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Local Anesthetic Injection Resolves Movement Pain, Motor Dysfunction, and Pain Catastrophizing in Individuals With Chronic Achilles Tendinopathy: A Nonrandomized Clinical Trial

OBJECTIVES: Peripherally directed treatments (targeted exercise, surgery) can reduce, but not fully eliminate, pain for up to 40% of patients with Achilles tendinopathy. The objectives of the present study were (1) to identify indicators of altered central processing in participants with Achilles tendinopathy compared to controls, and (2) to determine which indicators of altered central processing would persist after a local anesthetic injection in patients with Achilles tendinopathy.

DESIGN: Mechanistic clinical trial.

METHODS: Forty-six adults (23 with chronic Achilles tendinopathy, 23 matched controls) repeated (1) a movement-evoked pain rating, (2) motor performance assessment, (3) pain psychology questionnaires, and (4) quantitative sensory testing. Participants with Achilles tendinopathy received a local anesthetic injection before repeat testing and controls did not. Mixed-effects analyses of variance examined the effects of group, time, and group by time.

RESULTS: The Achilles tendinopathy group had movement-evoked pain, motor dysfunction, and higher pain psychological factors (pain catastrophizing, kinesiophobia) compared to controls ($P<.05$). The Achilles tendinopathy group did not have indicators of nociplastic pain with quantitative sensory testing ($P>.05$). In those with Achilles tendinopathy, local anesthetic injection eliminated pain and normalized the observed deficits in heel-raise performance and pain catastrophizing (group-by-time effect, $P<.01$), but not in kinesiophobia ($P = .45$). Injection did not affect measures of nociplastic pain ($P>.05$).

CONCLUSION: People with Achilles tendinopathy had elevated pain psychological factors and motor dysfunction but no signs of nociplastic pain with quantitative sensory testing. Removal of nociceptive input normalized movement-evoked pain and some indicators of altered central processing (motor dysfunction, pain catastrophizing), but not kinesiophobia. *J Orthop Sports Phys Ther 2020;50(6):334-343. Epub 29 Apr 2020. doi:10.2519/jospt.2020.9242*

KEY WORDS: *central sensitization, kinesiophobia, kinetics, movement-evoked pain, nociceptive*

People with Achilles tendinopathy report activity limitations and demonstrate motor dysfunction, particularly of the plantar flexors.[1-7,11,12,16-18,23,26-29,31,36,37,46,47] Peripheral nociceptive input can cause motor dysfunction. In healthy volunteers, experimentally induced Achilles tendon pain reduces muscle activation[20] and experimentally induced knee pain intensity correlates with strength.[21] Pain and motor dysfunction can be perpetuated by psychological factors. To date, only 1 study has examined pain psychology in Achilles tendinopathy.[25,35] Participants with Achilles tendinopathy and higher fear of movement (ie, kinesiophobia) regained less calf muscle endurance (fewer heel raises) with a progressive Achilles tendon loading program than participants with lower kinesiophobia.[35] Nociplastic pain is driven by sensitization of the central nervous system and, despite resolution of the initial cause(s),[22] may contribute to persistent Achilles tendinopathy, although there are conflicting findings.[33,41]

Our aims were (1) to identify indicators of altered central processing in participants with Achilles tendinopathy compared to control participants without chronic pain, matched by age, sex, and body mass index (BMI); and (2) to determine which indicators of altered central processing persist after a local anesthetic

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injection to the Achilles tendon in patients with Achilles tendinopathy.

A secondary analysis examined correlations between indicators of altered central processing in participants with Achilles tendinopathy that changed with an anesthetic injection.

METHODS

In this mechanistic, nonrandomized controlled trial, all participants repeated testing twice in the following order within a single laboratory-based testing session: (1) movement-evoked pain ratings, (2) motor performance, (3) pain psychology questionnaires, and (4) sensory testing. The Achilles tendinopathy group received an anesthetic injection after the first set of tests. For participants with bilateral Achilles tendinopathy, the more painful side was designated the involved side for testing and injection.

Injection

A sports medicine physician performed an ultrasound examination to determine the presence of tendinosis, enthesophytes, and/or bursitis. The participant's reported area of maximum pain within the insertion or midportion of the Achilles tendon was used to individualize the location of the injection (**FIGURE 1**). The onset for ropivacaine was 10 to 20 minutes, and pain relief lasted for 6 to 8 hours. Repeat testing began 30 minutes after the injection. Participants with Achilles tendinopathy were contacted 1 day and 1 week following testing to ask about any injection-related adverse events.

