould.*** Majewski et al36 conducted a similar prospective cohort study and reported faster RTW as well as superior patient-reported outcomes in patients who were allowed to perform early weight bearing exercise in an orthotic shoe, in contrast to rigid immobilization. ***Early weight bearing vs Late weight bearing*** ***Return to Work*** ***2021, Gould.*** De la Fuente et al23 conducted a prospective study that compared one month of postoperative casting to a post- operative protocol that incorporated early ROM and weight bearing. The accelerated rehabilitation program resulted in better outcomes with regard to AT strength, ATRS scores, verbal pain scores, medication consumption, and RTW compared with rigid postoperative immobiliza- tion. ***Early weight bearing vs Late weight bearing*** ***Return to Work*** ***2021, Gould.*** A retrospective study by Buchgraber et al20 reported better performance in the EFR group (consisting of isokinetic exercise) in terms of RTW, VAS pain scores, ankle ROM, and distance from heel to floor during toe walking. ***Early mobilization and weight bearing vs Late mobilization***	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	Return to Work ***2021, Gould.*** Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25 and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2021, Gould.*** Kerkhoffs et al31 compared cast immobilization to a less restrictive wrap and reported a shorter hospital stay as well as faster RTP in the wrap group ***Early mobilization vs Late mobilization*** ***Return to Sport*** ***2021, Gould.*** Mortensen et al37 compared casting versus bracing with early ROM and early weight bearing; better subjective results as well as faster RTW and RTP were reported in the brace group, though no difference was found between groups with regard to tendon elongation. ***Early mobilization vs Late mobilization*** ***Return to Sport*** ***2021, Gould.*** Likewise, Maffulli and colleagues con- ducted 2 prospective cohort studies comparing cast immo- bilization with immediate weight bearing and earlier exercise versus casting with delayed weight bearing.34,35 In these studies, early weight bearing was associated with decreased crutch utilization, fewer outpatient physical therapy visits, earlier discharge from physical therapy, and faster RTP and	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	RTW postoperatively. ***Early weight bearing vs Late weight bearing*** ***Return to Sport*** ***2021, Gould.*** Porter and colleagues conducted an RCT to compare a CR protocol that allowed PWB at 6 weeks and resistance strengthening at 10 weeks to an accelerated protocol that allowed PWB at 2 weeks and resistance strengthening at 6 weeks.38 This article reported less lengthening of the AT and faster return to running in the accelerated rehabilitation group, although no difference in ATRS scores was observed between groups. ***Early mobilization and weight bearing vs Late mobilization*** ***Return to Sport*** ***2021, Gould.*** an RCT by Agres and col- leagues compared an EFR group consisting of weightbear- ing exercise to a CR group consisting of NWB exercise; no difference was found between groups in terms of ankle kinematics, ankle kinetics, or AT properties postoperatively, though EFR was associated with faster RTP and less AT elongation postoperatively.19 ***Early mobilization and weight bearing vs Late mobilization*** ***Return to Sport*** ***2021, Gould.*** Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25 and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing***	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	Return to Sport ***2021, Gould.*** Saxena et al39 con- ducted a prospective cohort study to assess the utility of an antigravity treadmill for postoperative rehabilitation fol- lowing AT repair and reported no effect of this intervention on the time to return to outside running.	
Clinical and Functional Outcomes	***Ankle Range of Motion*** ***2021, Gould.*** Cetti et al21 conducted an RCT to compare post- operative casting and NWB to the application of a mobile cast with immediate weight bearing and early active ROM following AT repair. The mobile cast group that was allowed to weight bear reported less edema, faster RTW, and better active ROM at 6 weeks, as well as greater ankle mobility, stronger ankle plantarflexion, and less calf atrophy at 12 months. ***Early weight bearing vs Late weight bearing*** ***Ankle Range of Motion*** ***2021, Gould.*** A retrospective study by Buchgraber et al20 reported better performance in the EFR group (consisting of isokinetic exercise) in terms of RTW, VAS pain scores, ankle ROM, and distance from heel to floor during toe walking. ***Early mobilization and weight bearing vs Late mobilization*** ***Ankle Range of Motion*** ***2021, Gould.*** Kangas et al28 also compared postoperative casting to early ankle ROM and reported no significant difference between groups with regard to tendon elongation, pain, stiffness, ROM, isokinetic calf muscle strength, or overall outcome.29 ***Early mobilization vs Late mobilization*** ***Ankle Range of Motion*** ***2021, Gould.*** Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25	***Clinical and Functional Outcomes*** ***2021, Gould.*** Taken together, the results of these studies suggest that less rigid forms of immobilization with early ROM facilitate faster RTP and RTW, though this is not consistently asso- ciated with a significant difference in subjective or objective postoperative outcomes. ***Early mobilization vs Late mobilization*** ***Clinical and Functional Outcomes*** ***2021, Gould.*** Overall, the literature pertaining to postoperative weight bearing following AT repair is characterized by het- erogeneous results. While some studies suggest a short-term benefit of early weight bearing with regard to functional outcomes, resource utilization, and RTW, it is not clear whether any of these differences in the early postoperative period have a sustained effect on long-term outcomes. ***Early weight bearing vs Late weight bearing*** ***Clinical and Functional Outcomes*** ***2021, Gould.*** Following AT repair, early postoperative weightbear- ing with less rigid immobilization appears to facilitate accelerated functional recovery in the short-term. An aggressive rehabilitation program can be safely incorporated during the postoperative period and may offer some short- term benefits over a more conservative rehabilitation protocol. However, the current literature is unclear in terms of whether these early differences in outcome are sustained longitudinally. ***Overall***

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing*** ***Heel-Rise*** ***2021, Gould.*** Kim et al32 compared NWB in a cast for 4 weeks versus splinting for 2 weeks, followed by WBAT and earlier initiation of exercise. Although there was no differ- ence in the postoperative heel-raise test performance between groups, the early weight bearing group performed better in terms of RTW as well as AOFAS and ATRS outcome scores. ***Early weight bearing vs Late weight bearing*** ***Heel-Rise*** ***2021, Gould.*** Finally, Valkering and colleagues reported improved healing response and better functional outcomes with rcompared with rigid immobilization and NWB, though no difference in heel-raise testing was found at 6 or 12 months postoperatively.42 ***Plantarflexion Strength*** ***2021, Gould.*** Cetti et al21 conducted an RCT to compare post- operative casting and NWB to the application of a mobile cast with immediate weight bearing and early active ROM following AT repair. The mobile cast group that was allowed to weight bear reported less edema, faster RTW, and better active ROM at 6 weeks, as well as greater ankle mobility, stronger ankle plantarflexion, and less calf atrophy at 12 months. ***Early weight bearing vs Late weight bearing***	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	Plantarflexion Strength ***2021, Gould.*** Kangas et al28 also compared postoperative casting to early ankle ROM and reported no significant difference between groups with regard to tendon elongation, pain, stiffness, ROM, isokinetic calf muscle strength, or overall outcome.29 ***Early mobilization vs Late mobilization*** ***Plantarflexion Strength*** ***2021, Gould.*** Lantto and colleagues executed a long-term RCT to compare early weight bearing with cast immobili- zation versus early weight bearing with a motion-preserving brace. This study found no difference between groups in Leppilahti score, isokinetic plantarflexion torque, or average work deficit in plantarflexion at 11 years postoperatively.33 ***Early mobilization vs Late mobilization*** ***Plantarflexion Strength*** ***2021, Gould.*** Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25 and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing*** ***Calf Muscle Loss*** ***2021, Gould.*** Cetti et al21 conducted an RCT to compare post- operative casting and NWB to the application of a mobile cast with immediate weight bearing and early active ROM following AT repair. The mobile cast group that was allowed to weight bear reported less edema, faster RTW, and better active ROM at 6 weeks, as well as greater ankle	

Categories	Study: Gould et al. (2021) Results Coded	Conclusions Coded
	mobility, stronger ankle plantarflexion, and less calf atrophy at 12 months. ***Early weight bearing vs Late weight bearing*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** Kim et al32 compared NWB in a cast for 4 weeks versus splinting for 2 weeks, followed by WBAT and earlier initiation of exercise. Although there was no differ- ence in the postoperative heel-raise test performance between groups, the early weight bearing group performed better in terms of RTW as well as AOFAS and ATRS outcome scores. ***Early weight bearing vs Late weight bearing*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** De la Fuente et al23 conducted a prospective study that compared one month of postoperative casting to a post- operative protocol that incorporated early ROM and weight bearing. The accelerated rehabilitation program resulted in better outcomes with regard to AT strength, ATRS scores, verbal pain scores, medication consumption, and RTW compared with rigid postoperative immobiliza- tion. ***Early weight bearing vs Late weight bearing*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** In a prospective cohort study, Vitomskyi et al43 reported better ATRS and Leppilahti scores with accelerated rehabilitation compared with CR at 16 weeks postoperatively. ***Early mobilization and weight bearing vs Late mobilization*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** Lantto and colleagues executed a long-term RCT to compare early weight bearing with cast immobili- zation versus early weight bearing with a motion-preserving brace. This study found no difference	

Study: Gould et al. (2021)		
Categories	**Results Coded**	**Conclusions Coded**
	between groups in Leppilahti score ***Early mobilization vs Late mobilization*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** Moreover, other RCTs performed by Costa et al,22 Eliasson et al,25 and Groetelaers et al27 did not find any significant differences between weight bearing groups with regard to ankle ROM, ankle peak torque, ankle plantarflexion strength, AT elongation, RTP, RTW, or ATRS scores at 12 months postoperatively. Of note, however, none of these studies reported a significant difference in complication rate (including AT re-rupture) associated with earlier initiation of weight bearing. ***Early weight bearing vs Late weight bearing*** ***Multi-Item Scoring Scale*** ***2021, Gould.*** Porter and colleagues conducted an RCT to compare a CR protocol that allowed PWB at 6 weeks and resistance strengthening at 10 weeks to an accelerated protocol that allowed PWB at 2 weeks and resistance strengthening at 6 weeks.38 This article reported less lengthening of the AT and faster return to running in the accelerated rehabilitation group, although no difference in ATRS scores was observed between groups. ***Early mobilization and weight bearing vs Late mobilization***	

Study: Massen et al. (2022)		
Categories	**Results Coded**	**Conclusions Coded**
Complications	***Re-rupture*** ***2022, Massen.*** Overall, Group 1 had the lowest prevalence for re-rupture (0.04; 95% CI: 0.02–0.06). For all groups, a low heterogeneity (I2=0%; P =0.38–0.96) was found. ***Re-rupture*** ***2022, Massen.*** Four studies compared Group 1 (WB+M) to Group 2 (WB+IM) with a non-significant OR of 0.63 (95% CI: 0.16–2.55; P=0.520) in favour for Group 1. All studies used an open surgical repair. ***Re-rupture*** ***2022, Massen.*** Seven studies compared Group 1 (WB+M) to Group 4 (NWB+IM), again, with a non-significant OR of 0.61 (95% CI: 0.15–2.47; P=0.490) in favour of Group 1, based on 4 studies reporting events. An open repair was used in half of the studies, while the other half used a minimally invasive technique ***Re-rupture*** ***2022, Massen.*** Four studies compared Group 2 (WB+IM) to Group 4 (NWB+IM) with a non- significant OR of 2.13 (95% CI: 0.33–13.61; P=0.420) in favour for Group 4, based on 3 studies reporting events. All studies used an open surgical repair. **Complications** **2022, Massen**. Group 1 having the lowest prevalence for a major complication (0.02; 95% CI: 0.01–0.03). The overall risk of bias was low (I2 = 0%; P = 0.75–0.94).	***Re-rupture*** ***2022, Massen.*** This systematic review and meta-analysis proved early functional rehabilitation protocols with early ankle M and WB following surgical repair of acute Achilles tendon ruptures to be safe. It appears these protocols may allow for a quicker RTW and RTS. Whether they also result in superior functional outcomes remains a matter of debate. Consequently, the previously postulated best evidence rehabilitation protocol for surgically treated Achilles tendon ruptures (14) remains the standard at our clinic.

Categories	Results Coded	Conclusions Coded
	Study: Massen et al. (2022)	
	Complications ***2022, Massen.*** with Group 1 revealing the lowest prevalence for a minor complication (0.04; 95% CI: 0.02–0.07) at a moderate level of heterogeneity (I2=49% 84%; P =0.0011–0.03). ***Complications*** 2022, Massen. Four studies compared Group 1 (WB +M) to Group 2 (WB + IM) with an OR of 0.97 (95% CI: 0.21–4.52; P = 0.960) based on three studies reporting events. ***Complications*** 2022, Massen. Six studies compared Group 1 (WB +M) to Group 4 (NWB + IM), with two studies not reporting events, and a non-significant OR of 0.82 (95% CI: 0.24–2.83; P = 0.750) in favour of Group 1. ***Complications*** ***2022, Massen.*** A group comparing meta-analysis could only be conducted for Group 2 vs Group 4 (Fig. 5), reporting no relevant differences (OR: 0.96; 95% CI: 0.47– 1.96; P=0.910) between the 4 studies included at no heterogeneity (I2 = 0%; P=0.750).	
Return to Activities	***Return to Work/Sport*** ***2022, Massen.*** Overall, Group 4 revealed the poorest results for RTW and RTS.	***Return to Activities*** ***2022, Massen.*** This systematic review and meta-analysis proved early functional rehabilitation protocols with early ankle M and WB following surgical repair of acute Achilles tendon ruptures to be safe. It appears these protocols may allow for a quicker RTW and RTS. Whether they also result in superior functional outcomes remains a matter of debate.
Clinical and Functional Outcomes	***Multi-Item Scoring Scale*** ***2022, Massen.***	***Clinical and Functional Outcomes*** ***2022, Massen.***

Study: Massen et al. (2022)		
Categories	Results Coded	Conclusions Coded
	The ATRS assessed at 12 months follow-up was reported in three studies (8, 36, 37). No study reported significant differences between the treatment groups (Table 5). Due to the limited number of studies within each group, no cumulative analysis could be conducted.	This systematic review and meta-analysis proved early functional rehabilitation protocols with early ankle M and WB following surgical repair of acute Achilles tendon ruptures to be safe. It appears these protocols may allow for a quicker RTW and RTS. Whether they also result in superior functional outcomes remains a matter of debate.

Chapter II – Postoperative Rehabilitation Approaches for Achilles Tendon Rupture: A Systematic Review of Randomized Controlled Trials

Appendix 2A

PRISMA 2020 Main Checklist

Topic	No.	Item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	pag. 47
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist	App. 2B
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	pag. 49-50
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	pag. 49-50
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	pag. 51-52/ 54-56
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	pag. 50-51
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	pag. 50-51
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	pag. 50-52
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	pag. 52
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	pag. 51-52
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	pag. 51-52
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	pag. 52-53
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	pag. 54-56

Topic	No.	Item	Location where item is reported
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item 5)).	pag. 54-56
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	pag. 54-56
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	pag. 54-56
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	pag. 56
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	pag. 56
Study characteristics	17	Cite each included study and present its characteristics.	pag. 58-67
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	pag. 66-67/ 70
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	pag. 80-100
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	pag. 58-67
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	pag. 80-100
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	pag. 80-100
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	pag. 80-100
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	pag. 58-67
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	pag. 80-100/ App. 2G
DISCUSSION			

Topic	No.	Item	Location where item is reported
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	pag. 100
	23b	Discuss any limitations of the evidence included in the review.	pag. 110/111
	23c	Discuss any limitations of the review processes used.	pag. 110/111
	23d	Discuss implications of the results for practice, policy, and future research.	pag. 110/11
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	pag. 50
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	pag. 50
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	pag.50/ App. 2C
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	pag. 112
Competing interests	26	Declare any competing interests of review authors.	pag. 112
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	NA

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. MetaArXiv. 2020, September 14. DOI: 10.31222/osf.io/v7gm2. For more information, visit: www.prisma-statement.org

Appendix 2B

PRISMA Abstract Checklist

Topic	No.	Item	Reported?
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesize results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	No
Registration	12	Provide the register name and registration number.	Yes

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. MetaArXiv. 2020, September 14. DOI: 10.31222/osf.io/v7gm2. For more information, visit: www.prisma-statement.org

Appendix 2C

PROSPERO Protocol Deviations

Item Number 16 (Searches)

In our previous search strategy, we planned to use an Embase filter for randomized controlled trials proposed by Wong et al. (2006). Nonetheless, we have updated the search filter used in Embase considering a recent filter proposed by Glanville et al. (2019). This adjustment aims to optimize the search strategy using an updated tool.

Item Number 20 and 21 (Intervention and Comparator)

In the previous version of our protocol, the PICOS strategy defined the intervention as “Early rehabilitation approaches (i.e., immediately to 2 weeks post-surgery)” and the control as ‘Conservative/Delayed rehabilitation approaches (i.e., more than 2 weeks post-surgery)’. However, we have revised the PICOS strategy to define the intervention as ‘Postoperative rehabilitation following ATR repair (randomized rehabilitation assignment)’ and the comparator as ‘At least two different types of rehabilitation after surgical treatment’. These adjustments were designed to better align the PICOS strategy with our research question.

Item Number 24 (Main Outcomes)

In the previous version of our protocol, we planned to include outcomes from two clinical and functional scales (Achilles Tendon Rupture Score and the AOFAS - Ankle Hindfoot Scale). However, based on the findings of Pearsall et al. (2023), which reported that the most frequently used multi-item scoring scales in randomized controlled trials involving Achilles tendon ruptures were Achilles Tendon Rupture Score (48%), AOFAS - Ankle Hindfoot Scale (46%), and Leppilahti Score (20%), we have added the Leppilahti Score as an outcome in our study.

Item Number 25 (Additional Outcomes)

We previously defined two outcomes as “ankle range of motion” and “plantar flexion strength”. The outcome “range of motion” has been specified to “plantar flexion range of motion” and “dorsiflexion range of motion”, while “plantar flexion strength” has been specified as “isometric plantar flexion strength”. These adjusts were applied during the data synthesis process, to improve the clearness of results reporting (ankle range of motion) and prevent multiple outcomes of a single parameter (plantar flexion strength).

Item Number 26 (Data Extraction)

In the previous version of our protocol, we planned to perform the data extraction using a standardized spreadsheet. However, we have changed from this approach to the use of a coding software. This approach allows for less biased data extraction by reducing typing errors and providing a direct comparison of agreement between investigators.

We previously planned to extract data on “Sample’s characteristics” including “sex, age, body mass, height, anthropometrics, and total sample size”. To improve the clearness of results reporting we revised this to “sex, age, body mass index, and total sample size”. Similarly, to improve reporting clarity, we revised the terms under “Rehabilitation characteristics” from “immobilization approach, time to weight bearing, exercise descriptors, weekly intervention frequency, duration of interventions/sessions, adherence, and Consensus on Exercise Reporting Template Checklist results” to “immobilization approach, time to weight bearing, mobilization exercise descriptors, and duration of interventions/sessions”. The Consensus on Exercise Reporting Template Checklist were considered in the methodological appraisal section.

