11-1-2019

Defining components of early functional rehabilitation for acute achilles tendon rupture: A systematic review

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Defining Components of Early Functional Rehabilitation for Acute Achilles Tendon Rupture

A Systematic Review

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Background: Early functional rehabilitation is frequently discussed in treating Achilles tendon rupture. A consistent definition of what constitutes early functional rehabilitation has not been established across the literature, despite studies supporting its efficacy. A standardized definition would be helpful to pool data across studies, allow for between-study comparisons, and ultimately work toward developing clinical guidelines.

Purpose: To define early functional rehabilitation (including when it is initiated and what it entails) when used to treat Achilles tendon rupture and to identify outcome measures for evaluating the effect of treatment.

Study Design: Systematic review; Level of evidence, 4.

Methods: Ovid MEDLINE, EMBASE, PEDro, CINAHL, and Cochrane databases were searched for relevant studies. Eligibility criteria for selecting studies consisted of randomized controlled trials, cohort studies, and case series ($\geq$10 participants) including weightbearing or exercise-based interventions within 8 weeks after Achilles tendon rupture.

Results: A total of 174 studies published between 1979 and 2018 were included. Studies were rated a median (interquartile range [IQR]) of 17 (15-20) on the Downs & Black checklist and included 9098 participants. Early functional rehabilitation incorporated weightbearing (95%), range of motion (73%), and isometric/strengthening exercises (50%). Weightbearing was initiated within the first week, whereas exercise (eg, ankle range of motion, strengthening, whole-body conditioning) was initiated in the second week. Initiation of exercises varied based on whether treatment was nonsurgical (mean, 3.0 weeks; IQR, 2.0-4.0 weeks) or simple (mean, 2.0 weeks; IQR, 0.0-2.3 weeks) or augmented surgical repair (mean, 0.5 weeks; IQR, 0.0-2.8 weeks) ($P = .017$). Functional outcomes including ankle range of motion (n = 84) and strength (n = 76) were reported in 130 studies. Other outcome domains included patient-reported outcomes (n = 89), survey-based functional outcomes (n = 50), and tendon properties (n = 53).

Conclusion: Early functional rehabilitation includes weightbearing and a variety of exercise-based interventions initiated within the first 2 weeks after acute Achilles tendon rupture/repair. Because early functional rehabilitation has lacked a standardized definition, interventions and outcome measures are highly variable, and pooling data across studies should be done with attention paid to what was included in the intervention and how treatment was assessed.

Keywords: Achilles; mobilization; weightbearing; ankle; outcomes

The yearly incidence of Achilles tendon rupture is up to 37 per 100,000 individuals.[61,105,160] There is ongoing debate regarding optimal treatment, as attention has shifted away from outcomes such as rerupture rates and toward function-based outcomes.[74] Plantar flexor weakness[22,72,103] and biomechanical asymmetries with running and jumping activities[23,200] persist in the long term. These may limit performance capacity or predispose these individuals to other orthopaedic conditions such as patellofemoral joint pain.[200] It is important that patients recover within the first year after injury, as 1-year outcomes predict whether individuals will be left with long-term disabilities.[23,69]

Early functional rehabilitation has become a buzz phrase in treating Achilles tendon rupture. A consistent definition of what constitutes early functional rehabilitation has not been established across the literature, despite studies identifying that early functional rehabilitation was safe, resulted in higher patient satisfaction, improved function,

The Orthopaedic Journal of Sports Medicine, 7(11), 2325967119884071
DOI: 10.1177/2325967119884071

and led to faster return to work and sport in some instances.[24,67,99,117,193] Systematic reviews have supported the use of early functional rehabilitation to optimize patient outcomes regardless of whether a participant is managed nonsurgically[55] or surgically.[21,24,78,128] A standardized definition would be helpful to pool data across studies, allow for between-study comparison, and ultimately work toward developing clinical guidelines.

The components in defining early functional rehabilitation include establishing what types of treatment recommendations comprise early functional rehabilitation and when they are initiated. Prior systematic reviews investigating the efficacy of early functional rehabilitation[21,24,55,78,128] have provided limited guidance as to the working definition of this term, relying on author-delineated, inconsistent definitions of *early*. For example, Brumann et al[24] limited studies to those including weightbearing or ankle mobilization in the first 3 weeks, McCormack and Bovard[128] included only studies that included any type of rehabilitation by 2 weeks, and El-Akkawi et al[55] limited study inclusion to those that initiated rehabilitation by 4 weeks. Variations between systematic review–level evidence point to the lack of uniform definition of early functional rehabilitation.

The standardization of outcomes used to assess patient response to intervention is another critical piece in understanding the effectiveness of early functional rehabilitation. As part of the Core Outcome Measures in Effectiveness Trials (COMET) Initiative, core outcome sets are being developed and applied in an effort to improve direct comparisons across studies.[198] This is in response to the challenge of pooling literature with large variability in reported outcomes[13] as well as substantial problems with missing data for primary outcomes.[198] A first step in the development of a core outcome set is to identify the outcome measures used in clinical trials. A core outcome set is being discussed for Achilles tendinopathy[114,176]; however, to date, an Achilles tendon rupture–specific set has not been initiated in the literature.

The purpose of this study was to comprehensively define early functional rehabilitation in terms of what types of interventions are delivered to patients with Achilles tendon rupture and when. We hypothesized that treatment was initiated earlier in more recent studies, so we investigated changes in trends of early functional rehabilitation onset over time. Secondarily, we sought to identify the outcome measures that have been used to assess patient response to these rehabilitative protocols as a first step in identifying a core outcome set for this patient population.

METHODS

This study was a systematic review of the literature on early functional rehabilitation for Achilles tendon rupture. The study was performed according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and was registered on the Prospero database (registration ID: CRD42017062300). Due to the size of the study, we are reporting results for the definition of early functional rehabilitation portion of the Prospero protocol, and work regarding specific rehabilitation protocols is ongoing. The search was completed on May 9, 2018.

Search Strategy

The search strategy was based on the PICO (Patient, Intervention, Comparator, and Outcome) model. Development of the search string and conduct of the search were done with the assistance of a research librarian. The complete search string is included in Appendix Table A1. Databases included in the search were Ovid MEDLINE, EMBASE, PEDro, CINAHL, and the Cochrane Database.

Study Inclusion and Exclusion

For the purposes of this review, we broadly defined early functional rehabilitation as having weightbearing and/or ankle-focused exercises beginning within the first 8 weeks and while the patient is still using an immobilization device (ie, orthosis, cast, specialized treatment boot). In the event that no immobilization device was used during the course of treatment, early functional rehabilitation was defined as weightbearing and exercises started within the first 8 weeks after injury or surgery.

Included studies needed to involve patients at least 18 years of age treated with early functional rehabilitation after acute (defined as treated within 2 weeks) Achilles tendon rupture. Studies needed to be randomized controlled trials (RCTs), cohort studies, or case series with a minimum of 10 participants. Narrative reviews, systematic reviews and meta-analyses, and case studies were excluded. Studies were excluded if participants with diabetes, neurological conditions, or only chronic or delayed treatment were included. In studies including participants

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One or more of the authors has declared the following potential conflict of interest or source of funding: The project received financial support from the Danish Physiotherapy Research Foundation (to M.C.). This study was also funded by the Foundation for Physical Therapy (to K.G.S. and J.A.Z.) and National Institutes of Health under award numbers 1R01AR072034-01A1 (to K.G.S. and J.A.Z.) and T32HD007434 (to J.A.Z.). Funding sources had no role in describing the protocol, planning the project, performing analyses, or interpreting the results. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

with acute and delayed ruptures, only data pertaining to the acute rupture group were included in the review. Due to the limitations of languages spoken by the investigatory team and access to translators, only studies in English, Danish, Swedish, Norwegian, German, French, Spanish, or Portuguese were included.