Participants

Participants were recruited from January 2016 to May 2018. The flow of participants from enrollment to analysis is reported using a Consolidated Standards of Reporting Trials diagram (**FIGURE 2**). Participants with Achilles tendinopathy were recruited at university-based orthopaedic surgery foot and ankle clinics and sports medicine tendinopathy clinics when scheduling notes indicated evaluation for pain that could be related to Achilles tendinopathy. Participants with Achilles tendinopathy were also recruited with a university-wide mass e-mail and chart review of patients seeking care for Achilles-related pain at university-affiliated clinics. Screening was completed in person (recruitment in the clinic) and by phone (mass e-mail or chart review recruitment). Controls were recruited through a university-wide mass e-mail and www.researchmatch.org, and screened via an online survey to identify persons who

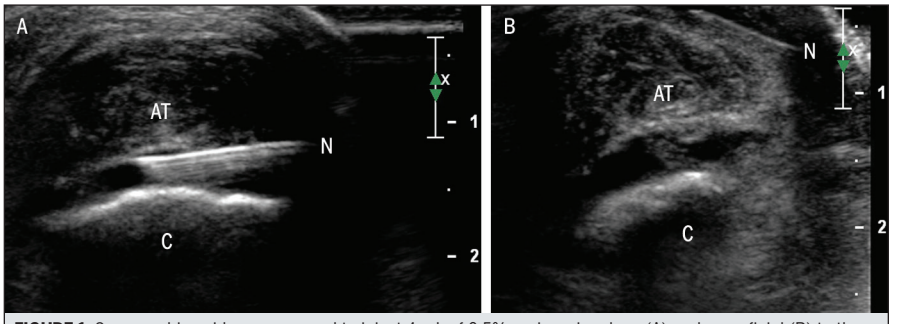

FIGURE 1. Sonographic guidance was used to inject 4 mL of 0.5% ropivacaine deep (A) and superficial (B) to the tendon to ensure coverage of the painful region. The needle was first inserted between the AT and the calcaneus to administer ropivacaine. The needle was then redirected posterior to the AT to administer more anesthetic. Abbreviations: AT, Achilles tendon; C, calcaneus; N, needle.