Item Number 28 (Strategy for data synthesis)

We previously planned to perform meta-analysis if five or more studies presented comparable characteristics and outcomes. However, we performed a quantitative data synthesis (i.e., meta-analysis) if two or more studies presented common designs and outcomes, reporting the statistical power using a post hoc approach. In addition, we chose to present the results from the meta-analysis, regardless of whether the models exhibited high heterogeneity (I^2>75%) or low statistical power (1-β<80%). This approach aims to provide a comprehensive understanding of the current state of the literature (Fletcher, 2007; Nunes et al., 2022) and to support future meta-analyses in their sample size calculations.

To deal with the inherent heterogeneity across studies, we performed the meta-analysis by grouping studies based on the comparison of rehabilitation approaches and, when possible, the timeframe of outcome assessment. Although this approach reduced the number of studies pooled in each meta-analysis, we opted to change the variance estimator method from (DerSimonian and Laird, 1986) to the (Paule and Mandel, 1982). This approach aimed to provide a more robust estimation of parameters, specifically in the meta-analysis models with small sample sizes and high heterogeneity (Veroniki et al., 2016).

In the previous version of our protocol, we planned to perform the quantitative data synthesis using the meta and metafor R packages. However, we opted to use only the metafor package and incorporated the metapower package to estimate the statistical power of the models.

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Appendix 2D

Search strategy that was used for each database.

PubMed	Cochrane CENTRAL	EMBASE
#1 "Achilles Tendon"[Mesh] OR "Achilles Tendon" OR "Tendon, Achilles" OR "Calcaneal Tendon" OR "Calcaneal Tendons" OR "Tendon, Calcaneal" OR "Tendons, Calcaneal" OR "Tendo Calcaneus" **#2** "Rupture"[Mesh] OR "Rupture" OR "Tendon Injuries"[Mesh] OR "Tendon Injuries" OR "Injuries, Tendon" OR "Injury, Tendon" OR "Tendon Injury" **#3** "Rehabilitation" OR "early functional rehabilitation" OR "early rehabilitation" OR "early mobilization" **#4** (randomized controlled trial [pt] OR controlled clinical trial [pt] OR randomized [tiab] OR placebo [tiab] OR drug therapy [sh] OR randomly [tiab] OR trial [tiab] OR groups [tiab]) NOT (animals [mh] NOT humans [mh]) **#5** #1 AND #2 AND #3 AND #4	**#1** MeSH descriptor: [Achilles Tendon] explode all trees **#2** MeSH descriptor: [Tendon Injuries] explode all trees **#3** MeSH descriptor: [Rehabilitation] explode all trees **#4** 1# AND #2 AND #3	**#1** 'achilles tendon rupture'/exp OR 'achilles tendon rupture' OR 'tendo achillis rupture' AND ('functional readaptation' OR 'medical rehabilitation' OR 'readaption' OR 'readjustment' OR 'rehabilitation concept' OR 'rehabilitation engineering' OR 'rehabilitation potential' OR 'rehabilitation process' OR 'rehabilitation program' OR 'rehabilitation programme' OR 'rehabilitation, medical' OR 'rehabilitative treatment' OR 'resocialisation' OR 'resocialisation therapy' OR 'resocialization' OR 'resocialization therapy' OR 'revalidation' OR 'rehabilitation' **#2** ‘randomized controlled trial’/exp OR ‘controlled clinical trial’/de OR random*:ti,ab,tt OR ‘randomization’/de OR ‘intermethod comparison’/de OR placebo:ti,ab,tt OR (compare:ti,tt OR compared:ti,tt OR comparison:ti,tt) OR ((evaluated:ab OR evaluate:ab OR evaluating:ab OR assessed:ab OR assess:ab) AND (compare:ab OR compared:ab OR comparing:ab OR comparison:ab)) OR (open NEXT/1 label):ti,ab,tt OR ((double OR single OR doubly OR singly) NEXT/1 (blind OR blinded OR blindly)):ti,ab,tt OR ‘double blind procedure’/de OR (parallel NEXT/1 group*):ti,ab,tt OR (crossover:ti,ab,tt OR ‘cross

Search strategy that was used for each database.

PubMed	Cochrane CENTRAL	EMBASE
		over':ti,ab,tt) OR ((assign* OR match OR matched OR allocation) NEAR/6 (alternate OR group OR groups OR intervention OR interventions OR patient OR patients OR subject OR subjects OR participant OR participants)):ti,ab,tt OR (assigned:ti,ab,tt OR allocated:ti,ab,tt) OR (controlled NEAR/8 (study OR design OR trial)):ti,ab,tt OR (volunteer:ti,ab,tt OR volunteers:ti,ab,tt) OR 'human experiment'/de OR trial:ti,tt **#3** OR (((random* NEXT/1 sampl* NEAR/8 ('cross section*' OR questionnaire* OR survey OR surveys OR database or databases)):ti,ab,tt) NOT ('comparative study'/de OR 'controlled study'/de OR 'randomised controlled':ti,ab,tt OR 'randomized controlled':ti,ab,tt OR 'randomly assigned':ti,ab,tt)) OR ('cross-sectional study'/de NOT ('randomized controlled trial'/exp OR 'controlled clinical trial'/de OR 'controlled study'/de OR 'randomised controlled':ti,ab,tt OR 'randomized controlled':ti,ab,tt OR 'control group':ti,ab,tt OR 'control groups':ti,ab,tt)) OR ('case control*':ti,ab,tt AND random*:ti,ab,tt NOT ('randomised controlled':ti,ab,tt OR 'randomized controlled':ti,ab,tt)) OR ('systematic review':ti,tt NOT (trial:ti,tt OR study:ti,tt)) OR (nonrandom*:ti,ab,tt NOT random*:ti,ab,tt) OR 'random field*':ti,ab,tt OR ('random cluster' NEAR/4 sampl*):ti,ab,tt OR (review:ab AND review:it) NOT trial:ti,tt OR ('we searched':ab AND

Search strategy that was used for each database.

PubMed	Cochrane CENTRAL	EMBASE
		(review:ti,tt OR review:it)) OR 'update review':ab OR (databases NEAR/5 searched):ab OR ((rat:ti,tt OR rats:ti,tt OR mouse:ti,tt OR mice:ti,tt OR swine:ti,tt OR porcine:ti,tt OR murine:ti,tt OR sheep:ti,tt OR lambs:ti,tt OR pigs:ti,tt OR piglets:ti,tt OR rabbit:ti,tt OR rabbits:ti,tt OR cat:ti,tt OR cats:ti,tt OR dog:ti,tt OR dogs:ti,tt OR cattle:ti,tt OR bovine:ti,tt OR monkey:ti,tt OR monkeys:ti,tt OR trout:ti,tt OR marmoset*:ti,tt) AND 'animal experiment'/de) OR ('animal experiment'/de NOT ('human experiment'/de OR 'human'/de)) **#4** **#2** NOT #3 **#5** #1 AND #4

Appendix 2E

Studies excluded and reasons.

Author and Year	Title	Reason
Carter, 1992	Functional postoperative treatment of Achilles tendon repair	One rehabilitation group only
Mortensen, 1999	Early motion of the ankle after operative treatment of a rupture of the Achilles tendon	Non-surgical treatment
Kauranen, 2002	Recovering motor performance of the foot after Achilles rupture repair: a randomized clinical study about early functional treatment vs. Early immobilization of Achilles tendon in tension	Any outcome related to PICOS
Kerkhoffs, 2002	Functional treatment after surgical repair of acute Achilles tendon rupture: wrap vs walking cast	Non-randomized rehabilitation assignment
Costa, 2006	Immediate full-weight-bearing mobilisation for repaired Achilles tendon ruptures: a pilot study	Pilot study
Maffulli, 2003	No adverse effect of early weight bearing following open repair of acute tears of the Achilles tendon	Non-randomized rehabilitation assignment
Maffulli, 2003	Early weight bearing and ankle mobilization after open repair of acute midsubstance tears of the Achilles tendon	Non-randomized rehabilitation assignment
Kangas, 2007	Elongation of the Achilles tendon after rupture repair occurred slightly less with postoperative early motion than with postoperative immobilization	Study design not related to PICOS (commentary)
Ateschrang, 2008	No influence of physiotherapy on outcome after open repair of Achilles tendon ruptures?	Non-randomized rehabilitation assignment

Studies excluded and reasons.

Author and Year	Title	Reason
Majewski, 2008	Postoperative rehabilitation after percutaneous Achilles tendon repair: early functional therapy versus cast immobilization	Non-randomized rehabilitation assignment
Vargas-Mena, 2013	Efecto de la rehabilitación temprana versus tardía, en pacientes con tenorrafia del tendón de aquiles	Non-randomized rehabilitation assignment
Kearney, 2016	Study of tendo Achilles rupture rehabilitation (star): a feasibility randomised controlled trial comparing plaster cast with functional bracing rehabilitation	Study design not related to PICOS (abstract from event proceedings)
Tsitsilonis, 2016	Rehabilitation after percutaneous Achilles tendon rupture: the effect of full-weight bearing	Study design not related to PICOS (abstract from event proceedings)
Kim, 2017	Early rehabilitation after open repair for patients with a rupture of the Achilles tendon	Non-randomized rehabilitation assignment
Magnusson, 2019	Heterotopic ossification after an Achilles tendon rupture cannot be prevented by early functional rehabilitation: a cohort study	Study design not related to PICOS (cohort study)
Nam, 2018	Comparison between early functional rehabilitation and cast immobilization after minimally invasive repair for an acute Achilles tendon rupture	Non-randomized rehabilitation assignment
Agres, 2020	Muscle fascicles exhibit limited passive elongation throughout the rehabilitation of Achilles tendon rupture after percutaneous repair	One rehabilitation group only
Barfod, 2020	Risk of deep vein thrombosis after acute Achilles tendon rupture a secondary analysis of a randomized controlled trial comparing early controlled motion of the ankle versus immobilization	Non-surgical treatment

Studies excluded and reasons.

Author and Year	Title	Reason
Costa, 2020	Plaster cast versus functional bracing for Achilles tendon rupture: the ukstar RCT	Non-surgical treatment
Maempel, 2020	A randomized controlled trial comparing traditional plaster cast rehabilitation with functional walking boot rehabilitation for acute Achilles tendon ruptures	Non-surgical treatment
Aufwerber, 2021	No effects of early functional mobilization on gait patterns after acute Achilles tendon rupture repair	Any outcome related to PICOS
Maffulli, 2021	Slowed-down rehabilitation following percutaneous repair of Achilles tendon rupture	Non-randomized rehabilitation assignment
Mosconi, 2022	Fast functional rehabilitation protocol versus plaster cast immobilization protocol after Achilles tendon tenorrhaphy: is it different? Clinical, ultrasonographic, and elastographic comparison	Non-randomized rehabilitation assignment
Hoffner, 2023	Delayed loading following repair of ruptured Achilles tendon – a randomized controlled trial	Study design not related to PICOS (abstract from event proceedings)
Cretnik, 2024	Prospective randomized comparison of functional bracing versus rigid immobilization with early weight bearing after modified percutaneous Achilles tendon repair under local anesthesia	Non-randomized rehabilitation assignment

Appendix 2F

Risk of bias of study results assessed using the RoB-2 tool.

Study / Outcome	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall risk of bias
Kangas, 2003 / Re-rupture	Low	Some concerns	Low	Low	Some concerns	Some concerns
Kangas, 2003 / Leppilahti Score	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Kangas, 2003 / Plantar flexion strength	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Costa, 2006 / Re-rupture	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Costa, 2006 / Major complications	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Costa, 2006 / Minor complications	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Costa, 2006 / Calf's muscle mass	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
Costa, 2006 / Return to work	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Costa, 2006 / Return to sport	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Costa, 2006 / Plantar flexion range of motion	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Costa, 2006 / Dorsiflexion range of motion	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Kangas, 2007 / Tendon elongation/length	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Suchak, 2008 / Re-rupture	Low	Low	Low	Low	Some concerns	Some concerns
Suchak, 2008 / Major complications	Low	Low	Low	Low	Some concerns	Some concerns
Suchak, 2008 / Minor complications	Low	Low	Low	Low	Some concerns	Some concerns
Schepull, 2013 / Re-rupture	Low	Some concerns	Low	Low	Some concerns	Some concerns
Schepull, 2013 / Major complications	Low	Some concerns	Low	Low	Some concerns	Some concerns
Schepull, 2013 / Achilles Tendon Rupture Score	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns

Risk of bias of study results assessed using the RoB-2 tool.

Study / Outcome	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall risk of bias
Schepull, 2013 / Heel-rise test (height and number)	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Groetelaers, 2014 / Re-rupture	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Groetelaers, 2014 / Major complications	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Groetelaers, 2014 / Minor complications	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Groetelaers, 2014 / Return to work	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Groetelaers, 2014 / Leppilahti Score	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Groetelaers, 2014 / Plantar flexion strength	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Porter, 2015 / Return to sport	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Porter, 2015 / Achilles Tendon Rupture Score	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Porter, 2015 / Heel-rise test (height)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Lantto, 2015 / Leppilahti Score	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Lantto, 2015 / Plantar flexion strength	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
De la Fuente, 2016a / Re-rupture	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
De la Fuente, 2016a / Major complications	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
De la Fuente, 2016a / Calf's muscle mass	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns	Some concerns
De la Fuente, 2016a / Return to work	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
De la Fuente, 2016a / Achilles Tendon Rupture Score	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
De la Fuente, 2016a / Dorsiflexion range of motion	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
De la Fuente, 2016a / Heel-rise test (number)	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns

Risk of bias of study results assessed using the RoB-2 tool.

Study / Outcome	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall risk of bias
De la Fuente, 2016b / Plantar flexion strength	Low	Some concerns	Low	Some concerns	Some concerns	Some concerns
Valkering, 2017 / Re-rupture	Low	Low	Low	Low	Low	Low
Valkering, 2017 / Dorsiflexion range of motion	Low	Low	Low	Some concerns	High	High
Valkering, 2017 / Heel-rise test (height and number)	Low	Low	Low	Some concerns	High	High
Eliasson, 2018 / Re-rupture	Some concerns	Some concerns	Low	Low	Low	Some concerns
Eliasson, 2018 / Tendon elongation/length	Some concerns	Some concerns	Low	Low	Low	Some concerns
Eliasson, 2018 / Calf's muscle mass	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Eliasson, 2018 / Return to work	Some concerns	Some concerns	Low	Low	Low	Some concerns
Eliasson, 2018 / Return to sport	Some concerns	Some concerns	Low	Low	Low	Some concerns
Eliasson, 2018 / Achilles Tendon Rupture Score	Some concerns	Some concerns	Low	Low	Low	Some concerns
Eliasson, 2018 / Dorsiflexion range of motion	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Eliasson, 2018 / Plantar flexion strength	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Eliasson, 2018 / Heel-rise test (height and work)	Some concerns	Some concerns	Low	Some concerns	Low	Some concerns
Agres, 2018 / Plantar flexion strength	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Agres, 2018 / Tendon elongation/length	Some concerns	Some concerns	Low	Some concerns	Some concerns	Some concerns
Aufwerber, 2020b / Re-rupture	Low	Some concerns	Low	Low	Low	Some concerns
Aufwerber, 2020b / Major complications	Low	Some concerns	Low	Low	Low	Some concerns
Aufwerber, 2020b / Minor complications	Low	Some concerns	Low	Low	Low	Some concerns
Aufwerber, 2020c / Achilles Tendon Rupture Score	Low	Some concerns	Low	Low	High	High
Aufwerber, 2020c / Heel-rise test (height, number,	Low	Some concerns	Low	Some concerns	High	High

Risk of bias of study results assessed using the RoB-2 tool.

Study / Outcome	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall risk of bias
and work)						
Aufwerber, 2020a / Tendon elongation/length	Low	Some concerns	Some concerns	Some concerns	High	High
Aufwerber, 2020a / Calf's muscle mass	Low	Some concerns	Some concerns	High	High	High
Okoroha, 2020 / Re-rupture	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Major complications	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Minor complications	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Tendon elongation/length	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Achilles Tendon Rupture Score	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Plantar flexion range of motion	Low	Low	Low	Low	Some concerns	Some concerns
Okoroha, 2020 / Dorsiflexion range of motion	Low	Low	Low	Low	Some concerns	Some concerns
Aufwerber, 2022 / Plantar flexion range of motion	Low	Some concerns	High	Some concerns	High	High
Deng, 2022 / Major complications	Low	Low	Low	Low	Low	Low
Deng, 2022 / Return to sport	Low	Low	Low	Low	Low	Low
Deng, 2022 / Return to work	Low	Low	Low	Low	Low	Low
Deng, 2022 / Achilles Tendon Rupture Score	Low	Low	Low	Low	Low	Low
Deng, 2022 / $AOFAS_{AHS}$	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Re-rupture	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Major complications	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Tendon elongation/length	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Calf's muscle mass	Low	Low	Low	Low	Low	Low

Risk of bias of study results assessed using the RoB-2 tool.