Data Extraction: Defining Early Functional Rehabilitation

Study inclusion and exclusion were determined by 2 independent reviewers (J.A.Z., M.C.) using Covidence systematic review software (Veritas Health Innovation) for citation management. In the event that consensus regarding inclusion could not be met, a third reviewer was consulted (K.G.S.). Data extraction was completed by 2 independent reviewers (J.A.Z., M.C.) using a REDCap database,[70] with the exception of non-English studies. Disagreements between reviewers were resolved through discussion, and if consensus could not be met, a third reviewer was consulted (K.G.S.). For non-English studies, a single reviewer completed data extraction due to language comprehension constraints among the study team.

Data extraction included study design (RCT, cohort study, or case series), number of participants, treatment type (surgical, nonsurgical, or both), and, when applicable, surgery type (simple repair or augmented repair). Type of early functional rehabilitation was categorized as follows: weightbearing, range of motion (exercises or as allowed by an orthosis permitting some movement), strength exercise with resistance and progression, isometric exercise, cardiovascular-based exercise (eg, stationary bike), general and core strengthening, balance, and other. All rehabilitation strategies used during the first 8 weeks and while participants were still using some form of immobilization were included. Timing of exercise and weightbearing onset was recorded. In cases where 2 or more groups with different rehabilitative protocols were used, the content of these protocols was combined for the purposes of describing type of rehabilitation, and the earliest onset time across groups was recorded.

Methodological Quality Assessment

Studies were assessed for methodological quality through use of the modified Downs & Black[79,98,145] checklist, in which 26 or above indicates excellent, 20-25 good, 15-19 fair, and 14 or less poor quality. Studies in English were scored by 2 independent reviewers. If there were inconsistencies in reviewer response, a third reviewer (J.A.Z. or M.C.) was consulted. Similar to data extraction, non–English language studies were scored by a single reviewer.

Data Extraction: Outcome Measures Data

Outcome measures used in each study were noted and subgrouped by domain (patient-reported outcome, survey-based functional outcome, functional outcome, and tendon properties). Time of outcomes assessment was recorded as 0-3 months, 4-6 months, 7-12 months, >1-5 years, and >5 years. All time points were extracted. If a study did not have predetermined time points for assessment, the mean or median time of assessment was recorded.

In cases where 2 or more studies analyzed the same group of participants, the studies were combined for the purposes of extracting outcome types and timing of outcomes assessment, and the primary study was used for total number of participants, rehabilitation strategy, and quality assessment. This was done to maximize the number of outcomes reported while not artificially inflating participant numbers.

Data Analysis

Data failed the assumptions of parametric statistics based on the Shapiro-Wilk test, so nonparametric tests were used for analysis. Descriptive statistics used are frequencies, medians, and interquartile ranges (IQRs). To better understand the types of studies included in this review, the relationship of study publication year and study quality was assessed by Spearman correlation.

To investigate timing of early functional rehabilitation, the onset of weightbearing and exercise (in weeks, with 0 indicating days 0-6, 1 indicating days 7-13, etc) is reported as frequencies of studies using a given start time. Time of weightbearing and exercise onset was also investigated by treatment intervention subgroup (nonsurgical, simple repair, or augmented repair), and differences in time of onset were compared between groups through use of an independent-samples Kruskal-Wallis test. Studies investigating only 1 type of treatment were included in the subgroup analysis. This is because it is possible that information from both treatment groups would have been listed together in studies comparing 2 different initial treatment strategies.

To identify changes in early functional rehabilitation over time, time of weightbearing and exercise onset was compared with publication year by use of Spearman correlation. Because not all studies included in the review were included in the individual analyses (eg, a study involving only early exercise would not be included in the weightbearing analyses), for each analysis the total number of primary studies included along with their median Downs & Black checklist score is reported.

RESULTS

Search Results and Study Inclusion

The results of the search and study inclusion are shown in Figure 1. Of the 174 included studies, 157 studies[#] were found to be primary studies, and 17 studies[**] were found to have overlapping populations and were included only in the reporting of additional outcomes and outcome

[#]References 1-12, 14, 16-18, 25-28, 30-36, 38-40, 42-46, 48, 50-54, 57, 58, 60, 62-68, 72, 73, 75-77, 80-86, 88-97, 99-103, 106-113, 115-117, 119-127, 129, 131-134, 137-144, 146, 150-159, 161-175, 179-187, 189-196, 199, 201-204.

[**]References 15, 19, 20, 41, 47, 71, 87, 104, 118, 130, 135, 136, 147-149, 188, 197.

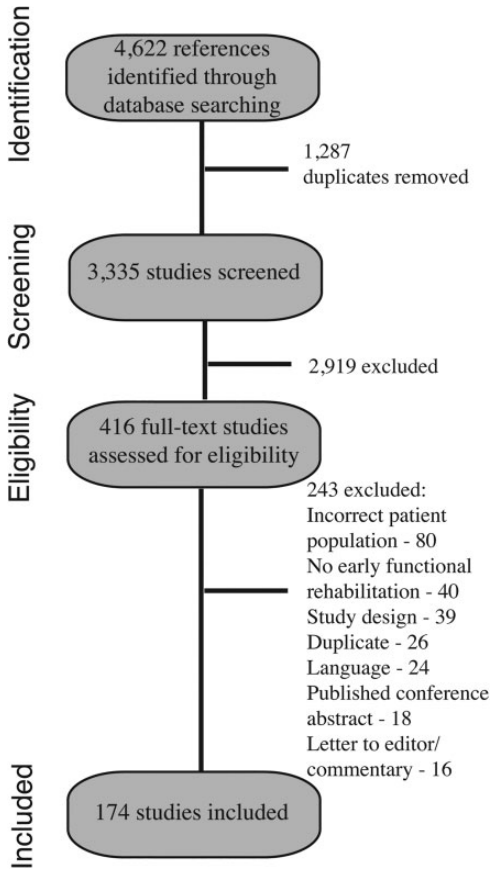

Figure 1. Search results and study inclusion-exclusion flowchart.

assessment timeframes. We included 16 non-English studies: 12 in German, 2 in Portuguese, 1 in Danish, and 1 in Spanish (see Appendix Tables A2 and A3).

Descriptive Analysis of Included Studies

Included primary studies were published between 1979 and 2018 (median [IQR], 2010 [2002-2015]), consisting of 38 RCTs and 119 cohort studies or case series. Studies rated a median [IQR] (range) of 17 [15-20] (4-25) on the Downs & Black checklist for quality assessment (see Appendix Table A2).

Included studies had a median [IQR] (range) of 40 [25-66] (10-363) participants, with a total of 9098 participants included in this systematic review. The included RCTs contained significantly more participants versus the cohort studies (median [IQR], range: RCTs, 52 [39-74], 14-156; cohort/case series, 35 [22-66], 10-363; $P = .011$) (Figure 2). Participants were managed surgically in 112 studies and nonsurgically in 20 studies (see Appendix Tables A2 and A3). A total of 24 studies included both surgical and nonsurgical groups, and 1 study had treatment described as "other" (open fibrin gluing without end-to-end repair). Surgery type was a simple repair in 114 studies and augmented repair in 33 studies.