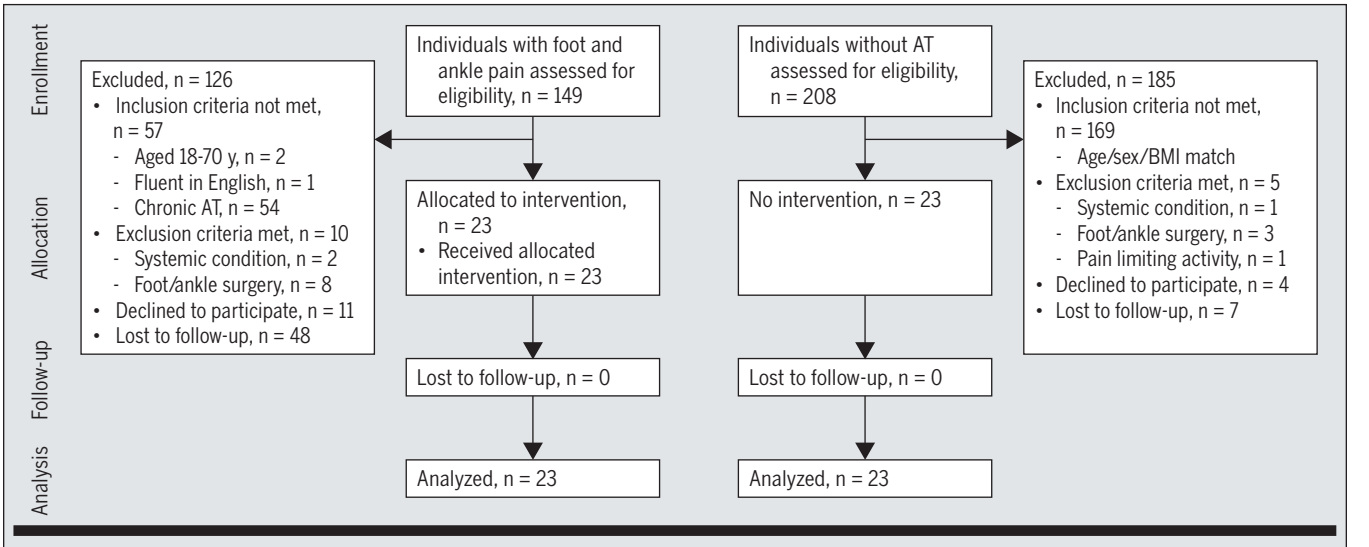

FIGURE 2. Flow chart of participants from enrollment through analysis. Among participants excluded from participation, "lost to follow-up" and "declined" were most common (59/149 screened), with fear of an injection or lack of time being commonly reported reasons. Fifty-four individuals screened did not meet the criteria for chronic AT due to their AT pain being too acute/infrequent (less than 3 months in duration or no current symptoms), or they did not have AT pain but rather a differential diagnosis. Abbreviations: AT, Achilles tendinopathy; BMI, body mass index.

best matched the participants with Achilles tendinopathy based on age, sex, and BMI. Eligibility criteria are listed in **TABLE 1**. All participants consented to participate in this study, which was approved by the University of Iowa Institutional Review Board (IRB-01 Biomedical) and registered at www.clinicaltrials.gov (Achilles Pain Block, NCT03316378). Study data were collected and managed using the REDCap electronic data-capture tools hosted at the University of Iowa.

Baseline Sample Characteristics

The Patient-Reported Outcomes Measurement Information System (PROMIS) short form 8b (depression) assessed self-reported depression.[32] The Brief Pain Inventory (BPI) quantified global pain intensity and interference with activity participation.[40] The Victorian Institute of Sport Assessment-Achilles (VISA-A) questionnaire measured symptom severity.[34] The International Physical Activity Questionnaire (IPAQ) short form quantified participant-reported physical activity in metabolic equivalents of task minutes over the past week.[14] The numeric pain-rating scale was used to quantify pain over the past week and monitor movement-evoked pain during study participation.[49]

Repeated Measures

All of the following repeated measures demonstrated good test-retest reliability in the control group (intraclass correlation coefficient of 0.8 or greater), except for temporal summation (TS) measures (intraclass correlation coefficient of 0.43 to 0.76) (**APPENDIX TABLE 1**, available at www.jospt.org).

Motor Control Performance

Plantar flexor endurance was assessed by the maximum number of single-limb heel raises on each side. For balance, participants were permitted to use a railing at elbow height to support themselves with their fingertips. Participants were encouraged to do as many repetitions as possible until they could not do any more with proper form (heel-raise height at least 50% of first repetition, knee straight, trunk upright) or until the task became too painful (greater than 4/10).

Routine (stair ascent) and novel (waltz box step) activities were collected with 3-D motion analysis. Stair ascent represented a rhythmic task, which may not be as susceptible to changes in peripheral nociception due to established brain activation patterns and locomotor central pattern generators.[24] The waltz box step represented a novel task, which may be more susceptible to change. As previously described,[13] the transitional step from the ground to the stairs was analyzed. Cadence was standardized using a metronome at 100 beats per minute.[24] For the waltz task, the push-off from the supporting limb onto the contralateral side during a lateral sidestep was analyzed (**APPENDIX FIGURE**). Speed was standardized with the auditory cue of music at 80 beats per minute.

A minimum of 3 trials per task were normalized to stance phase and averaged to create one representative trial. Digitized points defined the ankle joint center as the midpoint between the malleoli, using Visual3D software (C-Motion, Inc, Germantown, MD). The ankle was modeled as the calcaneus relative to the tibia. A 9-camera Optotrak 3-D motion-analysis system (Northern Digital Inc, Waterloo, Canada) tracked motion at a rate of 60 Hz. A force plate embedded in the floor provided 3-D ground reaction forces (Kistler Group, Winterthur, Switzerland). Kinematic data were smoothed using a fourth-order, zero-phase-lag Butterworth filter with a cutoff frequency of 6 Hz.

Pain Psychology Questionnaires

Controls were instructed to think about any pain/discomfort during the motor tasks when completing the Tampa Scale of Kinesiophobia (TSK)[44] and the Pain Catastrophizing Scale (PCS).[39] Participants with Achilles tendinopathy were given the same instruction, except to specifically think about any pain/discomfort in their Achilles tendon. To explore the potential short-term effect of an anesthetic injection on pain psychology, participants also completed the PCS during a 1-week follow-up phone call.