Study / Outcome	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall risk of bias
Hoeffner, 2024 / Achilles Tendon Rupture Score	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Plantar flexion strength	Low	Low	Low	Low	Low	Low
Hoeffner, 2024 / Heel-rise test (height, number, and work)	Low	Low	Low	Low	Low	Low

Appendix 2G

Table 1. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Re-rupture	5 RCT	serious[a]	not serious	not serious	very serious[e]	The re-rupture rate was presented by five studies (Aufwerber et al., 2020b; De la Fuente et al., 2016a; Eliasson et al., 2018; Groetelaers et al., 2014; Valkering et al., 2017) with similar occurrence of re-ruptures between rehabilitation approaches (LWB+LLE: 0-5%; EWB+ELE: 0-5%).	⊕◯◯◯ Very low[a,e]
Major and Minor Complications	3 RCT	serious[a]	not serious	not serious	very serious[e]	Three studies reported the major complications occurrence (Aufwerber et al., 2020b; De la Fuente et al., 2016a; Groetelaers et al., 2014), these events occurred in 0-10% and 0-15% of participants in LWB+LLE and EWB+ELE, respectively. The occurrence of minor complications was reported by two studies (Aufwerber et al., 2020b; Groetelaers et al., 2014), which reported similar number of complications in both rehabilitation approaches (LWB+LLE: 0-20%; EWB+ELE: 0-26%).	⊕◯◯◯ Very low[a,e]
Calf's Muscle Mass	3 RCT	very serious[b]	not serious	not serious	very serious[e]	Three studies presented outcomes on the calf's muscle mass/loss (Aufwerber et al., 2020a; De la Fuente et al., 2016a; Eliasson et al., 2018). De la Fuente et al. (2016a) reported no groups differences in injured-contralateral side difference of calf circumference at post-4 (LWB+LLE: 1.6 mm; EWB+ELE: 1.2 mm), post-8 (LWB+LLE: 1.2 mm; EWB+ELE: 1.4 mm), post-12 (LWB+LLE: 1.6 mm; EWB+ELE: 1.4 mm) weeks of surgery. Eliasson et al. (2018) found no groups differences for injured side cross-sectional area of gastrocnemius medialis (LWB+LLE: 12.4 mm; EWB+ELE: 11.8 mm), gastrocnemius lateralis (LWB+LLE: 5.5 mm; EWB+ELE: 5.4 mm), and soleus (LWB+LLE: 25.0 mm; EWB+ELE: 24.5 mm) at 6 weeks postoperatively. At post-26 weeks of surgery, no groups differences were reported for injured side cross-sectional area of gastrocnemius medialis (LWB+LLE: 12.8 mm; EWB+ELE: 12.8 mm), gastrocnemius lateralis (LWB+LLE: 6.0 mm; EWB+ELE: 6.4 mm), and soleus (LWB+LLE: 22.4 mm; EWB+ELE: 23.2 mm). At post-52 weeks of surgery, no group differences were found for cross-sectional area of gastrocnemius medialis (LWB+LLE: 13.1 mm; EWB+ELE: 13.2 mm), gastrocnemius lateralis (LWB+LLE: 6.2 mm; EWB+ELE: 6.6 mm), and soleus (LWB+LLE: 23.1 mm; EWB+ELE: 23.0 mm) on the injured side. Aufwerber et al. (2020a) presented injured-contralateral side differences of cross-sectional area of gastrocnemius medialis and gastrocnemius lateralis, and muscle thickness of soleus. At post-2 weeks of surgery, both groups were similar for cross-sectional area difference	⊕◯◯◯ Very low[b,e]

Table 1. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						of gastrocnemius medialis (LWB+LLE: 1.90 cm; EWB+ELE: 1.77 cm) and gastrocnemius lateralis (LWB+LLE: 1.49 cm; EWB+ELE: 1.53 cm), and muscle thickness difference of soleus (LWB+LLE: 0.19 cm; EWB+ELE: 0.21 cm). At post-6 weeks of surgery, no between-group difference was found for cross-sectional area difference of gastrocnemius medialis (LWB+LLE: 3.21 cm; EWB+ELE: 2.26 cm) and gastrocnemius lateralis (LWB+LLE: 1.96 cm; EWB+ELE: 1.86 cm), and muscle thickness difference of soleus (LWB+LLE: 0.18 cm; EWB+ELE: 0.18 cm). At post-24 weeks of surgery, no between-group difference was found for cross-sectional area difference of gastrocnemius medialis (LWB+LLE: 1.99 cm; EWB+ELE: 1.61 cm) and gastrocnemius lateralis (LWB+LLE: 0.78 cm; EWB+ELE: 0.98 cm), and muscle thickness difference of soleus (LWB+LLE: 0.43 cm; EWB+ELE: 0.36 cm). At post-52 weeks of surgery, no between-groups differences were found for cross-sectional area difference of gastrocnemius medialis (LWB+LLE: 1.99 cm; EWB+ELE: 1.50 cm) and gastrocnemius lateralis (LWB+LLE: 0.24 cm; EWB+ELE: 0.74 cm), and muscle thickness difference of soleus (LWB+LLE: 0.43 cm; EWB+ELE: 0.35 cm).	
Tendon Elongation/Length	2 RCT	very serious[b]	not serious	not serious	very serious[e]	Tendon elongation was presented by two studies (Aufwerber et al., 2020a; Eliasson et al., 2018). Eliasson et al. (2018) found no between-group differences for injured tendon elongation at post-6 (LWB+LLE: 0.35 mm; EWB+ELE: 0.90 mm), post-12 (LWB+LLE: 0.66 mm; EWB+ELE: 2.05 mm), post-26 (LWB+LLE: 0.75 mm; EWB+ELE: 4.04 mm), and post-52 (LWB+LLE: 0.67 mm; EWB+ELE: 3.97 mm) weeks of surgical repair. Aufwerber et al. (2020a), at 2 and 6 weeks postoperatively, found higher injured-contralateral difference of tendon length in EWB+ELE (at 2 weeks: 1.88 cm; at 6 weeks: 1.99 cm) than LWB+LLE (at 2 weeks: 0.71 cm; at 6 weeks: 1.54 cm) group. No between-group differences were found at post-24 (LWB+LLE: 1.79 cm; EWB+ELE: 1.73 cm), and post-52 (LWB+LLE: 1.57 cm; EWB+ELE: 1.65 cm) weeks of surgical repair.	⊕◯◯◯ Very low[b,e]
Time to return to work	3 RCT	serious[a]	serious[c]	not serious	very serious[e]	Time to return to work was reported by three studies (De la Fuente et al., 2016a; Eliasson et al., 2018; Groetelaers et al., 2014). Groetelaers et al. (2014) reported no between-group differences (median in LWB+LLE: 28 days; median in EWB+ELE: 28 days). De la Fuente et al. (2016a) found an earlier return to work with EWB+ELE (6.2 days) than LWB+LLE (11.1 days). Eliasson et al. (2018) found no between-group difference for time to return to work with	⊕◯◯◯ Very low[a,c,e]

Table 1. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						both rehabilitation approaches (LWB+LLE: 46 days; EWB+ELE: 37 days).	
Time to return to sport	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study presented the time to return to sport (Eliasson et al., 2018) and found no differences in the time to return to sport between the LWB+LLE (188 days) and EWB+ELE (184 days) rehabilitation approaches.	⊕◯◯◯ Very low[a,e]
Multi-item Scoring Scales	4 RCT	very serious[b]	serious[c]	not serious	very serious[e]	Three studies reported Achilles Tendon Rupture Score outcomes (Aufwerber et al., 2020c; De la Fuente et al., 2016a; Eliasson et al., 2018). De la Fuente et al. (2016a) found better Achilles Tendon Rupture Score outcomes in EWB+ELE than LWB+LLE at post-4 (LWB+LLE: 18.4 points; EWB+ELE: 38.3 points), post-8 (LWB+LLE: 39.5 points; EWB+ELE: 60.3 points), and post-12 (LWB+LLE: 64.3 points; EWB+ELE: 77.7 points) weeks of surgery. Eliasson et al. (2018) reported no between-group differences for Achilles Tendon Rupture Score outcomes at post-12 (LWB+LLE: 31 points; EWB+ELE: 33 points), post-26 (LWB+LLE: 52 points; EWB+ELE: 54 points), and post-52 (LWB+LLE: 77 points; EWB+ELE: 74 points) weeks of surgical repair. Aufwerber et al. (2020c) reported no between-group differences for Achilles Tendon Rupture Score outcomes at post-24 (LWB+LLE: 59.1 points; EWB+ELE: 65.1 points), and post-48 (LWB+LLE: 81.1 points; EWB+ELE: 80.3 points) weeks after surgery. One study reported the outcomes of Leppilahti Score (Groetelaers et al., 2014). The proportion of excellent/good rating in both groups were similar at post-3 (LWB+LLE: 39%; EWB+ELE: 29%), post-6 (LWB+LLE: 68%; EWB+ELE: 76%), and post-12 (LWB+LLE: 83%; EWB+ELE: 96%) months of surgery.	⊕◯◯◯ Very low[b,c,e]
Dorsiflexion Range of Motion	2 RCT	serious[a]	serious[c]	not serious	very serious[e]	Dorsiflexion ROM was presented by two studies (De la Fuente et al., 2016a; Eliasson et al., 2018). De la Fuente et al. (2016a) found no groups differences for dorsiflexion ROM on injured side at post-4 weeks of surgery (LWB+LLE: 16.7º; EWB+ELE: 16.7º), and higher dorsiflexion ROM were found on injured side of EWB+ELE than EWB+LLE group at post-8 (EWB+ELE: 18.0º; LWB+LLE: 17.5º) and post-12 (EWB+ELE: 20.9º; LWB+LLE: 17.8º) weeks of surgery. Eliasson et al. (2018) found no between-group differences for limb symmetry index of dorsiflexion ROM during weight bearing lunge test at post-26 (LWB+LLE: 65%; EWB+ELE: 65%) and post-52 (LWB+LLE: 80%; EWB+ELE: 72%) weeks of surgery.	⊕◯◯◯ Very low[a,c,e]

Table 1. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Plantar Flexion Range of Motion	1 RCT	very serious[b]	not serious	not serious	very serious[e]	One study reported plantar flexion ROM (Aufwerber et al., 2022). Aufwerber et al. (2022) evaluated the maximal plantar flexion ROM during bilateral and unilateral heel-rises. At post-8 weeks of surgery, there was no between-group differences for plantar flexion ROM during bilateral movements on contralateral (LWB+LLE: 23.6º; EWB+ELE: 20.4º) and injured (LWB+LLE: 18.7º; EWB+ELE: 16.8º) side. At post-24 weeks of surgery, no differences were found between rehabilitation approaches for plantar flexion ROM during bilateral heel-rises on contralateral (LWB+LLE: 28.9º; EWB+ELE: 25.9º) and injured (LWB+LLE: 23.5º; EWB+ELE: 22.3º) side. At 48 weeks postoperatively, no between-group differences were found for plantar flexion ROM during unilateral movements on contralateral (LWB+LLE: 25.2º; EWB+ELE: 23.6º) and injured (LWB+LLE: 15.2º; EWB+ELE: 13.1º) side.	⊕◯◯◯ Very low[b,e]
Isometric Plantar Flexion Strength	3 RCT	serious[a]	not serious	not serious	very serious[e]	Isometric plantar flexion strength was presented by three studies (De la Fuente et al., 2016b; Eliasson et al., 2018; Groetelaers et al., 2014). Groetelaers et al. (2014) found no groups differences for limb symmetry index of isometric plantar flexion (0º of dorsiflexion) at post-12 (LWB+LLE: 77%; EWB+ELE: 80%), post-24 (LWB+LLE: 87%; EWB+ELE: 87%), post-48 (LWB+LLE: 97%; EWB+ELE: 102%) weeks of surgical repair. De la Fuente et al. (2016b) found higher isometric plantar flexion strength (0º of dorsiflexion) on injured side in EWB+ELE (281.3 N) than LWB+LLE (162.5 N) group, at four weeks postoperatively. No between-group differences were found at post-8 (LWB+LLE: 345.7 N; EWB+ELE: 418.0 N), and post-12 (LWB+LLE: 455.0 N; EWB+ELE: 490.6 N) weeks of surgery. Eliasson et al. (2018) found no differences between rehabilitation approaches for limb symmetry index of isometric plantar flexion strength at post-26 (0º of dorsiflexion: LWB+LLE: 96%, EWB+ELE: 85%; 12º of dorsiflexion: LWB+LLE: 76%, EWB+ELE: 72%) and at post-52 (0º of dorsiflexion: LWB+LLE: 105%, EWB+ELE 97%; 12º of dorsiflexion: LWB+LLE: 85%, EWB+ELE: 88%) weeks of surgical repair.	⊕◯◯◯ Very low[a,e]
Heel-rise height	2 RCT	very serious[b]	not serious	not serious	very serious[e]	Height during heel-rise test were presented by two studies (Aufwerber et al., 2020c; Eliasson et al., 2018). Eliasson et al. (2018) reported no between-group differences for limb symmetry index of heel-rise height at post-26 (LWB+LLE: 68%; EWB+ELE: 61%), and post-52 (LWB+LLE: 79%; EWB+ELE: 76%) weeks of surgical repair. Similarly, Aufwerber et al. (2020c) found no groups differences for limb symmetry index of heel-rise height at post-24 (LWB+LLE: 73.3%; EWB+ELE: 72.3%), and post-48 (LWB+LLE: 83.4%; EWB+ELE:	⊕◯◯◯ Very low[b,e]

Table 1. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						79.2%) weeks of surgical repair.	
Heel-rise number	2 RCT	very serious[b]	serious[c]	not serious	very serious[e]	Two studies presented the number of movements during the heel-rise test (Aufwerber et al., 2020c; De la Fuente et al., 2016a). De la Fuente (2016a) reported smaller injured-contralateral side difference of repetitions in EWB+ELE (33.7 repetitions) than LWB+LLE (16.0 repetitions) groups after 12 weeks of surgery. Aufwerber et al. (2020c) found no between-group differences for limb symmetry index of heel-rise repetitions at post-24 (LWB+LLE: 80.0%; EWB+ELE: 80.3%), and post-48 (LWB+LLE: 95.3%; EWB+ELE: 92.6%) weeks of surgery.	⊕◯◯◯ Very low[b,c,e]
Heel-rise work	2 RCT	very serious[b]	not serious	not serious	very serious[e]	Total work during the heel-rise test was presented by two studies (Aufwerber et al., 2020c; Eliasson et al., 2018). Eliasson et al. (2018) found no between-group differences for limb symmetry index of heel-rise work at post-26 (LWB+LLE: 44%; EWB+ELE: 44%), and post-52 (LWB+LLE: 70%; EWB+ELE: 63%) weeks of surgery. Similarly, Aufwerber et al. (2020c) found no between-group differences for limb symmetry index of heel-rise work at post-24 (LWB+LLE: 58.6%; EWB+ELE: 58.6%), and post-48 (LWB+LLE: 77.7%; EWB+ELE: 74.4%) weeks of surgical repair.	⊕◯◯◯ Very low[b,e]

Explanations: a: studies with some concerns in RoB-2 analysis; b: studies with high risk of bias in RoB-2 analysis; c: some inconsistency was present (at least one study presented divergent directions of effect); d: severe inconsistency was present (two or more studies present divergent direction of effects); f: high imprecision (sample size smaller than 300 [dichotomous outcomes] and 400 [continuous outcomes]) following a “rule of thumb” presented by Ryan and Hill (2016).

Table 2. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+ELE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Re-rupture	3 RCT	serious[a]	serious[c]	not serious	very serious[e]	Re-rupture rate was reported by three studies (Eliasson et al., 2018; Hoeffner et al., 2024; Suchak et al., 2008). While two (Hoeffner et al., 2024; Suchak et al., 2008) reported no re-ruptures in both groups of rehabilitation, one (Eliasson et al., 2018) observed two re-ruptures in LWB+ELE group only (2/23; 8.7%).	⊕◯◯◯ Very low[a,e]
Major and Minor Complications	3 RCT	serious[a]	not serious	not serious	very serious[e]	Major complications occurrence was presented by three studies (Deng et al., 2022; Hoeffner et al., 2024; Suchak et al., 2008), which found similar number of complications in both groups (LWB+ELE: 0-12%; EWB+ELE: 15-17%). One study reported the occurrence of minor complications (Suchak et al., 2008), with similar rates of complications in LWB+ELE (9/55; 16.4%) and EWB+ELE (8/55; 14.5%) group.	⊕◯◯◯ Very low[a,e]
Calf's Muscle Mass	2 RCT	serious[a]	not serious	not serious	very serious[e]	Two studies reported outcomes on the calf's muscle mass/loss (Eliasson et al., 2018; Hoeffner et al., 2024). Eliasson et al. (2018) found no groups differences on injured side cross-sectional area of gastrocnemius medialis (LWB+ELE: 10.9 mm; EWB+ELE: 11.8 mm), gastrocnemius lateralis (LWB+ELE: 5.2 mm; EWB+ELE: 5.4 mm), and soleus (LWB+ELE: 21.7 mm; EWB+ELE: 24.5 mm) at 6 weeks postoperatively. At post-26 weeks of surgery, no groups differences were reported on injured side cross-sectional area of gastrocnemius medialis (LWB+ELE: 13.3 mm; EWB+ELE: 12.8 mm), gastrocnemius lateralis (LWB+ELE: 6.6 mm; EWB+ELE: 6.4 mm), and soleus (LWB+ELE: 21.3 mm; EWB+ELE: 23.2 mm). At post-52 weeks of surgery, no group differences were found in cross-sectional area of gastrocnemius medialis (LWB+ELE: 14.0 mm; EWB+ELE: 13.2 mm), gastrocnemius lateralis (LWB+ELE: 6.0 mm; EWB+ELE: 6.6 mm), and soleus (LWB+ELE: 22.8 mm; EWB+ELE: 23.0 mm) on the injured side. Hoeffner et al. (2024) found no between-group differences on injured side for muscle thickness of gastrocnemius medialis (LWB+ELE: 16.4 mm; EWB+ELE: 16.1 mm), and cross-sectional area of gastrocnemius lateralis (LWB+ELE: 564 mm; EWB+ELE: 483 mm) and soleus (LWB+ELE: 2339 mm; EWB+ELE: 2369 mm) after 12 weeks of surgical repair. At post-26 weeks of surgery, no groups differences were found on injured side for muscle thickness of gastrocnemius medialis (LWB+ELE: 17.8 mm; EWB+ELE: 17.7 mm), and cross-sectional area of gastrocnemius lateralis (LWB+ELE: 658 mm; EWB+ELE: 618 mm) and soleus (LWB+ELE: 2521 mm; EWB+ELE: 2422 mm). At post-52 weeks of surgery, no groups differences were found on injured side for muscle thickness of gastrocnemius medialis (LWB+ELE: 18.1 mm; EWB+ELE: 18.1 mm), and cross-sectional area of gastrocnemius lateralis (LWB+ELE: 754 mm; EWB+ELE: 670 mm) and soleus (LWB+ELE: 1374 mm; EWB+ELE: 1399 mm).	⊕◯◯◯ Very low[a,e]