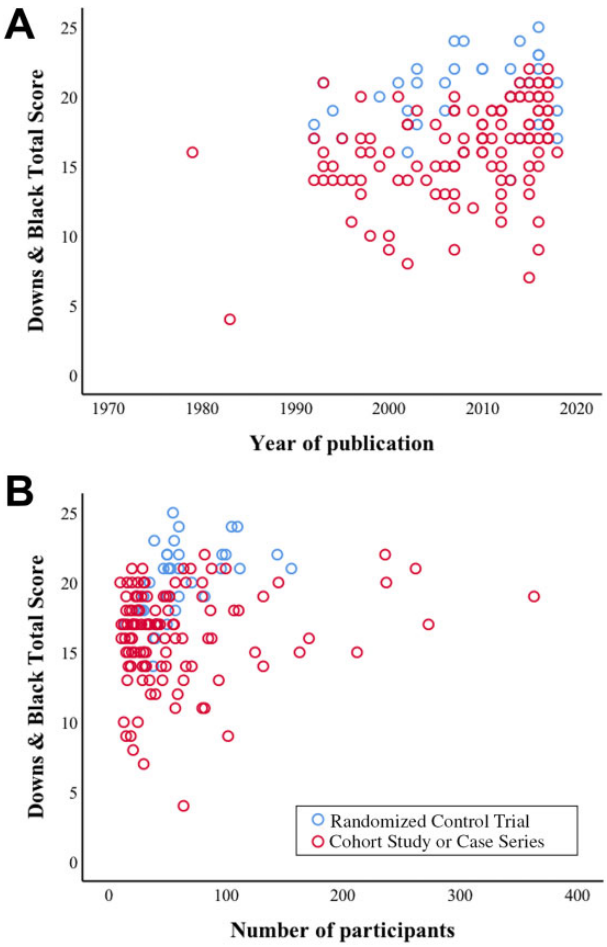

Figure 2. (A) Year of publication positively relates to study quality. (B) Distribution of number of participants to study quality by study design.

Onset of weightbearing was a median [IQR] of 2 weeks [0-3 weeks] after injury (Figure 3). Onset of exercise was a median (IQR) of 2 weeks (0-3 weeks) after injury (Figure 3).

Type of Early Functional Rehabilitation

Type of early functional rehabilitation is depicted in Figure 4. Interventions that were categorized as "other" (number of studies in parentheses) included massage (8), stretching (8), proprioception (8), electrical stimulation (5), cryotherapy (4), coordination (3), aqua therapy (3), proprioceptive neuromuscular facilitation (2), joint mobilization (1), ankle self-mobilization (1), neuromuscular exercise (1), night splint (1), and laser (1).

Descriptive Analysis of Early Functional Rehabilitation Onset by Treatment Subgroup

Distribution of the timing of weightbearing onset was not significantly different between groups (median [IQR]

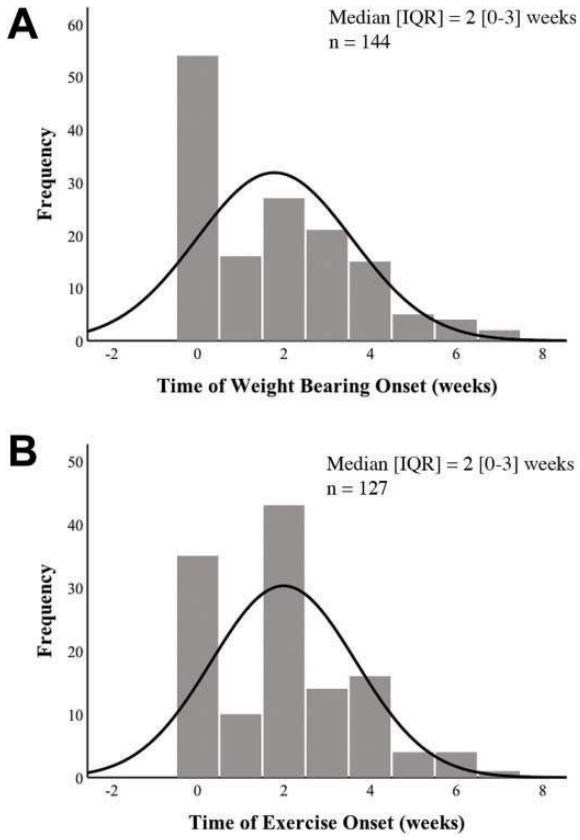

Figure 3. (A) Timing of weightbearing onset in entire group. (B) Timing of exercise onset in entire group.

nonsurgical, 0.0 [0.0-2.0]; simple surgical, 1.0 [0.0-3.0]; augmented surgical, 2.5 [0.0-3.0] weeks; $P = .060$) (Figure 5). Distribution of the timing of exercise onset was significantly different between groups (median [IQR] nonsurgical, 3.0 [2.0-4.0]; simple surgical, 2.0 [0.0-2.3]; augmented surgical, 0.5 [0.0-2.8 weeks]; $P = .017$) (Figure 5).

No differences were found in year of publication ($P = .530$) or study quality ($P = .148$) between studies based on initial intervention (nonsurgery, primary repair, or augmented repair) (nonsurgery: n = 20, median [IQR] year of publication = 2008 [1998-2016], study quality = 17 [14-20]; primary repair: n = 82, year of publication = 2011 [2003-2015], study quality = 17 [15-19]; augmented repair: n = 20, year of publication = 2007 [2001-2012], study quality = 15 [13-18]).

Change in Study Quality Over Time

Study quality improved with year of publication ($r_{sp} = 0.33$; $P < .001$) (Figure 2). In studies where exercise was initiated within the first 8 weeks (n = 127) (Downs & Black checklist score median [IQR], 17 [15-20]), time of exercise onset significantly increased with year of publication ($r_{sp} = 0.198$; $P = .026$) but was not significantly related to study quality ($r_{sp} = –0.016$; $P = .862$). In studies where weightbearing was initiated within the first 8 weeks (n = 144, Downs & Black checklist score median [IQR], 18 [15-20]), time of weightbearing onset was not significantly related to year of publication ($r_{sp} = –0.079$; $P = .344$) or study quality ($r_{sp} = 0.047$; $P = .572$).

Outcome Measures

Common outcome measures are shown in Figure 4 and Table 1. General outcomes categorized as "other" (number of studies in parentheses) in multiple studies included satisfaction (40), pain (29), time to a selected milestone (12), metrics regarding hospital stay or length (9), operative time (8), number of office or physical therapy visits (5), footwear restrictions (5), cost (4), Thompson/Matles test (4), Achilles tendon resting angle (3), Hannover scale (3), Boyden scale (3), aesthetics of surgical site (4), scale devised by the authors (2), Achilles tendon repair score (2), and pain medication use (2). A total of 4 studies included general "other" outcomes that were not used in any other study.

For the patient-reported outcomes domain, outcomes categorized as "other" in multiple studies included self-rating of specified functional activity (8), Victorian Institute of Sport Assessment – Achilles questionnaire (VISA-A) (6), EuroQol-5D (4), RAND 36-Item Health Survey (RAND-36) (3), Grimby Physical Activity Scale (4), Tegner Scale (3), Functional Index for Lower Leg (2), and 12-Item Short Form Health Survey (SF-12) (2). There were 9 studies that included outcomes not used by any other study.

For the functional outcomes domain, outcomes categorized as "other" in multiple studies included jump or hop testing (15), heel-toe walking (12), ankle circumference (4), pedobarography (3), ankle passive stiffness (3), muscle activity or electromyography (3), single-legged balance (3), and quadriceps circumference (2). For tendon-level outcomes, 2 studies reported other outcomes not used in any other study. Tendon-level outcomes categorized as "other" in multiple studies included tendon appearance on ultrasonography (11), tendon appearance on magnetic resonance imaging (7), tendon mechanical properties (7), gap distance (4), tendon adhesions (4), and muscle appearance on diagnostic imaging (3). We found that 7 studies reported outcomes that were not used in any other study.

Study outcomes were assessed between 0 and 3 months in 52 studies, between 4 and 6 months in 58 studies, between 7 and 12 months in 60 studies, between 1 and 5 years in 75 studies, and longer than 5 years in 8 studies (see Appendix Table A3).