Table 2. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+ELE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Tendon Elongation/Length	3 RCT	serious[a]	not serious	not serious	very serious[e]	Tendon elongation was presented by three studies (Agres et al., 2018; Eliasson et al., 2018; Hoeffner et al., 2024). Agres et al. (2018) reported no groups differences for injured tendon length at post-8 (LWB+ELE: 203.3 mm; EWB+ELE: 206.9 mm), and post-12 (LWB+ELE: 204.8 mm; EWB+ELE: 202.6 mm). Eliasson et al. (2018) found no between-group differences for injured tendon elongation at post-6 (LWB+ELE: 0.53 mm; EWB+ELE: 0.90 mm), post-12 (LWB+ELE: 1.36 mm; EWB+ELE: 2.05 mm), post-26 (LWB+ELE: 2.70 mm; EWB+ELE: 4.04 mm), and post-52 (LWB+ELE: 2.58 mm; EWB+ELE: 3.97 mm) weeks of surgical repair. Hoeffner et al. (2024) found no differences for groups comparison, on injured side, for tendon length of gastrocnemius part at post-1 (LWB+ELE: 191.9 mm; EWB+ELE: 189.7 mm), post-12 (LWB+ELE: 198.5 mm; EWB+ELE: 193.8 mm), post-26 (LWB+ELE: 201.3 mm; EWB+ELE: 198.0 mm), and post-52 (LWB+ELE: 202.7 mm; EWB+ELE: 199.4 mm) weeks of surgery. Moreover, the authors reported no between-group differences, on injured side, for tendon length of soleus part at post-1 (LWB+ELE: 67.7 mm; EWB+ELE: 68.8 mm), post-12 (LWB+ELE: 66.9 mm; EWB+ELE: 67.7 mm), post-26 (LWB+ELE: 71.3 mm; EWB+ELE: 74.7 mm), and post-52 (LWB+ELE: 71.2 mm; EWB+ELE: 74.0 mm) weeks of surgery.	⊕◯◯◯ Very low[a,e]
Time to return to work	2 RCT	serious[a]	serious[c]	not serious	very serious[e]	Two studies presented the time to return to work (Deng et al., 2022; Eliasson et al., 2018). Eliasson et al. (2018) reported no between-group differences (LWB+ELE: 44 days; EWB+ELE: 39 days). Deng et al. (2022) found an earlier return to work using EWB+ELE (31.5 days) than LWB+ELE (52.5 days) rehabilitation approach.	⊕◯◯◯ Very low[a,c,e]
Time to return to sport	3 RCT	serious[a]	serious[c]	not serious	very serious[e]	Three studies presented the time to return to sport (Deng et al., 2022; Eliasson et al., 2018; Porter and Shadbolt, 2015). Porter and Shadbolt (2015) reported an earlier return to running with EWB+ELE (120.6 days) than LWB+ELE (147.6 days) rehabilitation approach. Eliasson et al. (2018) found no groups differences (LWB+ELE: 170 days; EWB+ELE: 184 days), as well as Deng et al. (2022) that reported no differences in the time to return to sport (LWB+ELE: 146.3 days; EWB+ELE: 135.1 days).	⊕◯◯◯ Very low[a,c,e]
Multi-item Scoring Scales	5 RCT	serious[a]	serious[c]	not serious	very serious[e]	Achilles Tendon Rupture Score outcomes were presented by four studies (Deng et al., 2022; Eliasson et al., 2018; Hoeffner et al., 2024; Porter and Shadbolt, 2015). Porter and Shadbolt (2015) found no difference between rehabilitation approaches (LWB+ELE: 87.1 points; EWB+ELE: 87.5 points) at post-38 weeks of surgery. Eliasson et al. (2018) reported no between-group differences at post-12 (LWB+ELE: 36 points; EWB+ELE: 33 points), post-26 (LWB+ELE: 65 points; EWB+ELE: 54 points), and post-52 (LWB+ELE: 79	⊕◯◯◯ Very low[a,c,e]

Table 2. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+ELE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						points; EWB+ELE: 74 points) weeks of surgery. Deng et al. (2022) found better Achilles Tendon Rupture Score outcomes after 12 weeks postoperatively with EWB+ELE (91.1 points) than LWB+ELE (88.9 points) rehabilitation approach. No between-group differences were reported at post-24 (LWB+ELE: 92.8 points; EWB+ELE: 93.3 points), and post-48 (LWB+ELE: 96.8 points; EWB+ELE: 97.3 points) weeks of surgery. Hoeffner et al. (2024) reported no groups differences in Achilles Tendon Rupture Score (LWB+ELE: 72 points; EWB+ELE: 60 points) at post-52 weeks of surgery. One study reported the $AOFAS_{AHS}$ outcomes (Deng et al., 2022). At post-3 months of surgery, the EWB+ELE group (92.4 points) presented better results than EWB+ELE group (88.3 points). No between-group differences were found at post-6 (LWB+ELE: 93.9 points; EWB+ELE: 95.4 points), and post-12 (LWB+ELE: 97.5 points; EWB+ELE: 98.2 points) months of surgical repair.	
Dorsiflexion Range of Motion	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported the dorsiflexion ROM (Eliasson et al., 2018) and found no groups differences for limb symmetry index evaluated during weight bearing lunge test at post-26 (LWB+ELE: 58%; EWB+ELE: 65%) and post-52 (LWB+ELE: 74%; EWB+ELE: 72%) weeks of surgery.	⊕◯◯◯ Very low[a,e]
Isometric Plantar Flexion Strength	3 RCT	serious[a]	not serious	not serious	very serious[e]	Three studies reported the isometric plantar flexion strength (Agres et al., 2018; Eliasson et al., 2018; Hoeffner et al., 2024). Agres et al. (2018) found no groups differences for isometric plantar flexion torque (0º of dorsiflexion) on both sides at post-8 (contralateral side: LWB+ELE: 137.6 Nm, EWB+ELE: 122.1 Nm; injured side: LWB+ELE: 56.3 Nm, EWB+ELE: 51.5 Nm), and at post-12 (contralateral side: LWB+ELE: 133.1 Nm, EWB+ELE: 120.0 Nm; injured side: LWB+ELE: 72.6 Nm, EWB+ELE: 83.4 Nm) weeks of surgery. Eliasson et al. (2018) found no differences between rehabilitation approaches for limb symmetry index of isometric plantar flexion strength at post-26 (0º of dorsiflexion: LWB+ELE: 87%, EWB+ELE: 85%; 12º of dorsiflexion: LWB+ELE: 70%, EWB+ELE: 72%) and at post-52 (0º of dorsiflexion: LWB+ELE: 92%, EWB+ELE 97%; 12º of dorsiflexion: LWB+ELE: 83%, EWB+ELE: 88%) weeks of surgical repair. Hoeffner et al. (2024) reported no groups differences for deficit of isometric plantar flexion at -10º (LWB+ELE: -10%; EWB+ELE: -11%), 0º (LWB+ELE: -11%; EWB+ELE: -12%), 10º (LWB+ELE: -13%; EWB+ELE: -18%), and 20º (LWB+ELE: -20%; EWB+ELE: -25%) of dorsiflexion, at 52 weeks postoperatively.	⊕◯◯◯ Very low[a,e]
Heel-rise height	3 RCT	serious[a]	serious[c]	not serious	very serious[e]	Height during heel-rise test were presented by three studies (Eliasson et al., 2018; Hoeffner et al., 2024; Porter and Shadbolt, 2015). Porter and Shadbolt (2015) found a less difference between the heel-rise height on injured and	⊕◯◯◯ Very low[a,c,e]

Table 2. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+ELE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						contralateral side in EWB+ELE (0.3 cm) than LWB+ELE (1.0 cm) group, at post-48 weeks of surgery. Eliasson et al. (2018) reported no between-group differences for limb symmetry index of heel-rise height at post-26 (LWB+ELE: 69%; EWB+ELE: 61%), and post-52 (LWB+ELE: 84%; EWB+ELE: 76%) weeks of surgical repair. Similarly, Hoeffner et al. (2024) found no groups differences for heel-rise height on both sides at post-26 (contralateral side: LWB+ELE: 11.5 cm, EWB+ELE: 12.0 cm; injured side: LWB+ELE: 7.6 cm, EWB+ELE: 8.2 cm), and post-52 (contralateral side: LWB+ELE: 11.8 cm, EWB+ELE: 12.4 cm; injured side: LWB+ELE: 9.7 cm, EWB+ELE: 10.2 cm) weeks of surgery.	
Heel-rise number	1 RCT	not serious	not serious	not serious	very serious[e]	One study reported the repetitions during the heel-rise test (Hoeffner et al., 2024). There were no between-group differences on both sides at post-26 (contralateral side: LWB+ELE: 29.5 repetitions, EWB+ELE: 26.2 repetitions; injured side: LWB+ELE: 17.5 repetitions, EWB+ELE: 18.3 repetitions), and post-52 (contralateral side: LWB+ELE: 30.5 repetitions, EWB+ELE: 26.6 repetitions; injured side: LWB+ELE: 25.5 repetitions, EWB+ELE: 24.4 repetitions) weeks of surgery.	⊕⊕◯◯ Low[e]
Heel-rise work	2 RCT	serious[a]	not serious	not serious	very serious[e]	Two studies (Eliasson et al., 2018; Hoeffner et al., 2024) presented the total work during the heel-rise test. Eliasson et al. (2018) reported no between-group differences for limb symmetry index of heel-rise work at post-26 (LWB+ELE: 52%; EWB+ELE: 44%), and post-52 (LWB+ELE: 67%; EWB+ELE: 63%) weeks of surgery. Hoeffner et al. (2024) found no groups differences for heel-rise total work on both sides at post-26 (contralateral side: LWB+ELE: 2277.8 J, EWB+ELE: 1989.2 J; injured side: LWB+ELE: 948.9 J, EWB+ELE: 948.9 J), and post-52 (contralateral side: LWB+ELE: 2429.0 J, EWB+ELE: 2101.3 J; injured side: LWB+ELE: 1709.4 J, EWB+ELE: 1584.1 J) weeks of surgical repair.	⊕◯◯◯ Very low[a,e]

Explanations: a: studies with some concerns in RoB-2 analysis; b: studies with high risk of bias in RoB-2 analysis; c: some inconsistency was present (at least one study presented divergent directions of effect); d: severe inconsistency was present (two or more studies present divergent direction of effects); f: high imprecision (sample size smaller than 300 [dichotomous outcomes] and 400 [continuous outcomes]) following a “rule of thumb” presented by Ryan and Hill (2016).

Table 3A. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and LWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Re-rupture	2 RCT	serious[a]	not serious	not serious	very serious[e]	Re-rupture rate was reported by two studies (Eliasson et al., 2018; Kangas et al., 2003), which registered this event in 0-4% and 8-9% of participants in LWB+LLE and LWB+ELE approach, respectively.	⊕◯◯◯ Very low[a,e]
Calf's Muscle Mass	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported outcomes of calf's muscle mass/loss (Eliasson et al., 2018). At post-6 weeks of surgery, the authors found no between-group differences on injured side cross-sectional area of gastrocnemius medialis (LWB+LLE: 12.4 mm; LWB+ELE: 10.9 mm), gastrocnemius lateralis (LWB+LLE: 5.5 mm; LWB+ELE: 5.2 mm), and soleus (LWB+LLE: 25.0 mm; LWB+ELE: 21.7 mm). At post-26 weeks of surgery, no group differences of the cross-sectional area of gastrocnemius medialis (LWB+LLE: 12.8 mm; LWB+ELE: 13.3 mm), gastrocnemius lateralis (LWB+LLE: 6.0 mm; LWB+ELE: 6.6 mm), and soleus (LWB+LLE: 22.4 mm; LWB+ELE: 21.3 mm) were reported by authors. Similarly, no differences were found at post-52 weeks of surgery in cross-sectional area of gastrocnemius medialis (LWB+LLE: 13.1 mm; LWB+ELE: 14.0 mm), gastrocnemius lateralis (LWB+LLE: 6.2 mm; LWB+ELE: 6.0 mm), and soleus (LWB+LLE: 23.1 mm; LWB+ELE: 22.8 mm) on the injured side.	⊕◯◯◯ Very low[a,e]
Tendon Elongation/Length	2 RCT	serious[a]	not serious	not serious	very serious[e]	Tendon elongation was reported by two studies (Eliasson et al., 2018; Kangas et al., 2007). Kangas et al. (2007) reported no between-group differences for tendon elongation at post-1 (median: LWB+LLE: 4.5 mm, LWB+ELE: 1.0 mm), post-3 (median: LWB+LLE: 8.0 mm, LWB+ELE: 5.0 mm), post-6 (median: LWB+LLE: 7.0 mm, LWB+ELE: 7.5 mm), and post-24 (median: LWB+LLE: 5.0 mm, LWB+ELE: 4.0 mm) weeks of surgery. At a mean of 60 weeks after surgery, similar tendon elongation was reported in LWB+ELE (median: 2.0 mm) than LWB+LLE (median: 5.0 mm) group. Eliasson et al. (2018) reported no groups difference for tendon elongation on injured side at post-6 (LWB+LLE: 0.35 mm; LWB+ELE: 0.53 mm), post-12 (LWB+LLE: 0.66 mm; LWB+ELE: 1.36 mm), post-26 (LWB+LLE: 0.75 mm; LWB+ELE: 2.70 mm), and post-52 (LWB+LLE: 0.67 mm; LWB+ELE: 2.58 mm) weeks of surgery.	⊕◯◯◯ Very low[a,e]
Time to return to work and sport	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported the time to return to previous activities (Eliasson et al., 2018), which found no between-group differences for time to return to work (LWB+LLE: 46 days; LWB+ELE: 44 days) and sport (LWB+LLE: 188 days; LWB+ELE: 170 days).	⊕◯◯◯ Very low[a,e]
Multi-item Scoring Scales	3 RCT	serious[a]	not serious	not serious	very serious[e]	Achilles Tendon Rupture Score outcome was presented by one study (Eliasson et al., 2018), which reported no between-group differences at post-12 (LWB+LLE: 31 points; LWB+ELE: 36 points), post-26 (LWB+LLE: 52 points; LWB+ELE: 65 points), and post-	⊕◯◯◯ Very low[a,e]

Table 3A. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and LWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						52 (LWB+LLE: 77 points; LWB+ELE: 79 points) weeks of surgery. Outcomes evaluated using Leppilahti Score were presented by two studies (Kangas et al., 2003; Lantto et al., 2015a). There were no between-group differences at 15 months (LWB+LLE: 92% excellent/good outcomes; LWB+ELE: 88% excellent/good outcomes) (Kangas et al., 2003) and at 11 years (LWB+LLE: 78% excellent outcomes; LWB+ELE: 84% excellent outcomes) (Lantto et al., 2015a) after surgical repair.	
Dorsiflexion Range of Motion	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported the dorsiflexion ROM (Eliasson et al., 2018). The authors found no between-group differences for limb symmetry index during weight bearing lunge test at post-26 (LWB+LLE: 65%; LWB+ELE: 58%) and post-52 (LWB+LLE: 80%; LWB+ELE: 74%) weeks of surgery.	⊕◯◯◯ Very low[a,e]
Isometric Plantar Flexion Strength	3 RCT	serious[a]	not serious	not serious	very serious[e]	Isometric plantar flexion strength deficit was presented by three studies (Eliasson et al., 2018; Kangas et al., 2003; Lantto et al., 2015a). Kangas et al. (2003) found no differences between rehabilitation approaches for deficits of isometric plantar flexion (0º of dorsiflexion) at post-12 weeks after the surgical repair (LWB+LLE: 24.1%, LWB+ELE: 25.2%) and at a mean of 60 weeks postoperatively (LWB+LLE: 14.4%, LWB+ELE: 5.6%). Lantto et al. (2015) reported no between-group differences for limb symmetry index of isometric plantar flexion (0º of dorsiflexion) at post-11 years of surgery (LWB+LLE: 141.2%, LWB+ELE: 133.2%). Eliasson et al. (2018) found no groups differences for limb symmetry index of isometric plantar flexion strength at post-26 (0º of dorsiflexion: LWB+LLE: 96%, LWB+ELE: 87%; 12º of dorsiflexion: LWB+LLE: 76%, LWB+ELE: 70%) and at post-52 (0º of dorsiflexion: LWB+LLE: 105%, LWB+ELE: 92%; 12º of dorsiflexion: LWB+LLE: 85%, LWB+ELE: 83%) weeks of surgical repair.	⊕◯◯◯ Very low[a,e]
Heel-rise height, number, work	1 RCT	serious[a]	not serious	not serious	very serious[e]	Height and total work during heel-rise test was reported by one study (Eliasson et al., 2018). The authors found no between-group differences for limb symmetry index of height and work at post-26 (height: LWB+LLE: 68%, LWB+ELE: 69%; work: LWB+LLE: 44%, LWB+ELE: 52%) and at post-52 (height: LWB+LLE: 79%; LWB+ELE: 84%; work: LWB+LLE: 70%, LWB+ELE: 67%) weeks of surgery.	⊕◯◯◯ Very low[a,e]

a: studies with some concerns in RoB-2 analysis; b: studies with high risk of bias in RoB-2 analysis; c: some inconsistency was present (at least one study presented divergent directions of effect); d: severe inconsistency was present (two or more studies present divergent direction of effects); f: high imprecision (sample size smaller than 300 [dichotomous outcomes] and 400 [continuous outcomes]) following a "rule of thumb" presented by Ryan and Hill (2016).

Table 3B. Summary of findings of rehabilitation comparisons based on LWB+LLE vs LWB+ELE.

Outcome	No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Summary effect (95% CI)	Certainty
Re-rupture	2	RCT	serious[a]	not serious	not serious	very serious[b]	OR: 0.32 (0.05 to 2.19)	⊕◯◯◯ Very low[a,c]

LLE: late lower limb exercises; ELE: early lower limb exercises; LWB: late weightbearing; RCT: randomized controlled trails; CI: confidence interval; OR: odds ratio; SMD: standardized mean difference; ATRS: Achilles Tendon Rupture Score. Explanations: a: Studies with potential sources of some concerns in risk of bias; b: Very low statistical power achieved ($1-\beta<0.50$).

Table 4. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+LLE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Re-rupture	2 RCT	serious[a]	not serious	not serious	very serious[e]	Re-rupture rate was presented by two studies (Costa et al., 2006; Okoroha et al., 2020) with similar occurrence of re-ruptures between rehabilitation approaches (LWB+LLE: 0-4%; EWB+LLE: 0-8%).	⊕◯◯◯ Very low[a,e]
Major and Minor Complications	2 RCT	serious[a]	not serious	not serious	very serious[e]	Two studies reported the major and minor complications occurrence (Costa et al., 2006; Okoroha et al., 2020). Costa et al. (2006) found similar occurrence of major complications (LWB+LLE: 8%; EWB+LLE: 4%) and minor complications (LWB+LLE: 20%; EWB+LLE: 26%) in both groups. Okoroha et al. (2020) registered no complications in either group.	⊕◯◯◯ Very low[a,e]
Calf's Muscle Mass	1 RCT	serious[a]	not serious	not serious	very serious[e]	Calf's muscle mass was reported by one study (Costa et al., 2006), which found no between-group difference for injured-contralateral side difference of calf diameter (LWB+LLE: 0.73 mm, EWB+LLE: 1.47 mm) after 24 weeks postoperatively.	⊕◯◯◯ Very low[a,e]
Tendon Elongation/Length	1 RCT	serious[a]	not serious	not serious	very serious[e]	Tendon elongation was reported by one study (Okoroha et al., 2020). Okoroha et al. (2020) reported no groups differences for injured tendon elongation at post-0 to 2 (LWB+LLE: 7.3 mm; EWB+LLE: 4.8 mm), post-2 to 6 (LWB+LLE: 8.4 mm; EWB+LLE: 9.2 mm), and post-6 to 12 (LWB+LLE: -0.4 mm; LWB+LLE: 2.4 mm) weeks of surgery. Moreover, no differences in overall tendon elongation were found between LWB+LLE (15.3 mm) and EWB+LLE (16.4 mm) groups, from 0 to 12 weeks of surgery.	⊕◯◯◯ Very low[a,e]
Time to return to work and sport	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study presented the time to return to work and sport (Costa et al., 2006). The authors found no differences for time to return to work using rehabilitation approaches based on LWB+LLE (median: 28 days) or EWB+LLE (median: 56 days). Similarly, the time to return to sport did not differ between rehabilitation approaches (median: LWB+LLE: 182 days, EWB+LLE: 273 days).	⊕◯◯◯ Very low[a,e]
Multi-item Scoring Scales	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported Achilles Tendon Rupture Score outcomes (Okoroha et al., 2020), which found no groups differences at 12 weeks postoperatively (LWB+LLE: 80.5 points; EWB+LLE: 85.4 points).	⊕◯◯◯ Very low[a,e]
Dorsiflexion Range of Motion	2 RCT	serious[a]	not serious	not serious	very serious[e]	Two studies presented dorsiflexion ROM outcomes (Costa et al., 2006; Okoroha et al., 2020). Costa et al. (2006) reported no differences between rehabilitation approaches for injured-contralateral side difference of dorsiflexion ROM at 42 weeks postoperatively (LWB+LLE: 3.0º; EWB+LLE: 1.8º). Okoroha	⊕◯◯◯ Very low[a,e]

Table 4. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on LWB+LLE and EWB+LLE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
						et al. (2020) reported no groups differences in dorsiflexion ROM on injured side after 12 weeks of surgery (LWB+LLE: 15.7º; EWB+LLE: 12.5º).	
Plantar Flexion Range of Motion	2 RCT	serious[a]	not serious	not serious	very serious[e]	Two studies presented plantar flexion ROM outcomes (Costa et al., 2006; Okoroha et al., 2020). Costa et al. (2006) found no between-group differences for injured-contralateral side difference of plantar flexion ROM at 24 weeks postoperatively (LWB+LLE: 2.4º; EWB+LLE: 0.6º). Okoroha et al. (2020) reported no differences between rehabilitation approaches for plantar flexion ROM on injured side after 12 weeks of surgical repair (LWB+LLE: 28.5º; EWB+LLE: 33.3º).	⊕◯◯◯ Very low[a,e]

a: studies with some concerns in RoB-2 analysis; b: studies with high risk of bias in RoB-2 analysis; c: some inconsistency was present (at least one study presented divergent directions of effect); d: severe inconsistency was present (two or more studies present divergent direction of effects); f: high imprecision (sample size smaller than 300 [dichotomous outcomes] and 400 [continuous outcomes]) following a “rule of thumb” presented by Ryan and Hill (2016).

Table 5. Narrative synthesis of clinical and functional outcomes of rehabilitation approaches based on EWB+LLE and EWB+ELE.

Outcomes	Studies No./Design	Risk of bias	Inconsistency	Indirectness	Imprecision	Narrative Synthesis	Certainty
Re-rupture and Major and Minor Complications	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study reported the re-rupture and major complications events (Schepull and Aspenberg, 2013). The authors reported a total of three re-ruptures in EWB+LLE (2/17; 11.8%) and EWB+LLE (1/18; 5.6%) group. A total of four major complications (i.e., deep venous thrombosis) occurred in EWB+LLE (2/17; 11.8%) and EWB+LLE (2/18; 11.1%) group.	⊕◯◯◯ Very low[a,e]
Multi-item Scoring Scales	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study presented the Achilles Tendon Rupture Score outcomes (Schepull and Aspenberg, 2013). The authors found no differences between EWB+LLE (median: 91 points) and EWB+LLE (median: 91.5 points) rehabilitation approaches, at post-12 months of surgery.	⊕◯◯◯ Very low[a,e]
Heel-rise height and number	1 RCT	serious[a]	not serious	not serious	very serious[e]	One study presented the performance of height and total number of repetitions during heel-rise test (Schepull and Aspenberg, 2013). At post-12 months of surgery, no between-group differences were found for height (contralateral side: EWB+LLE: 10 cm, EWB+LLE: 11 cm; injured side: EWB+LLE: 8 cm, EWB+ELE: 8 cm) and number of movements (contralateral side: EWB+LLE: 47 repetitions, EWB+ELE: 55 repetitions; injured side: EWB+LLE: 35 repetitions, EWB+ELE: 36 repetitions) during the heel-rise test.	⊕◯◯◯ Very low[a,e]

a: studies with some concerns in RoB-2 analysis; b: studies with high risk of bias in RoB-2 analysis; c: some inconsistency was present (at least one study presented divergent directions of effect); d: severe inconsistency was present (two or more studies present divergent direction of effects); f: high imprecision (sample size smaller than 300 [dichotomous outcomes] and 400 [continuous outcomes]) following a “rule of thumb” presented by Ryan and Hill (2016).

Chapter III – Better Clinical and Functional Outcomes with Early vs. Conservative Rehabilitation Following Achilles Tendon Repair: A Controlled Trial

Appendix 3A

Approval of the research ethics committee – UFRGS

UFRGS UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

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PRÓ-REITORIA DE PESQUISA
COMITÊ DE ÉTICA EM PESQUISA
CARTA DE APROVAÇÃO

O Comitê de Ética em Pesquisa da Universidade Federal do Rio Grande do Sul analisou o projeto:

Número : 2007879

Título : Tratamento cirúrgico da ruptura aguda do tendão de Aquiles:estudo comparativo entre dois protocolos de reabilitação

Pesquisador (es) :

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O mesmo foi aprovado pelo Comitê de Ética em Pesquisa da UFRGS, reunião nº 31 , ata nº 111 , de 24/07/2008 , por estar adequado ética e metodologicamente e de acordo com a Resolução 196/96 e complementares do Conselho Nacional de Saúde.

Porto Alegre, quarta-feira, 30 de julho de 2008

ILMA SIMONI BRUM DA SILVA
Coordenador do CEP-UFRGS

Approval of the research ethics committee – PUCRS

Pontifícia Universidade Católica do Rio Grande do Sul
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO
COMITÊ DE ÉTICA EM PESQUISA

Ofício 220/08-CEP

Porto Alegre, 13 de março de 2008.

Senhor(a) Pesquisador(a)

O Comitê de Ética em Pesquisa da PUCRS apreciou e aprovou seu protocolo de pesquisa registro CEP 07/04008, intitulado: **"Tratamento cirúrgico da ruptura aguda do tendão de aquiles: estudo comparativo entre dois protocolos de reabilitação".**

Sua investigação está autorizada a partir da presente data.

Relatórios parciais e final da pesquisa devem ser entregues a este CEP.

Atenciosamente,

Prof. Dr. José Roberto Goldim
COORDENADOR DO CEP-PUCRS

Ilmo(a) Sr(a)
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Appendix 3B

Early Rehabilitation Program:

Extended Spreadsheet of Early Rehabilitation:

Postoperative week	1	2	3	4	5	6	7	8
Immobilizing	Plaster splint (EP)	Plaster splint (EP)	Removable brace (0º DF)	Removable brace (0º DF)	Removable brace (0º DF)	Removable brace (0º DF)	Removable brace (0º DF)	Removable brace (0º DF)
Weight bearing	Non-WB	Non-WB	Partial WB	Partial WB	Total WB	Total WB	Total WB	Total WB
Exercises*			Ankle ROM Foot strengthening Hip strengthening Gait training	Ankle ROM Foot strengthening Hip strengthening Gait training	Ankle ROM Foot strengthening Hip strengthening Gait training Knee strengthening	Ankle ROM Foot strengthening Hip strengthening Gait training Knee strengthening Ankle strengthening	Ankle ROM Ankle strengthening Knee strengthening	Ankle ROM Ankle strengthening Knee strengthening
Exercises progression*	-	-	Volume and complexity		Volume, load, and complexity		Volume and load	
Goal	Surgical repair healing		Facilitation of daily activities		Improve the calf-ankle range of motion and whole-leg muscle resistance		Improve calf-ankle complex function	
Rationale	Immobilizing to enable the healing of tendon repair		Improve calf-ankle function and muscle resistance by controlled range of motion, partial weight-bearing and low-load strengthening exercises		Introduction of controlled overload by increasing the intensity of weight-bearing and strengthening exercises		Improve the ankle range of motion and muscle resistance by the increment in intensity and complexity of exercises	

EP: equinus position; DF: dorsiflexion; WB: weight bearing; ROM: range of motion; *: exercises application and progression were detailed described on “Appendix 2: Descriptors of exercises”.

Descriptors of Early Rehabilitation Program:

Postoperative week 3:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
H1	Hip abduction	A	2	15	NC	-	PSR
H2	Hip flexion	A	2	15	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	P	2	15	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	A	2	15	NC	-	PSR
A1	Ankle eversion-inversion	P	2	15	NC	-	PSR
A1	Ankle eversion-inversion	A	2	15	NC	-	PSR
A2	Ankle plantar flexion	P	2	15	NC	-	PSR
A3	Ankle dorsiflexion	P	2	15	NC	-	PSR
A4	Ankle dorsi-plantar flexion	A	2	15	NC	-	PSR
G1	Gait training with partial support (three-point gait)	-	-	-	-	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Postoperative week 4:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
H1	Hip abduction	A	3	15	NC	-	PSR
H2	Hip flexion	A	3	15	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	P	3	15	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	A	3	15	NC	-	PSR
A1	Ankle eversion-inversion	P	2	15	NC	-	PSR
A1	Ankle eversion-inversion	A	2	15	NC	-	PSR
A2	Ankle plantar flexion	P	2	15	NC	-	PSR
A3	Ankle dorsiflexion	P	2	15	NC	-	PSR
A4	Ankle dorsi-plantar flexion	A	2	15	NC	-	PSR
G2	Gait training with partial support (two-point gait)	-	-	-	-	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Postoperative week 5:

ID	Exercise	Mode	Sets	Repetitions[1]	Cadence[2]	Load	Interval[3]
H1	Hip abduction	A	3	20	NC	-	PSR
H2	Hip flexion	A	3	20	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	P	3	20	NC	-	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	A	3	20	NC	-	PSR
A1	Ankle eversion-inversion	P	2	20	NC	-	PSR
A1	Ankle eversion-inversion	A	2	20	NC	-	PSR
A2	Ankle plantar flexion	P	2	20	NC	-	PSR
A3	Ankle dorsiflexion	P	2	20	NC	-	PSR
A4	Ankle dorsi-plantar flexion	A	2	15	NC	-	PSR
A5	Stretching for dorsi-plantar flexors	P	3	20”	NC	-	PSR
K1	Knee flexion	A	2	15	NC	-	PSR
G3	Gait training with full support (with crutches)	-	-	-	-	-	-
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Postoperative week 6:

ID	Exercise	Mode	Sets	Repetitions[1]	Cadence[2]	Load	Interval[3]
H1	Hip abduction	A	3	20	NC	1 Kg	PSR
H2	Hip flexion	A	3	20	NC	1 Kg	PSR
F1	Metatarsal-phalangeal and interphalangeal joints flexion and extension	A	3	20	NC	-	PSR
A1	Ankle eversion-inversion	P	2	20	NC	-	PSR
A2	Ankle plantar flexion	P	2	20	NC	-	PSR
A3	Ankle dorsiflexion	P	2	20	NC	-	PSR
A6	Rubber band ankle eversion	A	2	15	NC	5% BW	PSR
A7	Rubber band ankle inversion	A	2	15	NC	5% BW	PSR
A8	Rubber band ankle dorsiflexion	A	2	15	NC	5% BW	PSR
A9	Rubber band ankle plantar flexion	A	2	15	NC	5% BW	PSR
A5	Stretching for dorsi-plantar flexors	P	5	20”	NC	-	PSR
K1	Knee flexion	A	3	15	NC	1 Kg	PSR
G4	Gait training with full support (without crutches)	-	-	-	-	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; BW: body weight; PSR: perceived subjective recovery.

Postoperative week 7:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
H1	Hip abduction	A	3	20	NC	2 Kg	PSR
H2	Hip flexion	A	3	20	NC	2 Kg	PSR
A2	Ankle plantar flexion	P	2	20	NC	-	PSR
A3	Ankle dorsiflexion	P	2	20	NC	-	PSR
A6	Rubber band ankle eversion	A	2	15	NC	10% BW	PSR
A7	Rubber band ankle inversion	A	2	15	NC	10% BW	PSR
A8	Rubber band ankle dorsiflexion	A	2	15	NC	10% BW	PSR
A9	Rubber band ankle plantar flexion	A	2	15	NC	10% BW	PSR
A5	Stretching for dorsi-plantar flexors	P	5	20”	NC	-	PSR
K1	Knee flexion	A	3	20	NC	2 Kg	PSR
P1	Proprioceptive weight transfer	-	-	-	-	-	PSR
P2	Unipedal weight bearing	-	-	-	-	-	PSR
G5	Stair climbing/descent	-	-	-	-	-	PSR
G6	Gait training with full support (without crutches and orthosis)	-	-	-	-	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; BW: body weight; PSR: perceived subjective recovery.

Postoperative week 8:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
H1	Hip abduction	A	3	20	NC	3 Kg	PSR
H2	Hip flexion	A	3	20	NC	3 Kg	PSR
A2	Ankle plantar flexion	P	2	20	NC	-	PSR
A3	Ankle dorsiflexion	P	2	20	NC	-	PSR
A6	Rubber band ankle eversion	A	2	15	NC	20% BW	PSR
A7	Rubber band ankle inversion	A	2	15	NC	20% BW	PSR
A8	Rubber band ankle dorsiflexion	A	2	15	NC	20% BW	PSR
A9	Rubber band ankle plantar flexion	A	2	15	NC	20% BW	PSR
A5	Stretching for dorsi-plantar flexors	P	5	20”	NC	-	PSR
K1	Knee flexion	A	3	20	NC	3 Kg	PSR
K3	Bipedal squat	A	2	10	NC	-	PSR
A10	Bipedal heel rise	A	2	10	NC	-	PSR
P3	Proprioceptive mini trampoline balance	-	3	2’	-	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 3: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; BW: body weight; PSR: perceived subjective recovery.

Home-Based Rehabilitation Program:

Extended Spreadsheet of Home-Based Rehabilitation Program:

Postoperative week	**7**	**8**	**9**	**10**	**11**	**12**
Immobilizing	-	-	-	-	-	-
Weight bearing	Total WB[A]	Total WB[A]	Total WB[B]	Total WB[B]	Total WB[B]	Total WB[B]
Exercises*	Ankle ROM[A] Ankle strengthening[A] Knee strengthening[A]	Ankle ROM[A] Ankle strengthening[A] Knee strengthening[A]	Ankle ROM[B] Ankle strengthening[B] Knee strengthening[B]	Ankle ROM[B] Ankle strengthening[B] Knee strengthening[B]	Ankle ROM[B] Ankle strengthening[B] Knee strengthening[B]	Ankle ROM[B] Ankle strengthening[B] Knee strengthening[B]
Exercises progression*	-	-	Volume[A]		Volume[B]	
Goal	Improve calf-ankle complex function					
Rationale	Improve the ankle ROM and muscle resistance by the insert (CR group) exercises or increment (ER group) in intensity and complexity of exercises					

WB: weight bearing; ROM: range of motion; *: exercises application and progression were detailed described on "Appendix 2: Descriptors of exercises"; A: applied in conservative rehabilitation group; B: applied in both groups; CR: conservative rehabilitation; ER: early rehabilitation.

Descriptors of Home-Based Rehabilitation Program:

Conservative rehabilitation group:

Postoperative week 7-9:

ID	**Exercise**	**Mode**	**Sets**	**Repetitions¹**	**Cadence²**	**Load**	**Interval³**
A4	Ankle dorsi-plantar flexion	A	3	20	NC	-	PSR
A10	Bipedal heel rise	A	3	20	NC	-	PSR
K2	Bipedal squat	A	1/1/1	10/20/30	NC	-	PSR
A11	Standing plantar flexors stretching	P	5	20"	NC	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20'	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; E: Interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Postoperative week 10-12:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
A4	Ankle dorsi-plantar flexion	A	3	20	NC	-	PSR
A12	Unipedal heel rise	A	3	20	NC	-	PSR
K3	Unipedal squat	A	3	20	NC	-	PSR
A11	Standing plantar flexors stretching	P	5	20”	NC	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 2: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Early rehabilitation group:

Postoperative week 9-10:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
A4	Ankle dorsi-plantar flexion	A	3	20	NC	-	PSR
A10	Bipedal heel rise	A	3	20	NC	-	PSR
K2	Bipedal squat	A	1/1/1	10/20/30	NC	-	PSR
A11	Standing plantar flexors stretching	P	5	20”	NC	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 2: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled; PSR: perceived subjective recovery.

Postoperative week 10-12:

ID	Exercise	Mode	Sets	Repetitions¹	Cadence²	Load	Interval³
A4	Ankle dorsi-plantar flexion	A	3	20	NC	-	PSR
A12	Unipedal heel rise	A	3	20	NC	-	PSR
K3	Unipedal squat	A	3	20	NC	-	PSR
A11	Standing plantar flexors stretching	P	5	20”	NC	-	PSR
-	Cryotherapy with compression and ankle elevation	-	1	20’	-	-	-

ID: identification; 1: number of movements or time in seconds; 2: concentric/shortening-isometric-eccentric/lengthening movement time in seconds; 2: interval between sets and exercises in seconds; A: active movement; P: passive movement; NC: not controlled.

Toigo & Boutellier Exercise Descriptors:

ID	Exercise	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
A1	Ankle eversion-inversion	BW	2-3	15-20	NC	3	3	NC	NC	-	No	Full ROM*	≥24 h	#
A4	Ankle dorsi-plantar flexion (active)	BW	2-3	15-20	NC	3	3	NC	NC	-	No	Full ROM*	≥24 h	#
A6	Rubber band ankle eversion	↑5-20% BW	2	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
A7	Rubber band ankle inversion	↑1-4% BW	2	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
A8	Rubber band ankle dorsiflexion	↑1-4% BW	2	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
A9	Rubber band ankle plantar flexion	↑1-4% BW	2	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
A10	Bipedal heel rise	BW	2-3	10-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
A11	Unipedal heel rise	BW	3	20	NC	3	2	NC	NC	-	No	Full ROM	≥24 h	#
K1	Knee flexion	↑0-3 Kg	2-3	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
K3	Bipedal squat	BW	2-3	10-30	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
K4	Unipedal squat	BW	3	20	NC	3	2	NC	NC	-	No	Full ROM	≥24 h	#
H1	Hip abduction	↑0-3 Kg	2-3	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#
H2	Hip flexion	↑0-3 Kg	2-3	15-20	NC	3	3	NC	NC	-	No	Full ROM	≥24 h	#

Items: X_1: load magnitude; X_2: number of repetitions; X_3: number of sets; X_4: rest in-between sets (seconds); X_5: number of exercise intervention (per weeks); X_6: duration of the experimental period (weeks); X_7: fractional and temporal distribution of the contraction modes per repetition and duration of one repetition (concentric/shortening-isometric-eccentric/lengthening movement time in seconds); X_8: rest in-between repetitions (seconds); X_9: time under tension (seconds); X_{10}: volitional muscle failure; X_{11}: range of motion; X_{12}: recovery time in-between exercise session (hours); X_{12}: anatomical definition of exercise (exercise form).