DISCUSSION

This systematic review is the first to comprehensively evaluate the available literature to define early functional rehabilitation after Achilles tendon rupture with regard to type and timing of rehabilitative treatment. Early functional rehabilitation in the treatment of Achilles tendon rupture is commonly used (>150 publications) but still lacks a consistent definition. Lack of standardization of content and timing when this intervention is initiated hampers

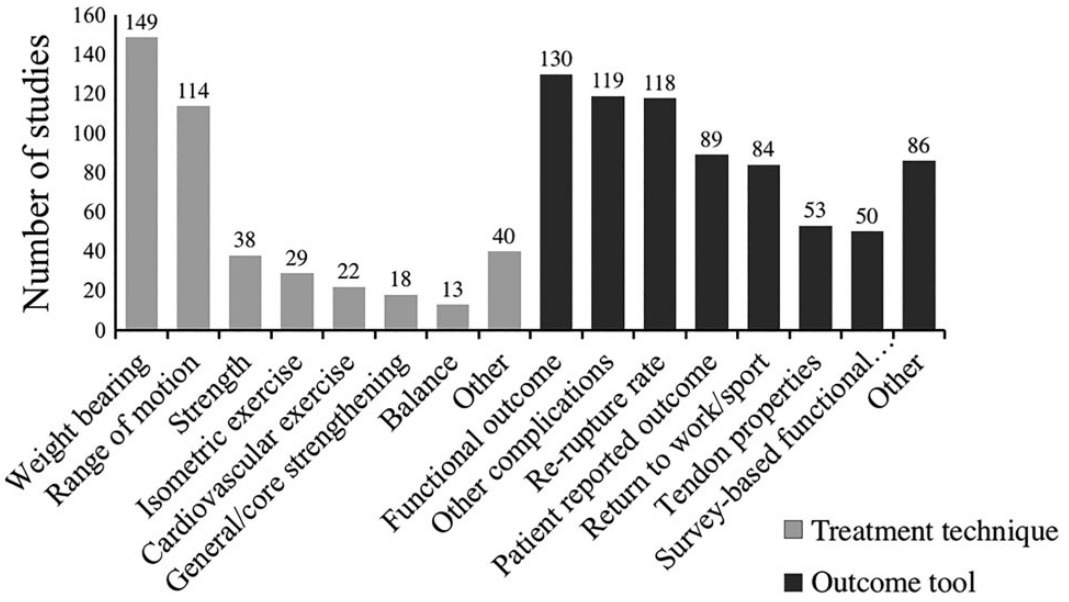

Figure 4. Type of early functional rehabilitation and outcome measures used.

evidence synthesis and implementation into clinical practice. Based on our comprehensive overview of the available literature, we define early functional rehabilitation as starting in the first 2 weeks after an acute Achilles tendon rupture. Such rehabilitation consists of a variety of weightbearing and exercise-based interventions.

Early functional rehabilitation tends to begin within the first 2 weeks after injury or surgery; however, there are subtleties in timing of weightbearing and exercise components based on initial treatment strategy (Figure 3). After surgical repair, both weightbearing and exercises tend to begin simultaneously—either immediately or 2 weeks after surgical repair. With nonsurgical management, the tendency is to initiate weightbearing immediately but delay initiation of exercise. Differences in trends of exercise onset between surgically and nonsurgically managed participants may result from clinical decision making aimed at approximating the tendon ends[37] and avoiding complications[29,49] while simultaneously providing enough tensile load to promote tendon healing.[59,174]

Early functional rehabilitation protocols incorporated a variety of different exercise-based intervention. Ankle range of motion was the most commonly included intervention. The goal of range of motion is likely to assist in tendon gliding and to prevent deep adhesion. In the context of this study, range of motion included both traditional ankle range of motion outside of the orthosis and use of a hinged orthosis. After ankle range of motion, strengthening was the next most common intervention. Despite mechanistic studies supporting the role of gradual tensile loading in order to promote tendon recovery,[6,59,174] only 52% (66/127) of studies with exercise-based interventions included isometric or other strengthening exercise. Less frequently did exercise interventions address more holistic concerns such as cardiovascular and global strengthening.

Timing of rehabilitation onset did not decrease relative to study year as we had hypothesized. Exercises were started later in more recent studies, and no relationship was observed between publication year and weightbearing onset. These findings could be explained by our inclusion criteria. A higher number of studies from more recent years were included, which may reflect more studies initiating rehabilitation within the first 8 weeks and when participants were still using an orthosis. Studies published less recently may have been excluded, skewing relationships between publication year and timing of rehabilitation onset.

A variety of outcome measures are used to assess patient response to treatment after Achilles tendon rupture. Broadly, these measures can be described in 2 groups: population-specific outcomes and general outcomes. Specific to this patient population, a variety of functional measures are commonly used along with tendon morphology and diagnosis-specific outcome measures, such as the Achilles tendon Total Rupture Score (ATRS). When looking at general outcomes, the American Orthopedic Foot and Ankle Score (AOFAS) was used in several studies as were numerous other patient-reported outcomes, such as patient satisfaction. From a research standpoint, it would be beneficial to develop a core outcome set that uses a combination of general and population-specific measures to allow comparison between populations of individuals with varying diagnoses as well as measures that more comprehensively assess the concerns of this particular patient population. The data from this study can be used as a first step in developing a core outcome set, as we have compiled frequencies of commonly used outcomes across multiple domains of patient assessment.

The available literature poses a variety of challenges regarding early functional rehabilitation after Achilles tendon rupture. Looking across the included literature, we find

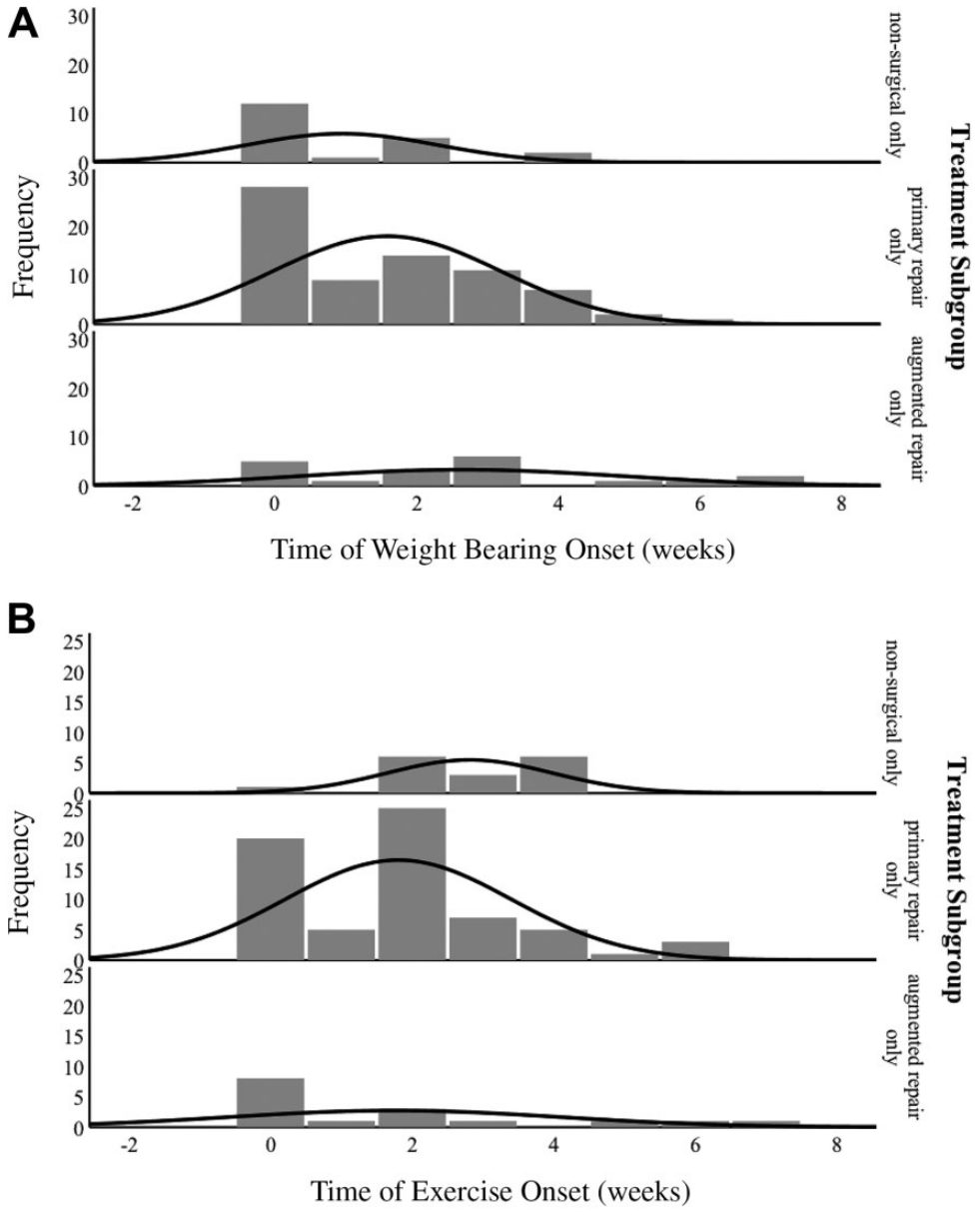

Figure 5. Timing of (A) weightbearing and (B) exercise onset in nonsurgically and surgically managed (primary and augmented repair) patients.

that studies are primarily cohort studies or case series. Although RCTs had significantly more participants on average, 73% of studies presenting data from 100 or more individuals were case series or cohort studies. The majority of research has been done on individuals undergoing simple surgical repair (73% of studies), whereas 28% of studies investigated individuals managed nonsurgically. It seems that little research is available on rehabilitative strategies for nonsurgically managed individuals, which is potentially concerning given trends of increasing numbers of patients managed without surgery.[61,177,178] Moving forward, it seems that tensile loading could be an area for rehabilitation protocol improvement. We found that only 1 in 2 studies included tensile-type loading, which has been suggested in basic science and mechanistic studies[6,7,59,174] to be of importance in the recovery of this patient population. Additionally, a variety of orthoses are used in immobilizing patients—casts, unhinged walking boots with wedging, hinged walking boots—and the effect of these devices on tendon healing from a mechanistic standpoint is not well-described, with 1 study comparing foot position between strategies.[56] The area of early functional rehabilitation continues to have great research potential, but standardizing outcomes and clearly stating rehabilitative protocols should be a focus moving forward.

Studies aimed at improving Achilles tendon rupture outcomes have used early functional rehabilitation, but this term has been applied without a well-established

TABLE 1
Outcome Measures Used[a]

Outcome Measure	No. of Studies
Patient-reported outcome (total)	89
Achilles tendon Total Rupture Score	27
Foot and Ankle Outcome Score	3
No information provided	1
Other patient-reported outcome	43
Survey-based functional outcome (total)	50
AOFAS	33
Leppilahti score	12
Thermann score	12
Functional outcome (total)	130
Ankle range of motion	84
Strength	76
Calf circumference	69
Heel-rise	56
Biomechanics/gait analysis	21
Other	39
Tendon properties (total)	53
Morphology	43
Biology (cellular studies)	1
Other	32

[a]AOFAS, American Orthopedic Foot and Ankle Score.

definition. Without a standardized definition, caution should be used when comparing outcomes between studies or pooling data from multiple studies, as the intervention could be very different even if treatment is labeled "early functional rehabilitation." This study was intended to describe trends across the literature regarding type and timing of early rehabilitation to synthesize an explicit definition. Therefore, the results of this study cannot be taken in a prescriptive sense, because efficacy of treatment protocols was not assessed. We intentionally took a broad approach to study inclusion, and it is important to consider that the Downs & Black checklist can substantially favor RCTs over even very large cohort studies and case series.

Clinically, the findings of this systematic review suggest that in most cases, early functional rehabilitation begins within the first 2 weeks after treatment initiation in individuals with Achilles tendon rupture. Weightbearing and range of motion are commonly used intervention strategies; however, a growing body of literature is using additional rehabilitative strategies such as strengthening interventions and general conditioning. Although general foot and ankle functional scores are regularly reported, several outcomes more specific to this patient population could be considered to assess patient response to treatment.

ACKNOWLEDGMENT

The authors thank Tyler Tice and Jordan Denesik for their assistance in scoring studies for risk of bias assessment and Anne Thielecke, Camilla Rams Rathleff, Barbara C. Brocki, Kathryn Wiser, and Susan Wiser for translation of foreign studies.

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APPENDIX

TABLE A1
Search String

Ovid Technologies
Database: Embase <1974 to 2017 Week 14>
Search Strategy:

1 achilles tendon rupture/
2 (calcaneus or calcanea* or achillis or achillean or achilles).mp.
3 (rupture* or injur* or tear or tears or lesion*).mp.
4 2 and 3
5 1 or 4
6 exp rehabilitation/
7 rehabilitation.fs.
8 (rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation).mp.
9 mobilization/
10 exp immobilization/
11 or/6-10
12 5 and 11

(continued)

Table A1 (continued)

Database: Ovid MEDLINE(R) Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) <1946 to Present>
Search Strategy:

1 Achilles Tendon/
2 exp Rupture/
3 (calcaneus or calcanea* or achillis or achillean or achilles).mp.
4 (rupture* or injur* or tear or tears or lesion*).mp.
5 1 or 3
6 2 or 4
7 5 and 6
8 exp Rehabilitation/
9 rehabilitation.fs.
10 (rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilisation).mp.
11 exp Immobilization/
12 or/8-11
13 7 and 12

Database: Pedro
Search Strategy:

1 Achilles tendon rupture

Database: CINAHL
Search Strategy:

1 (MH "Achilles Tendon Rupture")
2 calcaneus or calcanea* or achillis or achillean or achilles
3 rupture* or injur* or tear or tears or lesion*
4 #2 and #3
5 #1 or #4
6 (MH "Rehabilitation+")
7 rehabilitation or mobilization or mobilization or ambulation or exercise* or immobilization or immobilization
8 (MH "Immobilization")
9 #6 or #7 or #8
10 #5 and #9

Database: Cochrane
Search Strategy:

1 MeSH descriptor: [Achilles Tendon] explode all trees
2 (calcaneus or calcanea* or achillis or achillean or achilles): ti, ab
3 MeSH descriptor: [Rupture] explode all trees
4 (rupture* or injur* or tear or tears or lesion*): ti, ab
5 #1 or #2
6 #3 or #4
7 #5 or #6
8 MeSH descriptor: [Rehabilitation] explode all trees
9 rehabilitation or mobilization or mobilisation or ambulation or exercise* or immobilization or immobilization
10 #8 or #9
11 #7 and #10

TABLE A2
Summary of Interventions in All Included Studies[a]