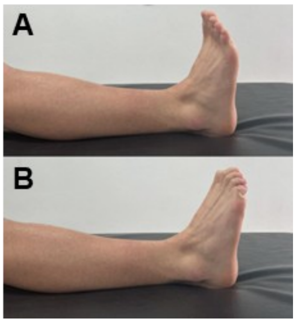
Legend: ID: identification; BW: body weight; ↑: overload; NC: Not controlled; ROM: range of motion; *: range of motion limited by pain; #: exercise form presented on Appendix 2 (Exercise Descriptors).

Appendix 3C

F1 - Metatarsal-phalangeal and interphalangeal joints flexion and extension

Starting position: seated with knees extended on the stretcher.

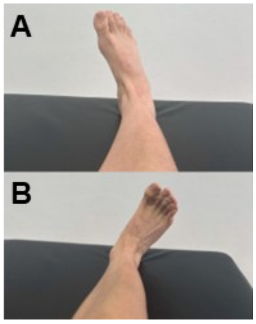
Instruction: for passive movements, the physiotherapist gently moved the metatarsal-phalangeal and interphalangeal joints in extension and flexion. For active movements, the physiotherapist guided the participant to perform extension (A) and flexion (B) movements at the metatarsal-phalangeal and interphalangeal joints.



A1 - Ankle eversion-inversion

Starting position: seated with knees extended on the stretcher.

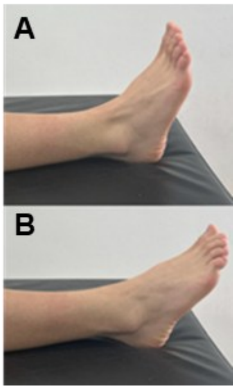
Instruction: for passive movements, the physiotherapist gently moved the subtalar joint in eversion and inversion. For active movements, the physiotherapist guided the participant to perform the movements of inversion (A) and eversion (B).



A2 - Ankle plantar flexion

Starting position: seated with knees extended on the stretcher.

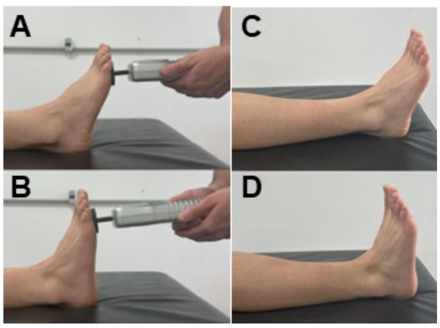
Instruction: for passive movements, the physiotherapist gently moved the ankle joint in plantar flexion (limited by pain). For active movements, the physiotherapist guided the participant to perform plantar flexion (B) movements, from the neutral position (A).



A3 - Ankle dorsiflexion

Starting position: seated with knees extended on the stretcher.

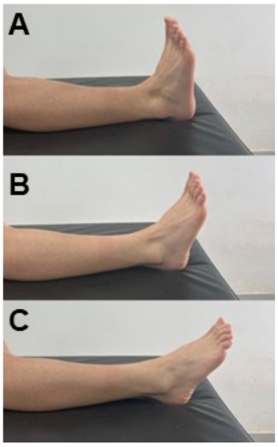
Instruction: for passive movements, the physiotherapist gently moved the ankle joint in dorsiflexion (A to B). Movement is limited by the tendon repair's strength test. For active movements, the physiotherapist guided the participant to perform the movements of dorsiflexion at the ankle joint (C to D), movement was limited by pain.



A4 - Ankle dorsi-plantar flexion

Starting position: seated with knees extended on the stretcher.

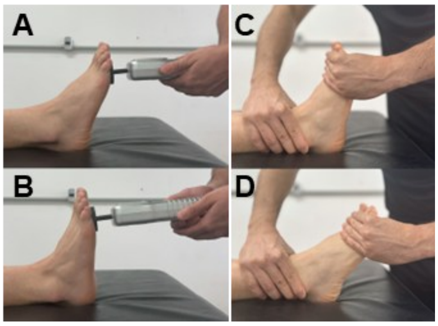
Instruction: the physiotherapist guided the participant to perform active movements from dorsiflexion to plantar flexion (A to C). Movement was limited by pain.



A5 - Stretching for dorsi-plantar flexors

Starting position: seated with knees extended on the stretcher.

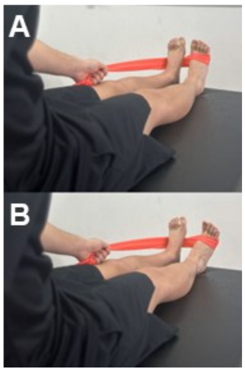
Instruction: the physiotherapist gently moved and held the ankle in dorsiflexion (limited by the tendon repair's strength test) (A to B), and then in plantar flexion (limited by pain) (C to D).



A6 - Rubber band ankle eversion

Starting position: seated with knees extended on the stretcher. A rubber band was passed through the sole of the exercises' contralateral foot, and attached to the foot.

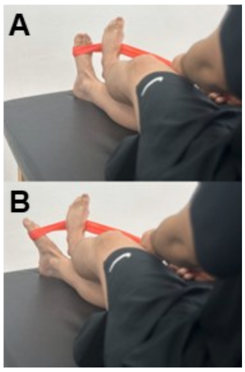
Instruction: the physiotherapist guided the participant to perform active eversion movements (A to B).



A7 - Rubber band ankle inversion

Starting position: seated with knees extended on the stretcher. With the legs crossed, the elastic band was passed over the sole of the exercises' contralateral foot, and attached to the foot.

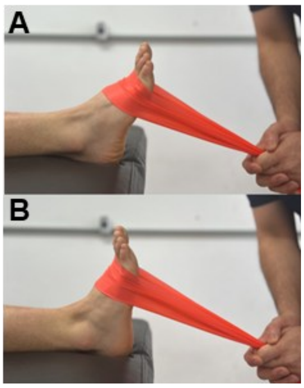
Instruction: the physiotherapist guided the participant to perform active inversion movements (A to B).



A8 - Rubber band dorsiflexion

Starting position: seated with knees extended on the stretcher. A rubber band was attached to the anterior region of the foot.

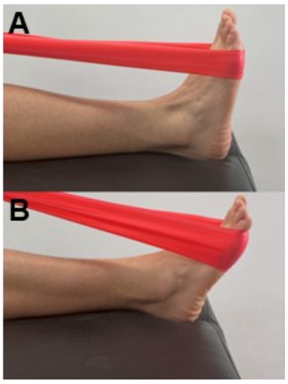
Instruction: the physiotherapist guided the participant to perform active dorsiflexion movements (A to B).



A9 - Rubber band plantar flexion

Starting position: seated with knees extended on the stretcher. A rubber band was attached to the sole of the foot.

Instruction: the physiotherapist guided the participant to perform active plantar flexion movements.



A10 - Bipedal heel rise

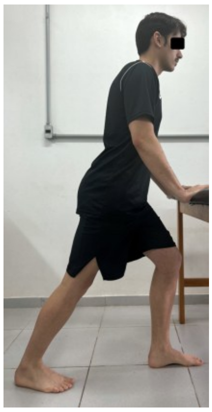
Starting position: stand with the feet in hip's line, and upper limbs supported.

Instruction: the physiotherapist instructed the participant to standing in a balanced position and perform a full heel rise with both legs (A to B).

A11 - Standing plantar flexors stretching

Starting position: standing with the upper limbs supported. With the contralateral leg in front and the ipsilateral leg behind.

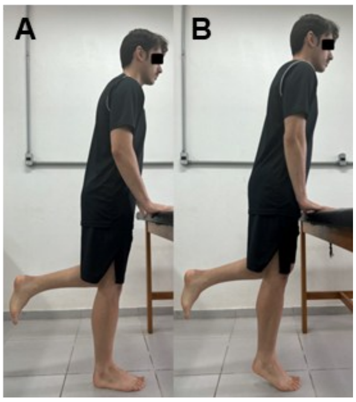
Instruction: the physiotherapist instructed the participant to move their torso forward.



A12 - Unipedal heel rise

Starting position: standing with the feet in hip's line, and upper limbs supported.

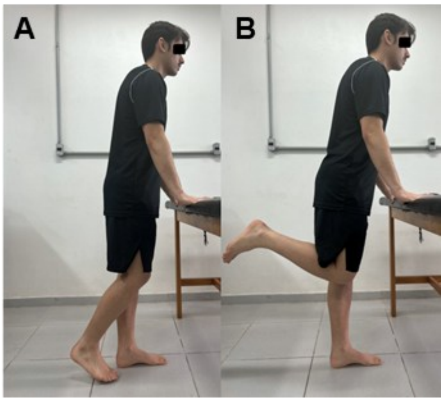
Instruction: the physiotherapist instructed the participant to standing in a balanced position and perform a full heel rise with one leg (A to B). The contralateral leg was kept without contact with the ground (knee flexed).



K1 - Knee flexion

Starting position: standing with the feet in hip's line, and upper limbs supported.

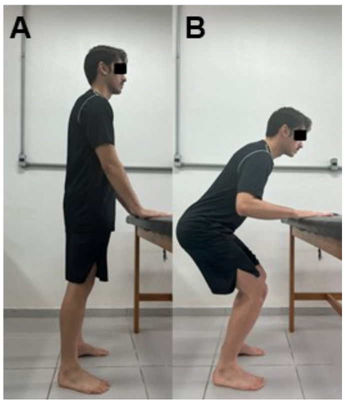
Instruction: the physiotherapist instructed the participant to standing in a balanced position and perform a knee flexion (A to B). The contralateral leg was supported on the floor.



K2 - Bipedal squat

Starting position: standing with the feet in hip's line, and upper limbs supported.

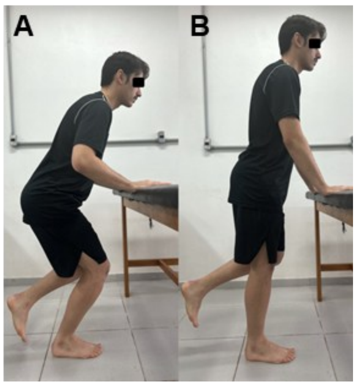
Instruction: the physiotherapist instructed the participant to standing in a balanced position and perform the squatting movement with both legs supported on the floor (A to B).



K3 - Unipedal squat

Starting position: standing with the feet in hip's line, and upper limbs supported.

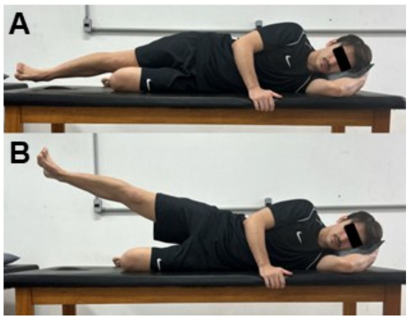
Instruction: the physiotherapist instructed the participant to standing in a balanced position and perform the squatting movement with one leg supported on the floor (A to B). The contralateral leg was kept without contact with the ground (knee flexed).



H1 - Hip abduction

Starting position: lateral decubitus with the ipsilateral knee extended. The contralateral leg supported on the stretcher (knee flexed).

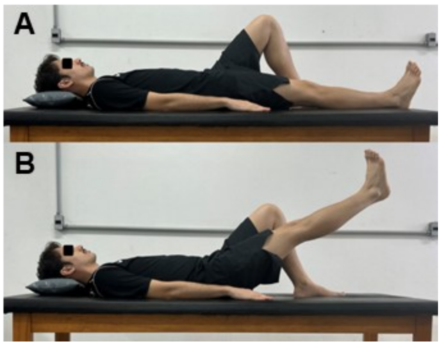
Instruction: the physiotherapist instructed the participant to perform hip abduction (A to B).



H2 - Hip flexion

Starting position: supine position with the ipsilateral knee extended. The exercises' contralateral side was supported on the stretcher with the knee flexed.

Instruction: the physiotherapist instructed the participant to perform hip flexion (A to B).



G1 - Gait training with partial support (three-point gait)

Starting position: standing, the feet in hip's line, and with support of two crutches.

Instruction: the participant was guided to perform a step with the injured leg (X) supported by two crutches, followed by a step with the uninjured leg.

G2 - Gait training with partial support (two-point gait)

Starting position: standing, the feet in hip's line, and with support of one crutch.

Instruction: the participant was guided to perform a step with the injured leg (X) supported by one crutch, followed by a step with the uninjured leg.

G3 - Gait training with full support (without crutches)

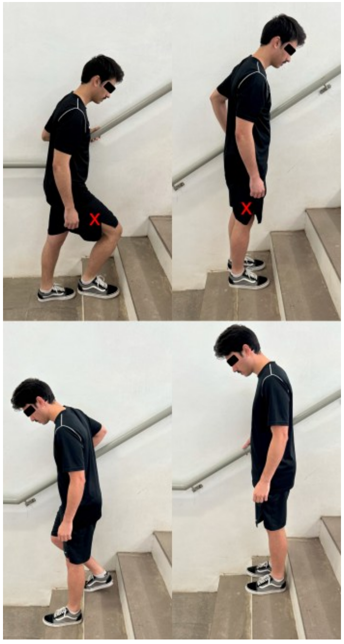
Starting position: standing, the feet in hip's line, and without crutches.

Instruction: the participant was guided to perform a step with the injured leg (X), followed by a step with the uninjured leg.

G4 - Stair climbing/descent

Starting position: standing, the feet in hip's line, and upper limbs supported on the stair's handrail.

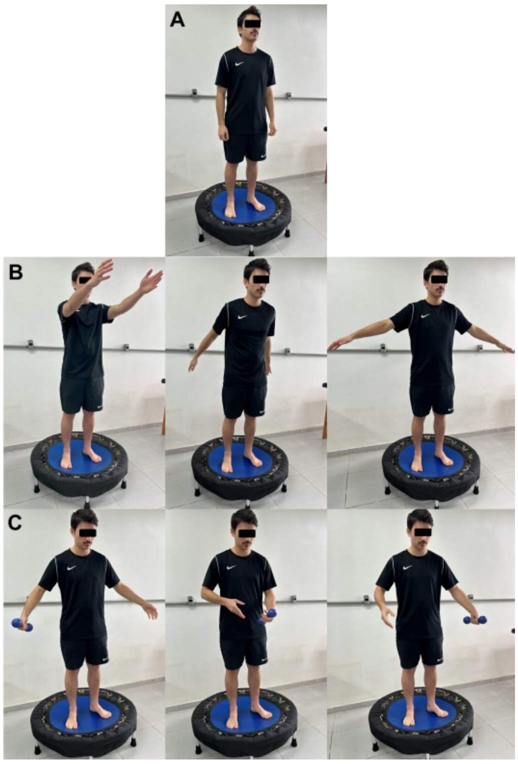
Instruction: the participant was instructed to climb stairs with the injured leg, followed by the uninjured leg. The stair descent was performed through by the uninjured leg support followed by the injured leg support.



P1 - Proprioceptive weight transfer balance

Starting position: standing with the feet in hip's line, without upper limbs support.

Instruction: the participant was instructed to transfer body weight from one side to the other as if lifting a leg, but without actually lifting the leg. One repetition consisted of weight transfer in the lateral to lateral, anterior to posterior, and posterior to anterior directions.

P2 - Unipedal weight bearing **Starting position:** standing in a balanced position, with the injured leg (X) supported on the ground, the contralateral leg was kept without contact with the ground and with the knee flexed. **Instruction:** the physiotherapist instructed the participant to maintain the balance position.	
P3 - Proprioceptive mini trampoline balance **Starting position:** standing on a mini trampoline with the feet in hip's line, without upper limbs support. **Instruction:** in a balanced position with both legs supported on the trampoline, the exercise consists of three sets: A) standing on the trampoline, B) standing on the trampoline while performing shoulder flexion-extension and abduction-adduction movements, and C) standing on the trampoline while transferring weight between hands from one side to the other.	

Appendix 3D

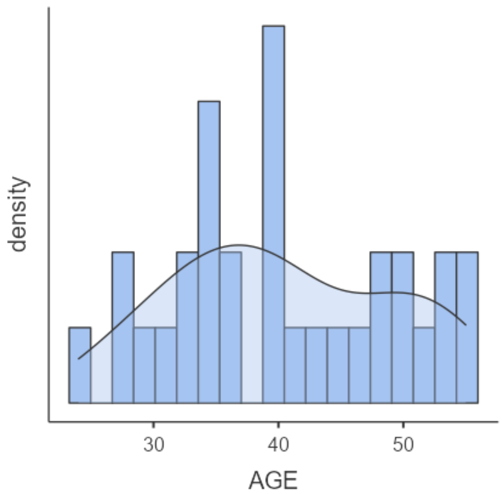
Descriptive of Baseline Characteristics:

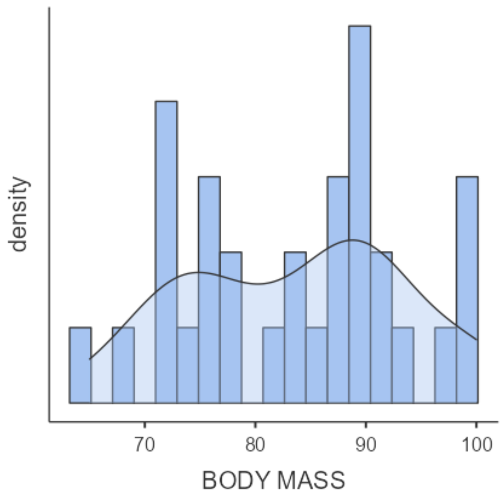
Descriptives

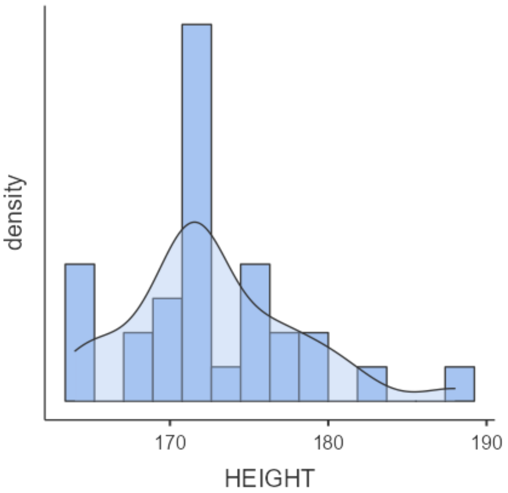
	N	Mean	95% Confidence Interval		Median	SD	Minimum	Maximum	Skewness		Kurtosis	
			Lower	Upper					Skewness	SE	Kurtosis	SE
AGE	31	40.39	37.13	43.65	40	8.89	24	55	0.1067	0.421	-1.002	0.821
BODY MASS	31	83.69	80.07	87.32	85.00	9.88	65.00	100.00	-0.0540	0.421	-0.979	0.821
HEIGHT	31	172.74	170.78	174.71	172.00	5.35	164.00	188.00	0.7268	0.421	0.985	0.821
INJxSUR	31	7.48	6.22	8.74	7	3.43	2	15	0.4981	0.421	-0.333	0.821
RST	31	4.89	4.41	5.36	5.00	1.29	2.00	7.50	0.1434	0.421	0.153	0.821
LSI_PF	31	68.33	61.91	74.75	67.40	17.51	31.30	113.00	0.0970	0.421	0.703	0.821
LSI_DF	31	41.18	29.56	52.80	31.30	31.68	0.00	127.30	0.8964	0.421	0.513	0.821