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Nonsurgical Management											
Aujla[12] (2018)	No	236	*	*							22
Aujla[11] (2016)	No	88	*	*							21
Barfod[14] (2014)	Yes	60	*	*							24
Dolphin[48] (2016)	No	25	*	*							20
Ecker[54] (2016)	No	171	*	*		*	*	*			16
Hüfner[81] (2006)	No	125	*	*	*	*				*	15
Hüfner[80] (2002)	No	21	*	*		*	*	*		*	8
Kaniki[89] (2014)	No	145	*	*	*		*	*	*		20
Korkmaz[99] (2015)	No	47	*								21
McComis[127] (1997)	No	30	*	*	*					*	20
McNair[129] (2013)	No	38	*								14
Neumayer[143] (2010)	No	57	*	*					*	*	16
Persson[155] (1979)	No	20	*								16
Petersen[156] (2002)[b]	No	50	*								19
Reilmann[161] (1996)[c]	No	132	*		*			*		*	14
Roberts[166] (2001)	No	49	*	*							14
Saleh[168] (1992)	No	40	*	*	*					*	17
Swennergren[185] (2017)	No	28	*	*							19
Vavra-Hadziahmetovic[194] (2000)	No	19	*	*	*	*	*			*	9
Walz[195] (1993)[c]	No	22	*	*							15
Surgical Management											
Agres[1] (2018)	No	14	*	*	*	*			*		17
Aisaiding[2] (2018)	No	52	*	*	*	*		*			21
Aktas[3] (2007)	No	30	*	*							19
Al-Mouazzen[4] (2015)	No	30	*	*				*			15
Alviti[5] (2017)	No	20	*	*						*	20
Aoki[8] (1998)	No	22	*	*	*						17
Aspenberg[9] (2015)	No	16	*	*							13
Assal[10] (2002)	No	87	*	*			*	*			18
Baumfeld[16] (2019)	No	38	*								16
Bevoni[17] (2014)	No	66	*	*		*	*			*	20
Bhattacharyya[18] (2009)	Yes	59	*							*	12
Buchgraber[25] (1997)	No	48	*	*	*	*				*	16
Calder[26] (2005)	No	46		*							13
Carmont[27] (2015)	No	26	*	*						*	18
Carmont[28] (2017)	No	70	*	*							21
Ceccarelli[30] (2007)	No	24	*	*			*			*	19
Cetti[32] (1994)	No	60	*	*						*	19
Chandrakant[33] (2012)	No	52	*	*	*	*				*	19
Chen[34] (2015)	No	82		*						*	22
Chiu[35] (2013)	No	19	*								14
Chmielnicki[36] (2016)[c]	No	212	*								15
Costa[39] (2003)	No	28	*							*	18
Čretnik[41] (2004)	Yes	237	*	*						*	20
De Carli[42] (2016)	No	30	*	*							20
De la Fuente[43] (2016)	No	39	*	*						*	23
De la Fuente[44] (2016)	No	26	*	*	*				*		18
Delgado-Brambila[45] (2012)[d]	No	35		*						*	13
Ding[46] (2012)	Yes	88				*					16
Don[50] (2007)	No	49	*	*							15
Doral[51] (2013)	No	32	*	*	*					*	17
Dos Santos Gomes[52] (1998)[e]	No	13	*	*		*	*				10
Fernández-Fairén[57] (1997)	No	29	*	*	*		*	*			13
Fitzgibbons[58] (1993)	No	14	*								16
Gaiani[60] (2012)	No	80	*				*				11

(continued)

Table A2 (continued)

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Garrido[62] (2010)	No	18	*	*							16
Geremia[63] (2015)	No	18	*	*	*			*	*		18
Gigante[64] (2008)	No	40	*	*							16
Gorschewsky[65] (2004)	No	66	*	*	*				*		14
Gorschewsky[66] (1999)	No	20	*	*	*						15
Groetelaers[67] (2014)	No	60	*	*							21
Heikkinen[72] (2016)	No	55	*	*							25
Henríquez[73] (2012)	No	32	*						*	*	14
Holmenschlager[75] (2002)[c]	No	45	*	*							14
Horter[76] (2007)[c]	No	102	*	*							9
Hrnack[77] (2012)	No	15	*	*							15
Jacob[84] (2007)	No	36	*	*							12
Jallageas[85] (2013)	No	31	*	*		*					20
Jielile[86] (2012)	No	107	*	*	*	*	*	*			18
Kangas[88] (2003)	Yes	50	*	*				*			22
Karabinas[91] (2014)	No	34	*								17
Kauranen[92] (2002)	No	30	*	*		*					18
Keller[94] (2014)	No	100	*								21
Kerkhoffs[95] (2002)	No	39	*								16
Kim[96] (2017)	No	56	*	*	*						17
Kuskucu[100] (2005)	No	32	*	*							15
Lacoste[101] (2012)	No	33	*	*							19
Lansdaal[102] (2007)	No	163	*			*					15
Lapidus[106] (2007)	No	105	*								24
Lee[107] (2008)	No	11	*								16
Leppilahti[108] (2000)	No	85	*								16
Li[109] (2017)	No	24	*	*							18
Lonzarić[112] (2017)	No	262	*	*							21
Maffulli[116] (2010)	No	35	*	*	*	*					17
Maffulli[117] (2003)	Yes	53	*	*		*					21
Maffulli[119] (2001)	No	16	*								20
Majewski[120] (2008)	No	28	*	*							17
Mandelbaum[121] (1995)	No	29	*	*	*		*				14
Marti[122] (1983)	No	64	*								4
Martinelli[123] (2000)	No	30	*								7
Mauch[124] (2017)[c]	No	42	*			*				*	17
Mavrodontidis[125] (2015)	No	11	*								17
Mayer[126] (2010)[e]	No	24	*	*	*						17
Mezzarobba[131] (2012)	No	40	*	*							12
Miyamoto[133] (2017)	No	44	*	*	*						17
Moberg[134] (1992)	No	17		*							14
Mortensen[139] (1992)	No	57	*								18
Mortensen[138] (1999)	No	71	*	*							20
Motta[140] (1997)	No	71	*	*							14
Mukundan[141] (2010)	No	21	*								17
Mullaney[142] (2006)	No	20	*	*							17
Ocguder[146] (2011)	No	41	*	*		*					17
Ozer[151] (2016)	No	23	*	*				*			19
Ozkan[152] (2016)	No	15	*	*							19
Ozkaya[153] (2009)	No	25	*	*		*			*	*	19
Peng[154] (2017)	No	15	*	*	*			*		*	18
Porter[157] (2014)	No	40	*	*	*		*		*		17
Porter[158] (2015)	No	51	*	*	*						21
Quagliarella[159] (2010)	No	51	*								18
Richardson[163] (2003)	No	30	*	*	*					*	15
Rozis[167] (2018)	No	82	*	*	*					*	19
Sandberg[169] (2015)	No	31	*	*							14
Saper[170] (2016)	No	82	*	*							11
Saw[171] (1993)	No	19	*	*							14
Saxena[172] (2011)	No	27	*	*	*						15
Schäfer[173] (2002)[c]	No	40	*								18

(continued)

Table A2 (continued)

First Author (Year)	Secondary Study?	No. of Patients	Weightbearing	ROM	Strength	Isometric Exercise	Cardiovascular Exercise	General Strength	Balance	Other	Quality Score
Schepull[174] (2013)	No	35	*	*	*						20
Schepull[175] (2007)	No	10	*								20
Solveborn[179] (1994)	No	17	*	*							15
Sorrenti[180] (2006)	No	64		*			*	*		*	13
Speck[181] (1998)	No	20	*	*							16
Steele[182] (1993)	No	20	*								21
Strauss[183] (2007)	No	52	*			*					19
Suchak[184] (2008)	Yes	110	*	*						*	24
Tarniţă[186] (2016)	No	15	*	*							9
Tezeren[187] (2006)	No	24	*	*	*		*			*	19
Troop[190] (1995)	No	13	*	*							17
Vadalá[192] (2012)	No	80	*								19
Valkering[193] (2017)	No	56	*	*							23
Wredmark[201] (1992)	No	34	*								17
Yotsumoto[202] (2010)	No	20	*	*	*						18
Zayni[203] (2017)	No	29	*	*							21
Zell[204] (2000)	No	25	*	*						*	10
Both Nonsurgical and Surgical Management											
Cetti[31] (1993)	No	156	*								21
Costa[38] (2006)	No	96	*								21
Ebinesan[53] (2008)	No	63	*	*		*				*	16
Gwynne-Jones[68] (2011)	No	363	*	*		*				*	19
Hutchison[82] (2015)	No	273	*	*	*						17
Jackson[83] (2013)	No	80	*	*							20
Karaaslan[90] (2016)	No	16		*							17
Kearney[93] (2011)	No	49	*	*							19
Lantto[103] (2016)	Yes	60	*	*							22
Lill[110] (1996)[c]	No	57	*			*	*		*	*	11
Lim[111] (2018)	No	132	*	*		*				*	19
Lorkowski[113] (2007)	No	94								*	13
Maffulli[115] (2017)	No	26	*	*	*					*	18
Miller[132] (2005)	No	111	*								18
Moller[137] (2001)	Yes	112	*	*							21
Nilsson-Helander[144] (2010)	Yes	97	*	*							22
Olsson[150] (2013)	Yes	100	*	*	*	*	*	*		*	22
Renninger[162] (2016)	No	57	*	*	*		*	*			20
Richter[164] (1994)[c]	No	32	*								14
Richter[165] (1997)[c]	No	55	*			*	*		*	*	17
Thermann[189] (1995)[c]	Yes	50	*			*	*	*		*	17
Twaddle[191] (2007)	No	50	*	*							22
Weber[196] (2003)	No	47	*	*	*	*	*		*		19
Willits[199] (2010)	No	144	*	*	*		*	*	*		22
Knobe[97] (2015)	No	64	*	*							21

[a]The quality score was determined using the modified Downs & Black[79,98,145] checklist, in which 26 or above indicates excellent, 20-25 good, 15-19 fair, and 14 or less poor quality. ROM, range of motion.

[b]In Danish.

[c]In German.

[d]In Spanish.

[e]In Portuguese.

TABLE A3
Summary of Outcomes in All Included Studies

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	≤3	4-6	7-12	>1-5	>5
Nonsurgical Management													
Aujla[12] (2018)		*	*	*									*
Aujla[11] (2016)		*	*	*									*
Barfod[14] (2014)	*		*	*	*			Quality of life		*	*		
Dolphin[48] (2016)		*	*	*						*			
Ecker[54] (2016)	*	*	*	*	*	*	*	Pain, satisfaction, meteosensitivity					*
Hüfner[81] (2006)	*	*	*	*	*	*		Pain					*
Hüfner[80] (2002)	*								*		*		
Kaniki[89] (2014)	*	*	*				*				*		*
Korkmaz[99] (2015)		*	*	*	*		*			*	*		
McComis[127] (1997)	*		*		*		*	Cost of treatment		*			*
McNair[129] (2013)	*			*						*			
Neumayer[143] (2010)	*	*	*	*			*	Satisfaction		*	*		*
Persson[155] (1979)	*	*	*	*		*		Satisfaction					*
Petersen[156] (2002)[b]	*		*	*						*	*		
Reilmann[161] (1996)[c]	*	*	*	*	*			Meteosensitivity, pain, shoewear problems			*		
Roberts[166] (2001)	*	*	*		*								*
Saleh[168] (1992)	*		*	*	*			Satisfaction	*	*	*		
Swennergren[185] (2017)						*		Achilles tendon resting angle	*	*			
Vavra-Hadziahmetovic[194] (2000)	*	*		*		*	*	Thompson, Simmond and Matles signs; pain	*				
Walz[195] (1993)	*		*		*	*			*	*			
Surgical Management													
Agres[1] (2018)	*					*			*				
Aisaiding[2] (2018)	*	*	*	*	*	*			*	*			*
Aktas[3] (2007)	*	*	*	*	*		*	Pain					*
Al-Mouazzen[4] (2015)		*	*	*	*			Satisfaction	*	*	*		
Alviti[5] (2017)	*												
Aoki[8] (1998)	*		*		*			Time from surgery to weightbearing/ heel rising	*	*			
Aspenberg[9] (2015)						*			*	*			
Assal[10] (2002)	*	*	*		*		*						*
Baumfeld[16] (2019)	*	*		*	*		*	Satisfaction					*
Bevoni[17] (2014)	*	*	*	*	*		*						*
Bhattacharyya[18] (2009)	*	*						Pain/stiffness, readmission to hospital, length of hospital stay, pain medication	*	*	*		
Buchgraber[25] (1997)	*	*	*	*									*
Calder[26] (2005)	*	*	*	*			*		*	*	*		
Carmont[27] (2015)	*	*	*	*				Achilles tendon resting angle	*	*	*		
Carmont[28] (2017)	*			*	*			Achilles tendon resting angle, calf squeeze test	*	*	*		
Ceccarelli[30] (2007)	*	*	*				*						*
Cetti[32] (1994)	*	*	*	*		*		Satisfaction	*	*	*		
Chandrakant[33] (2012)		*	*				*	Time to plateau in improvement					*

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	≤3	4-6	7-12	>1-5	>5
Chen[34] (2015)	*	*	*				*	Operative time, scar length			*	*	
Chiu[35] (2013)	*	*	*			*			*	*		*	
Chmielnicki[36] (2016)[c]		*	*									*	
Costa[39] (2003)	*	*	*			*			*	*	*		
Čretnik[41] (2004)	*	*	*	*		*	*	Holz score, satisfaction				*	
De Carli[42] (2016)	*	*	*	*	*	*		Pain	*	*		*	
De la Fuente[43] (2016)	*	*	*	*				Pain, pain medication	*				
De la Fuente[44] (2016)	*	*	*	*		*			*				
Delgado-Brambila[45] (2012)[d]				*	*			Number of physical therapy visits		*			
Ding[46] (2012)	*	*	*				*	Scar length				*	
Don[50] (2007)	*			*					*	*	*	*	
Doral[51] (2013)	*			*	*							*	
Dos Santos Gomes[52] (1998)[e]	*				*	*		Pain, edema in Achilles tendon area			*		
Fernández-Fairén[57] (1997)	*	*	*	*			*	Stiffness				*	
Fitzgibbons[58] (1993)	*	*	*		*							*	
Gaiani[60] (2012)		*	*	*			*	Satisfaction					
Garrido[62] (2010)	*	*	*	*	*		*	Satisfaction				*	
Geremia[63] (2015)	*					*						*	
Gigante[64] (2008)	*	*	*	*		*		Operative time		*	*		
Gorschewsky[65] (2004)	*	*	*		*			Satisfaction			*		
Gorschewsky[66] (1999)	*	*	*		*			Length of hospitalization, operative time, time to full weightbearing, wound healing, satisfaction			*		
Groetelaers[67] (2014)	*	*	*	*	*			Satisfaction, Achilles tendon repair score	*	*	*		
Heikkinen[72] (2016)	*	*	*	*		*	*		*		*		*
Henríquez[73] (2012)	*	*	*		*			Cosmesis, length of scar				*	
Holmenschlager[75] (2002)[c]	*	*	*	*	*	*	*					*	
Horter[76] (2007)[c]		*	*									*	
Hrnack[77] (2012)	*	*					*					*	
Jacob[84] (2007)	*	*	*		*			Pain, satisfaction				*	
Jallageas[85] (2013)	*	*	*	*	*		*	Number of physical therapy sessions, pain				*	
Jielile[86] (2012)	*	*	*	*	*	*			*	*		*	
Kangas[88] (2003)	*	*	*			*	*		*	*		*	*
Karabinas[91] (2014)	*	*	*	*	*		*	Satisfaction, wound healing, Thompson test				*	
Kauranen[92] (2002)	*			*				Satisfaction	*	*			
Keller[94] (2014)	*	*	*	*	*		*	Satisfaction				*	
Kerkhoffs[95] (2002)		*	*	*	*			Length of hospital stay, satisfaction					*