Note. The CI of the mean assumes sample means following a t-distribution with N - 1 degrees of freedom

Histogram and Density:



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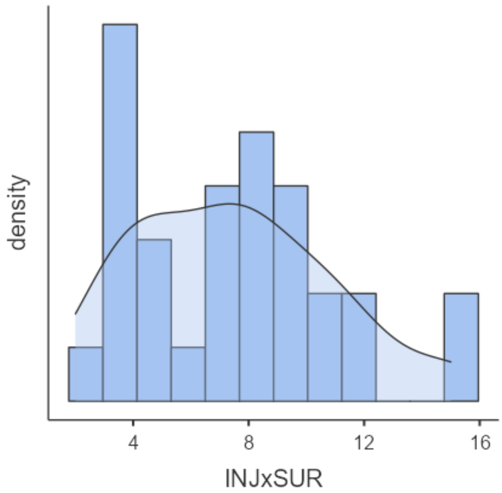
HEIGHT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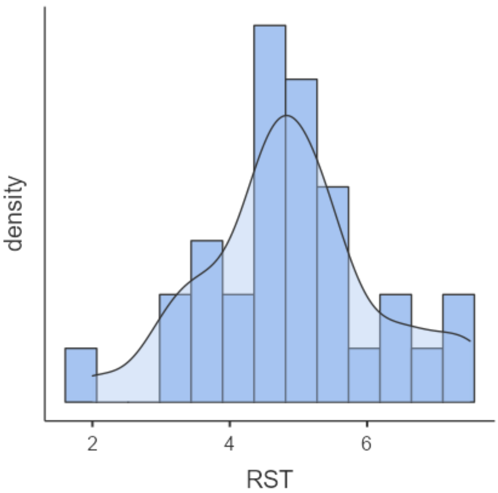
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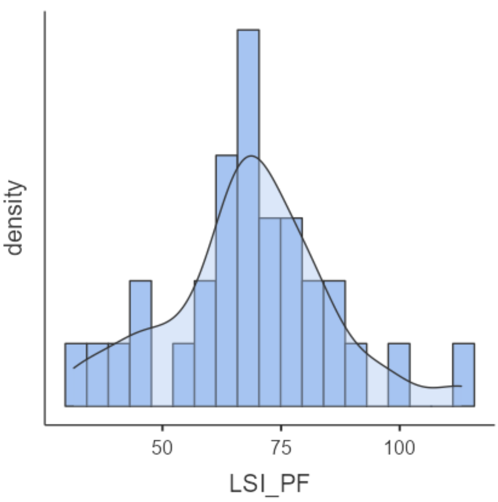
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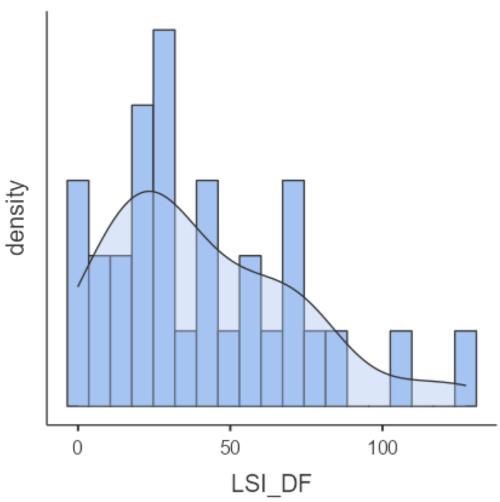
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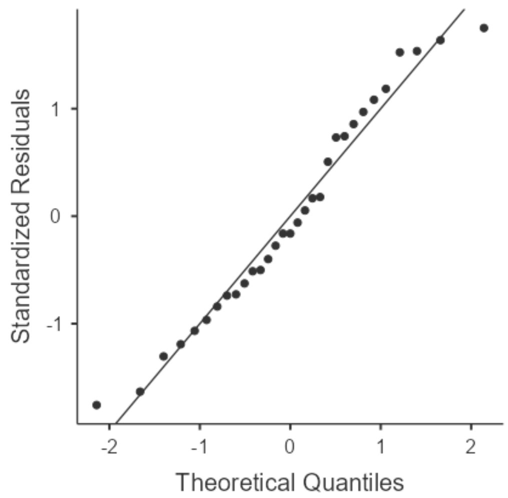
LSI_DF

Model Fit Analysis of ***Baseline Characteristics****:*

Age:

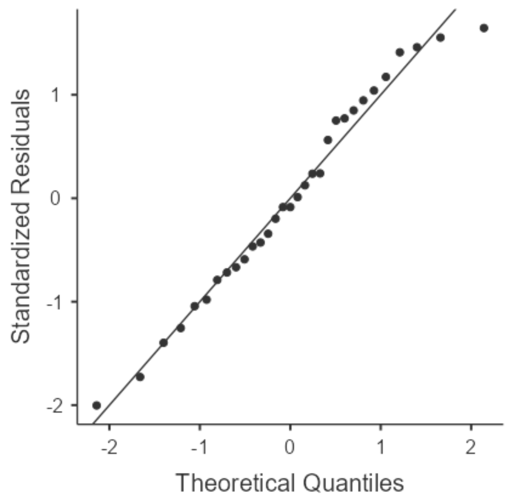
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AGE ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0117	Proportion of reduction of error
AIC	228.0640	Less is better
BIC	232.3660	Less is better
Deviance	2343.6639	Less is better
Residual DF	29	
Chi-squared/DF	80.8160	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model.

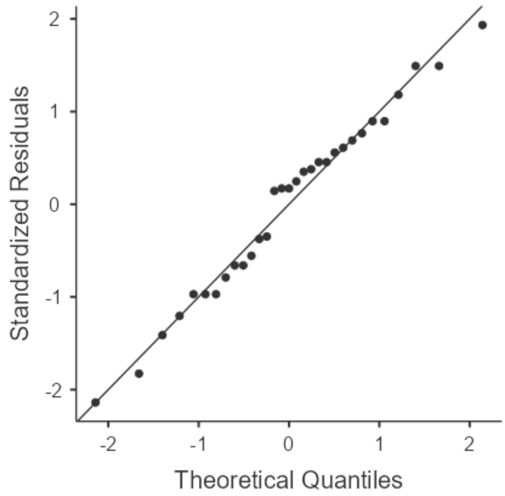
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AGE ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0113	Proportion of reduction of error
AIC	227.8790	Less is better
BIC	232.1810	Less is better
Deviance	1.4874	Less is better
Residual DF	29	
Chi-squared/DF	0.0500	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Body mass:

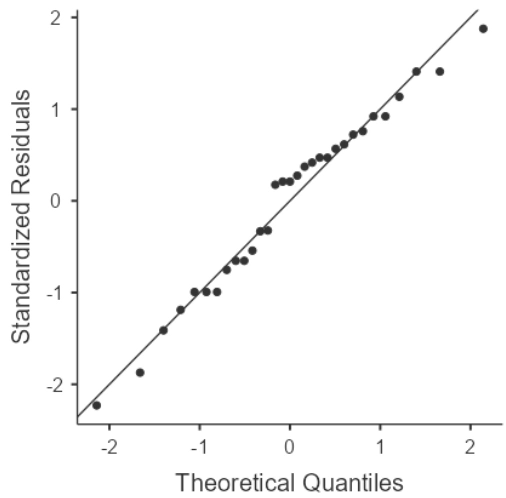
Model Info
Best-fit model considering in addition to the AIC value the distribution of the dependent variable.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	BODY MASS ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0476	Proportion of reduction of error
AIC	233.4570	Less is better
BIC	237.7590	Less is better
Deviance	2788.9790	Less is better
Residual DF	29	
Chi-squared/DF	96.1717	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

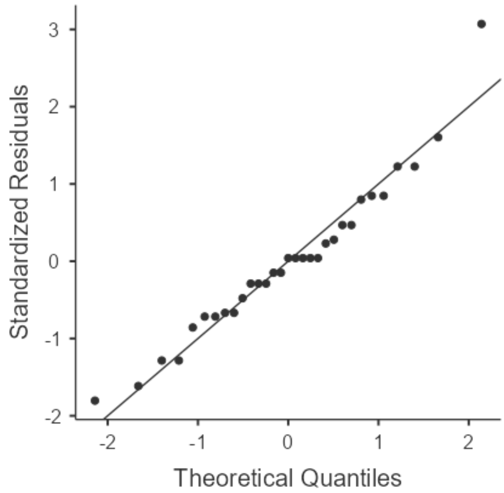
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	BODY MASS ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0469	Proportion of reduction of error
AIC	233.6660	Less is better
BIC	237.9680	Less is better
Deviance	0.4055	Less is better
Residual DF	29	
Chi-squared/DF	0.0136	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Height:

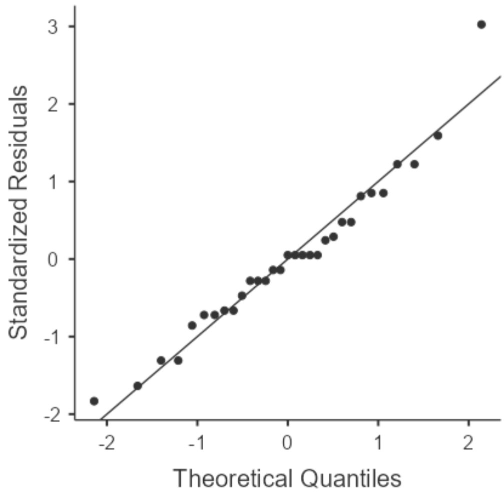
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	HEIGHT ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0271	Proportion of reduction of error
AIC	196.1300	Less is better
BIC	200.4320	Less is better
Deviance	836.5924	Less is better
Residual DF	29	
Chi-squared/DF	28.8480	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model.

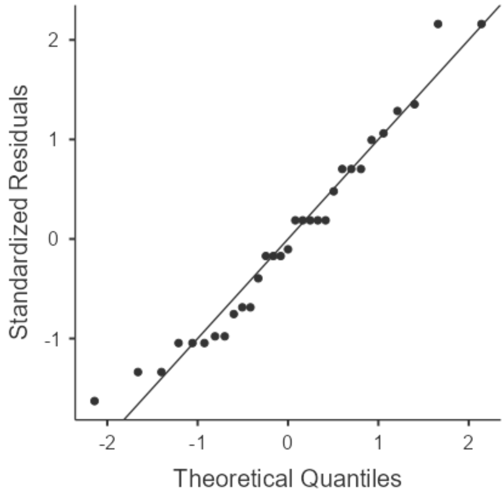
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	HEIGHT ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0275	Proportion of reduction of error
AIC	195.7070	Less is better
BIC	200.0090	Less is better
Deviance	0.0277	Less is better
Residual DF	29	
Chi-squared/DF	9.67e-4	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Time between injury and surgery:

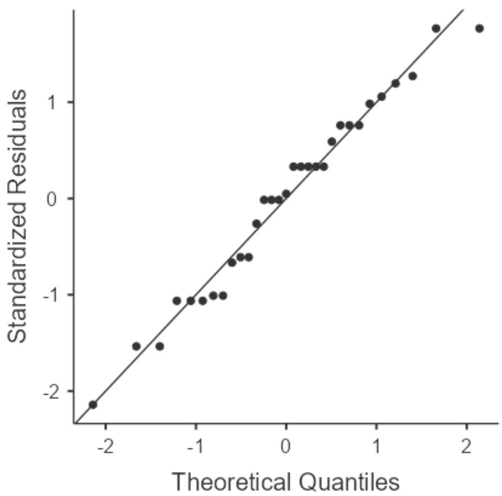
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	INJxSUR ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.00116	Proportion of reduction of error
AIC	169.41000	Less is better
BIC	173.71200	Less is better
Deviance	353.33193	Less is better
Residual DF	29	
Chi-squared/DF	12.18386	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model considering in addition to the residuals analysis and AIC value the distribution of the dependent variable.

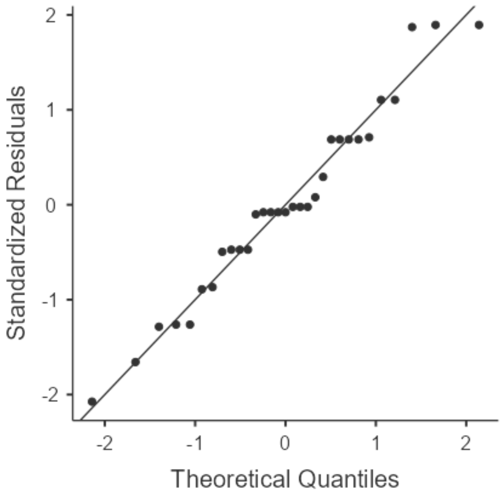
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	INJxSUR ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.00105	Proportion of reduction of error
AIC	166.66300	Less is better
BIC	170.96500	Less is better
Deviance	6.96428	Less is better
Residual DF	29	
Chi-squared/DF	0.21447	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Tendon Repair's Strength Test:

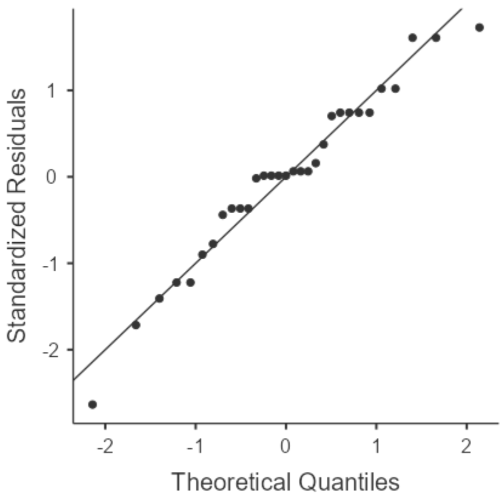
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	RST ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0342	Proportion of reduction of error
AIC	107.6360	Less is better
BIC	111.9380	Less is better
Deviance	48.1686	Less is better
Residual DF	29	
Chi-squared/DF	1.6610	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	RST ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0315	Proportion of reduction of error
AIC	108.6090	Less is better
BIC	112.9110	Less is better
Deviance	2.2138	Less is better
Residual DF	29	
Chi-squared/DF	0.0695	Overdispersion indicator
Converged	yes	Whether the estimation found a solution

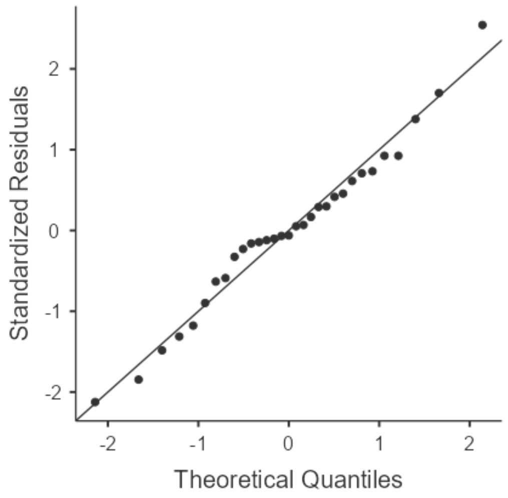


Plantar Flexion Range of Motion:

Post-2 Weeks of Surgery:

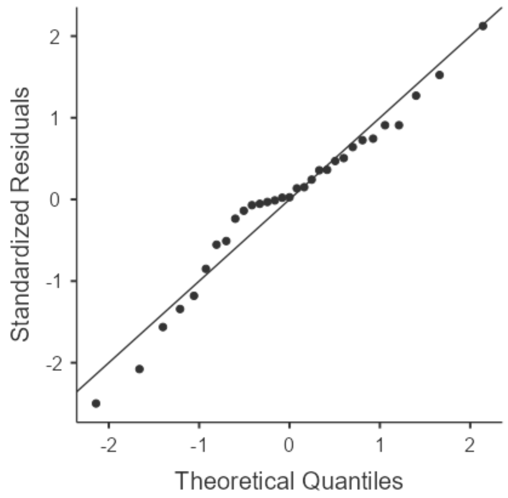
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	5.95e-5	Proportion of reduction of error
AIC	270	Less is better
BIC	275	Less is better
Deviance	9192	Less is better
Residual DF	29	
Chi-squared/DF	317	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	5.39e-5	Proportion of reduction of error
AIC	271.6750	Less is better
BIC	275.9770	Less is better
Deviance	2.1726	Less is better
Residual DF	29	
Chi-squared/DF	0.0678	Overdispersion indicator
Converged	yes	Whether the estimation found a solution

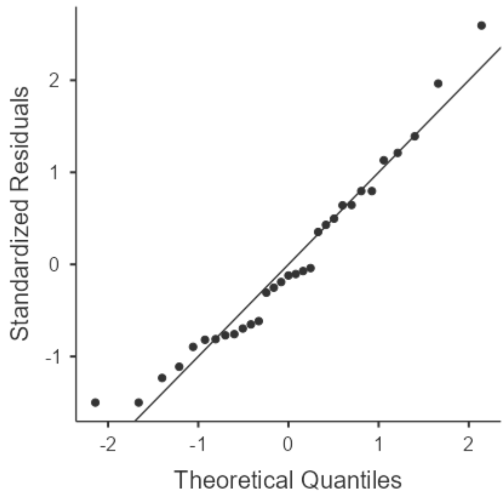


Dorsiflexion Range of Motion:

Post-2 Weeks of Surgery:

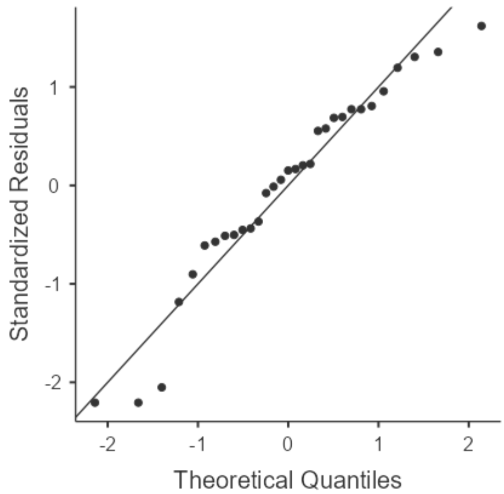
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0373	Proportion of reduction of error
AIC	306.0340	Less is better
BIC	310.3360	Less is better
Deviance	28988.0362	Less is better
Residual DF	29	
Chi-squared/DF	999.5875	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF - Transform 2 ~ 1 + GROUP
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0256	Proportion of reduction of error
AIC	298.6060	Less is better
BIC	302.9070	Less is better
Deviance	23.5674	Less is better
Residual DF	29	
Chi-squared/DF	0.4996	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Descriptives of Ankle Range of Motion:

Descriptives (Post-12 Weeks of Surgery)