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	≤3	4-6	7-12	>1-5	>5
Kim[96] (2017)	*			*	*		*	Time until able to do single heel-raise			*		
Kuskucu[100] (2005)	*	*	*		*		*		*	*		*	
Lacoste[101] (2012)	*	*	*		*			Socioeconomic and global satisfaction			*	*	
Lansdaal[102] (2007)		*	*		*		*	Operative time			*		
Lapidus[106] (2007)		*	*						*				
Lee[107] (2008)	*	*	*	*	*		*	Pain	*	*	*	*	
Leppilahti[108] (2000)	*					*						*	
Li[109] (2017)	*	*	*	*		*	*	Satisfaction, pain		*	*		
Lonzarić[112] (2017)	*	*	*		*			Number of physical therapy/clinic sessions, duration of immobilization, duration of crutch use	*	*			
Maffulli[116] (2010)	*	*	*	*	*			Time to full weightbearing					*
Maffulli[117] (2003)	*	*	*	*	*	*		Number of clinic/ physical therapy sessions, Boyden scale, satisfaction, footwear restrictions, time to full weightbearing				*	
Maffulli[119] (2001)	*	*	*			*		Boyden scale				*	
Majewski[120] (2008)	*			*	*			Hannover score, satisfaction			*		
Mandelbaum[121] (1995)	*	*	*		*				*	*	*		
Marti[122] (1983)	*	*	*		*							*	
Martinelli[123] (2000)	*		*		*	*							*
Mauch[124] (2017)[c]	*									*			
Mavrodontidis[125] (2015)	*	*	*	*	*	*		Pain, satisfaction					*
Mayer[126] (2010)[e]	*								*				
Mezzarobba[131] (2012)	*					*						*	
Miyamoto[133] (2017)	*	*	*		*	*	*	Time until able to perform heel-rises	*	*		*	
Moberg[134] (1992)	*										*		
Mortensen[139] (1992)	*	*	*	*	*	*		Satisfaction	*		*		
Mortensen[138] (1999)	*	*	*	*	*	*		Whether they had physical therapy, pain, satisfaction	*			*	
Motta[140] (1997)	*	*	*		*	*		Length of hospital stay	*		*	*	
Mukundan[141] (2010)	*	*			*		*				*		
Mullaney[142] (2006)	*											*	
Ocguder[146] (2011)	*	*	*	*	*		*	Operative time, pain				*	
Ozer[151] (2016)	*	*			*		*				*		

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type: Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	Time of Outcome Assessment, mo: ≤3	4-6	7-12	>1-5	>5
Ozkan[152] (2016)	*	*	*									*	
Ozkaya[153] (2009)	*	*	*		*		*					*	
Peng[154] (2017)	*			*		*				*			
Porter[157] (2014)	*			*								*	
Porter[158] (2015)	*	*		*	*						*		
Quagliarella[159] (2010)	*							Hannover score				*	
Richardson[163] (2003)	*	*	*	*	*		*	Footwear restrictions, satisfaction, pain				*	
Rozis[167] (2018)	*	*	*	*	*		*				*		
Sandberg[169] (2015)	*					*			*		*		
Saper[170] (2016)		*	*								*		
Saw[171] (1993)	*	*	*		*							*	
Saxena[172] (2011)					*								
Schäfer[173] (2002)[c]	*	*	*		*	*	*	Length of time using crutches, special shoe and night splint		*	*		
Schepull[174] (2013)	*		*	*		*			*	*	*		
Schepull[175] (2007)	*	*		*	*	*	*	Pain	*	*	*		
Solveborn[179] (1994)	*	*	*	*	*	*		Satisfaction	*		*		
Sorrenti[180] (2006)		*	*		*			Time to activities of daily living				*	
Speck[181] (1998)	*	*	*	*	*	*		Achilles tendon evaluation score (created by the authors), pain, satisfaction	*	*	*		
Steele[182] (1993)	*	*	*									*	
Strauss[183] (2007)		*	*	*	*		*	Pain, satisfaction, footwear restrictions, Boyden scale				*	
Suchak[184] (2008)	*	*	*	*				Number of steps	*	*	*		
Tarniţă[186] (2016)	*	*						Aesthetics of surgical site			*		
Tezeren[187] (2006)	*	*	*	*		*		Operative time, duration of hospital stay, scar adhesions, footwear problems, satisfaction, pain				*	
Troop[190] (1995)	*	*	*	*	*			Satisfaction				*	
Vadalá[192] (2012)	*	*	*	*	*	*		Hannover score				*	
Valkering[193] (2017)	*	*	*			*			*	*	*		
Wredmark[201] (1992)	*	*	*		*	*					*		
Yotsumoto[202] (2010)	*	*		*	*	*	*	Time to walk without pain or fear, time to normal walk, double- and single-legged heel-rises	*	*			
Zayni[203] (2017)	*	*		*	*	*	*	Satisfaction				*	
Zell[204] (2000)	*	*	*		*				*	*			

(continued)

Table A3 (continued)

First Author (Year)	Outcome Type								Time of Outcome Assessment, mo				
	Functional Outcome	Other Complications	Rerupture Rate	PROs	Return to Work/ Sport	Tendon Properties	Survey-Based Functional Outcome	Other General Outcome (Description)	≤3	4-6	7-12	>1-5	>5
Both Nonsurgical and Surgical Management													
Cetti[31] (1993)	*	*	*	*				Length of hospital stay, pain		*	*		
Costa[38] (2006)	*	*	*	*				Time to activities (sport, walking, stair climbing, work)	*	*	*		
Ebinesan[53] (2008)		*	*					Operative time, length of hospital stay, cost		*			
Gwynne-Jones[68] (2011)		*	*					Operative time					
Hutchison[82] (2015)		*	*	*				Achilles tendon repair score, cost		*	*		
Jackson[83] (2013)		*	*	*	*								
Karaaslan[90] (2016)	*	*	*	*	*			Satisfaction			*		
Kearney[93] (2011)				*				Completion rates	*	*	*		
Lantto[103] (2016)	*	*	*	*		*	*		*	*		*	
Lill[110] (1996)[c]	*	*	*		*	*	*	Length of hospital stay				*	
Lim[111] (2018)			*	*									*
Lorkowski[113] (2007)	*	*	*	*			*	Pain				*	
Maffulli[115] (2017)	*	*		*	*	*	*	Satisfaction				*	
Miller[132] (2005)		*	*	*	*			Pain, satisfaction					*
Moller[137] (2001)	*	*	*	*	*	*		Pain, satisfaction	*	*	*	*	
Nilsson-Helander[144] (2010)	*	*	*	*						*	*		
Olsson[150] (2013)	*	*	*	*					*	*	*		
Renninger[162] (2016)		*	*		*						*		
Richter[164] (1994)[c]	*		*	*	*					*			
Richter[165] (1997)[c]	*	*	*		*	*		Pain				*	
Thermann[189] (1995)[c]	*	*	*	*	*	*		Author-developed score, pain, satisfaction	*	*	*	*	
Twaddle[191] (2007)	*		*	*				Squeeze test	*	*	*		
Weber[196] (2003)	*	*	*	*	*		*	Length of hospital stay, pain, time to discontinuation of crutch use, satisfaction		*		*	
Willits[199] (2010)	*	*	*				*				*	*	
Knobe[97] (2015)	*	*	*	*	*	*	*	Satisfaction, pain				*	

[a]PROs, patient-reported outcomes.
[b]In Danish.
[c]In German.
[d]In Spanish.
[e]In Portuguese.