	N	Mean	95% Confidence Interval		Median	SD	Minimum	Maximum	Skewness		Kurtosis	
			Lower	Upper					Skewness	SE	Kurtosis	SE
LSI_PF	31	86.7	80.7	92.7	87.5	16.4	55.6	125	-0.165	0.421	-0.0765	0.821
LSI_DF	31	105.2	88.2	122.3	95.8	46.5	28.6	240	0.970	0.421	1.5204	0.821

Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

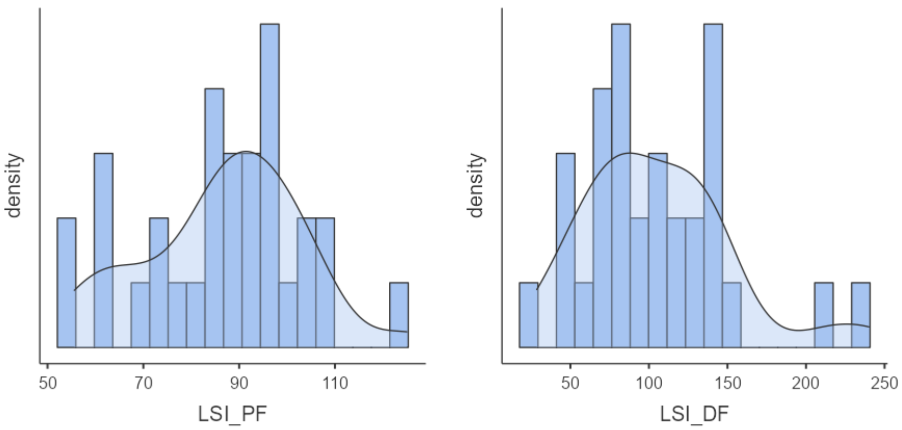
Descriptives (Post-26 Weeks of Surgery)

	N	Mean	95% Confidence Interval		Median	SD	Minimum	Maximum	Skewness		Kurtosis	
			Lower	Upper					Skewness	SE	Kurtosis	SE
LSI_PF	31	93.3	86.4	100	94.5	19.0	57.1	150	0.8487	0.421	2.006	0.821
LSI_DF	31	116.0	101.0	131	120.0	40.9	33.3	200	-0.0296	0.421	0.477	0.821

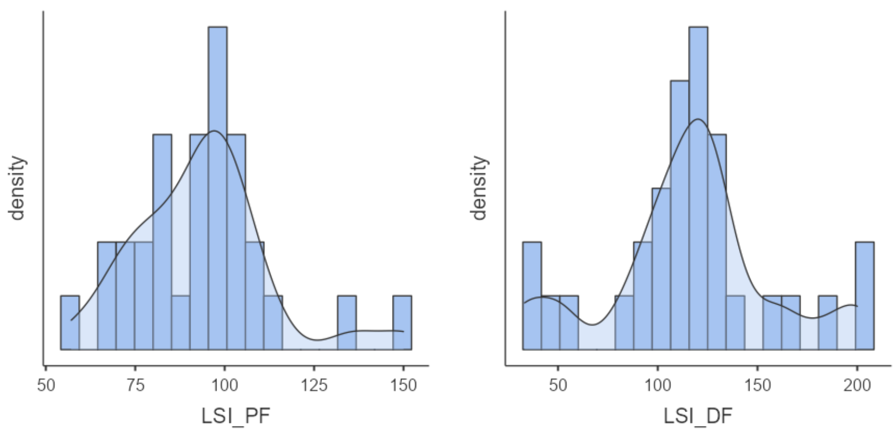
Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

Histogram and Density:

Post-12 Weeks of Surgery:



Post-26 Weeks of Surgery:



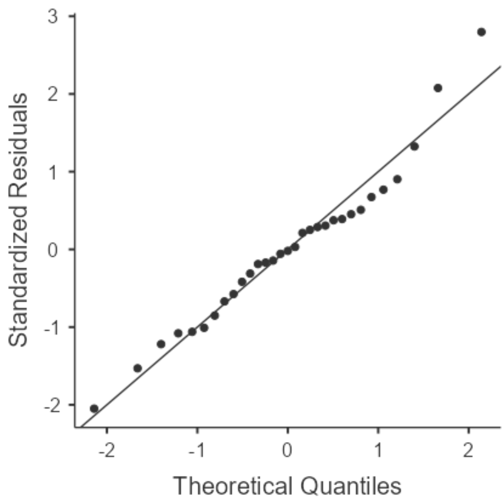
Model Fit Analysis of Ankle Range of Motion:

Post-12 Weeks of Surgery:

Plantar Flexion:

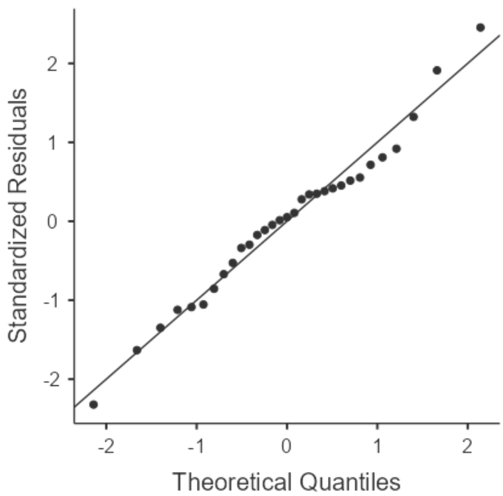
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0204	Proportion of reduction of error
AIC	276.8160	Less is better
BIC	282.5520	Less is better
Deviance	10589.3731	Less is better
Residual DF	28	
Chi-squared/DF	378.1919	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model.

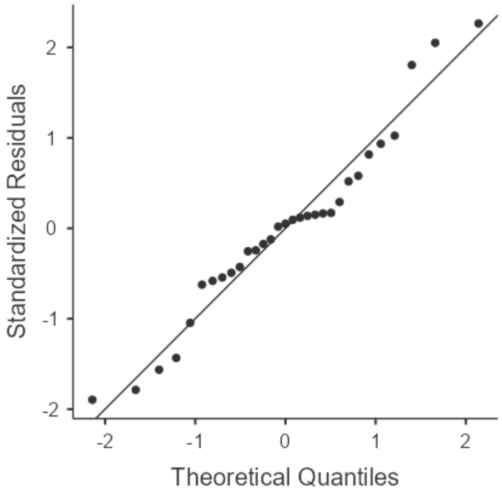
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0176	Proportion of reduction of error
AIC	274.8380	Less is better
BIC	280.5740	Less is better
Deviance	1.1784	Less is better
Residual DF	28	
Chi-squared/DF	0.0423	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Dorsiflexion:

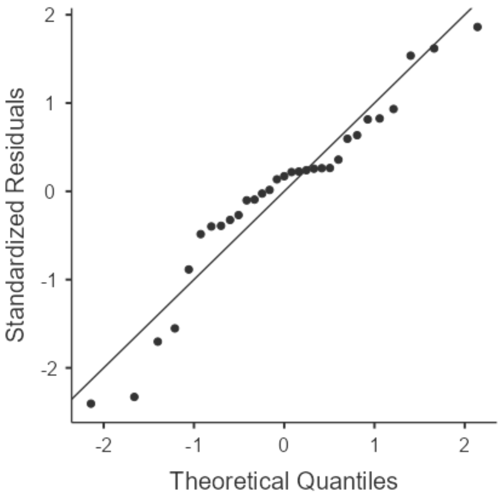
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0200	Proportion of reduction of error
AIC	324.3800	Less is better
BIC	330.1160	Less is better
Deviance	49114.1936	Less is better
Residual DF	28	
Chi-squared/DF	1754.0783	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0159	Proportion of reduction of error
AIC	328.4310	Less is better
BIC	334.1670	Less is better
Deviance	4.7346	Less is better
Residual DF	28	
Chi-squared/DF	0.1404	Overdispersion indicator
Converged	yes	Whether the estimation found a solution

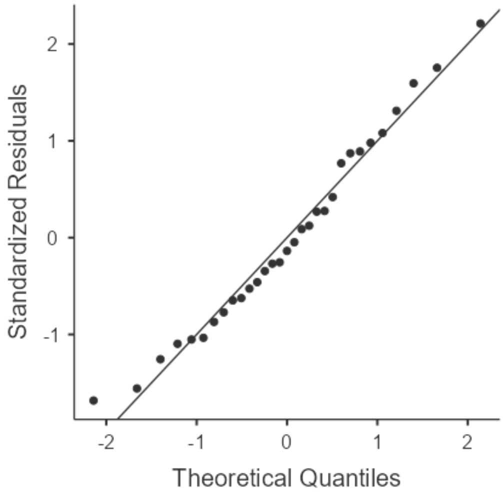


Post-26 Weeks of Surgery:

Plantar Flexion:

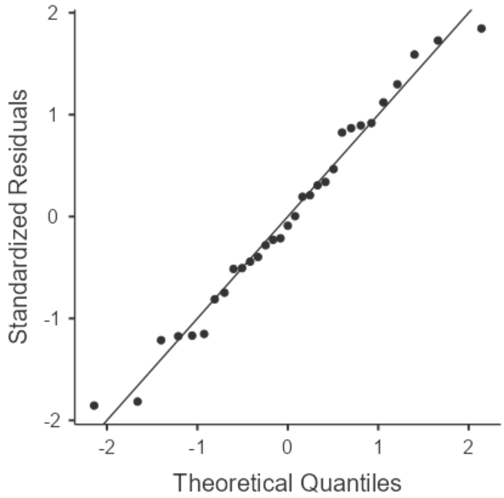
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.178	Proportion of reduction of error
AIC	262.231	Less is better
BIC	267.967	Less is better
Deviance	6615.103	Less is better
Residual DF	28	
Chi-squared/DF	236.254	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

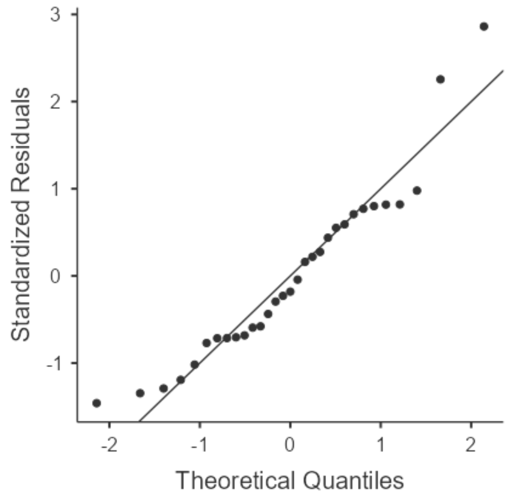
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_PF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.1677	Proportion of reduction of error
AIC	263.7570	Less is better
BIC	269.4930	Less is better
Deviance	0.9549	Less is better
Residual DF	28	
Chi-squared/DF	0.0340	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Dorsiflexion:

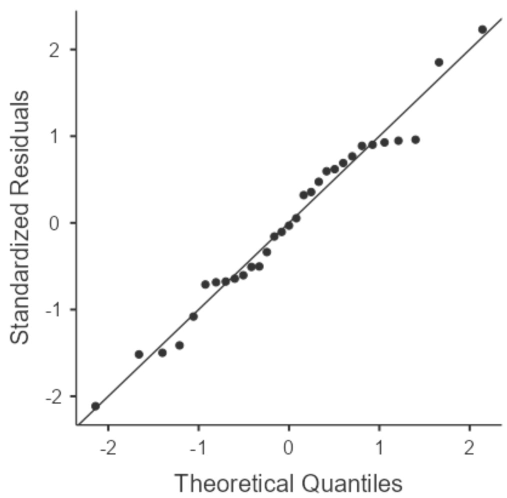
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.0130	Proportion of reduction of error
AIC	332.5690	Less is better
BIC	338.3050	Less is better
Deviance	63964.6386	Less is better
Residual DF	28	
Chi-squared/DF	2284.4514	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	LSI_DF ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.0165	Proportion of reduction of error
AIC	328.0970	Less is better
BIC	333.8330	Less is better
Deviance	5.8754	Less is better
Residual DF	28	
Chi-squared/DF	0.2030	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



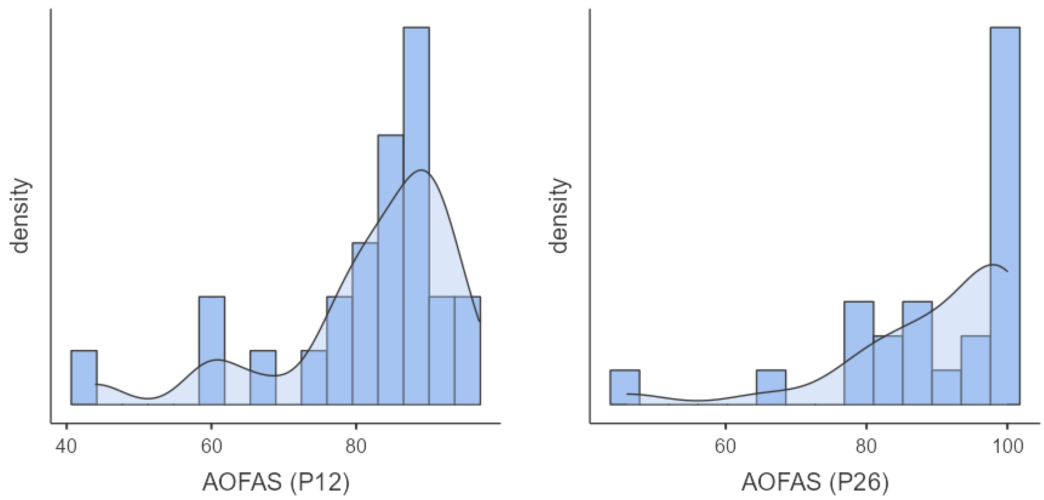
Descriptives of AOFAS Ankle Hindfoot Scale:

Descriptives

			95% Confidence Interval						Skewness		Kurtosis	
	N	Mean	Lower	Upper	Median	SD	Minimum	Maximum	Skewness	SE	Kurtosis	SE
AOFAS (P12)	26	82.2	77.1	87.2	85.0	12.4	44.0	97.0	-1.60	0.456	2.61	0.887
AOFAS (P26)	24	89.9	84.4	95.5	95.0	13.2	46	100	-1.93	0.472	4.45	0.918

Note. The CI of the mean assumes sample means follow a t-distribution with N - 1 degrees of freedom

Histogram and Density:

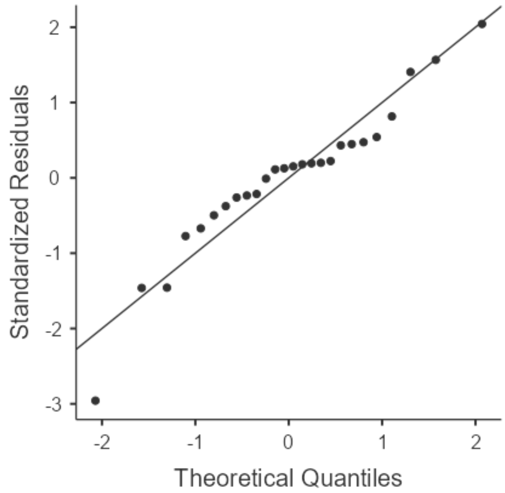


Model Fit Analysis of AOFAS Ankle Hindfoot Scale:

Post-12 Weeks of Surgery:

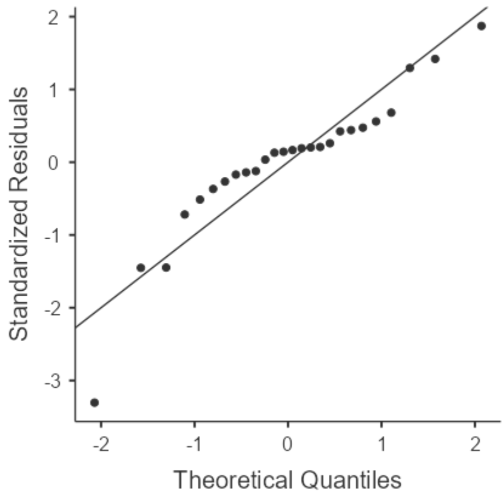
Model Info
Best-fit model.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AOFAS (P12) ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.306	Proportion of reduction of error
AIC	202.136	Less is better
BIC	207.169	Less is better
Deviance	2662.444	Less is better
Residual DF	23	
Chi-squared/DF	115.758	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info

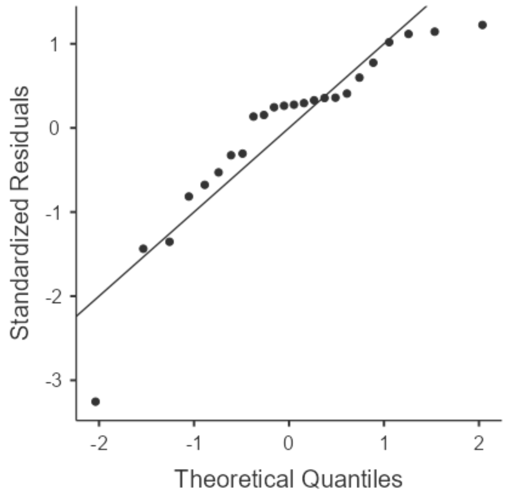
Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AOFAS (P12) ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.2526	Proportion of reduction of error
AIC	208.8340	Less is better
BIC	213.8670	Less is better
Deviance	0.5226	Less is better
Residual DF	23	
Chi-squared/DF	0.0202	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Post-26 Weeks of Surgery:

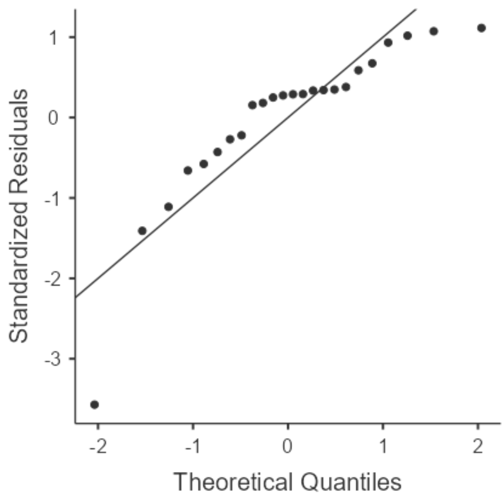
Model Info

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AOFAS (P26) ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gaussian	Normal distribution of residual
R-squared	0.163	Proportion of reduction of error
AIC	194.522	Less is better
BIC	199.234	Less is better
Deviance	3334.013	Less is better
Residual DF	21	
Chi-squared/DF	158.763	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



Model Info
Best-fit model considering the distribution of dependent variable.

Info	Value	Comment
Model Type	Custom	Model with custom family
Call	glm	AOFAS (P26) ~ 1 + GROUP + PropScore
Link function	Identity	Coefficients in the same scale of y
Distribution	Gamma	Skewed continuous distribution
R-squared	0.1281	Proportion of reduction of error
AIC	200.8450	Less is better
BIC	205.5570	Less is better
Deviance	0.5488	Less is better
Residual DF	21	
Chi-squared/DF	0.0213	Overdispersion indicator
Converged	yes	Whether the estimation found a solution



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