Quantitative Sensory Testing

The pressure pain threshold (PPT) was used to detect primary hyperalgesia at the (more) involved Achilles and widespread hyperalgesia (heel and hamstring on the contralateral side; near the elbow at the muscle belly of the wrist extensors bilaterally). A pressure algometer (Somedic

TABLE 1 Eligibility Criteria for All Participants and Specific Criteria Per Group

Inclusion Criteria		Exclusion Criteria	
AT Group	**Control Group**	**AT Group**	**Control Group**
• Adults aged 18-70 y • Speak and read English • Chronic (>3 mo) AT: - Pain aggravated by activity - Tendon stiffness after prolonged rest - Localized tenderness to palpation (insertional: within 2 cm of tendon insertion; midportion: 2-6 cm proximal to tendon insertion)	• Adults aged 18-70 y • Speak and read English • Matched with an AT participant - Age (±3 y) - Sex - BMI (±4 kg/m^2)	• Unable to do stairs unassisted (eg, use of assistive device) • History of foot or ankle surgery • Currently pregnant or nursing • Systemic condition contributing to pain with activity (eg, fibromyalgia) • Previous adverse reaction to local anesthetic	• Unable to do stairs unassisted (eg, use of assistive device) • History of foot or ankle surgery • Currently pregnant or nursing • Systemic condition contributing to pain with activity (eg, fibromyalgia) • Disease or pathology that contributed to pain, limiting activity in the past 6 mo

Abbreviations: AT, Achilles tendinopathy; BMI, body mass index.

SenseLab AB, Sösdala, Sweden) was applied perpendicular to the skin at a rate of 50 kPa/s with a 1-cm^2 tip. Participants pressed a button when the sensation of pressure first became painful (greater than 0/10). The mean of 3 trials per area represented the PPT. After the anesthetic injection, the Achilles PPT on the involved side was greater than 600 kPa, which confirmed adequate anesthesia and absence of peripheral nociceptive input.

For conditioned pain modulation (CPM), the conditioning stimulus was a 120-second cold-water bath of the hand. Pressure pain thresholds were assessed at the hamstring and heel on the contralateral Achilles tendinopathy side after the hand was in the cold-water bath for at least 20 seconds. An increase in PPT during the conditioning stimulus indicated CPM.

We used 2 methods to assess TS to cold and heat. For cold, participants rated their hand pain at 5 and 20 seconds during a 120-second cold-water bath, with the hand submerged up to the wrist crease. An increase in hand pain from 5 to 20 seconds during the cold-water bath indicated TS. Because of variable reliability, heat TS was not analyzed (**APPENDIX TABLE 1**).

Statistical Analysis

Changes in Achilles tendon pain from preinjection to postinjection were compared with Wilcoxon signed-rank tests. Mixed-effects analyses of variance were used to examine group, time, and group-by-time interaction effects for motor performance, pain psychology, and sensory testing. The type I error rate for the analyses of variance was maintained at .05 by using a Bonferroni adjustment for multiple comparisons (3 comparisons for motor performance, 2 comparisons for pain psychology, and 4 comparisons for sensory testing). The elbow PPTs for the left and right sides were averaged because there were no side-to-side differences (paired *t* test; first repetition, $P = .116$; second repetition, $P = .932$). Post hoc comparisons examined significant interaction effects, and *P* values were Bonferroni adjusted for the number of time points. We used sensitivity analysis to check whether our results were consistent across Achilles tendinopathy subtypes (midportion/insertional) and laterality (unilateral/bilateral). This study was not sufficiently powered to detect changes in the primary outcomes with smaller subgroups (n = 7-16), so statistical significance was defined as $P<.05$ (unadjusted) for this exploratory post hoc analysis. We used Pearson correlations to examine relationships between the magnitudes of change after an anesthetic injection of identified indicators of altered central processing in the Achilles tendinopathy group.

A priori power analysis determined that a sample size of 20 per group was needed to detect effect sizes (between groups, >0.91; over time, >0.68) less than or equal to published results for ankle power (mean difference, 0.9 ± 0.9 W/kg),[13] kinesiophobia (minimal detectable change, 5.6 ± 5.7 points),[19] and PPT (group difference, 171.8 ± 174.8 kPa),[30] with a power of at least 80% and statistical significance defined as $P\leq.05$. Because 3 participants with Achilles tendinopathy had insufficient movement-evoked pain relief from the anesthetic injection, an additional 3 participants were recruited per group.

RESULTS

Sample Characteristics

The groups were matched by age, sex, and BMI ($P>.05$) (**TABLE 2**). Additional participant characteristics are reported in **TABLE 2**. Most participants with Achilles tendinopathy had had symptoms for at least a year (median, 1.3 years; interquartile range, 0.8-2.8 years). Many had seen a physical therapist (52%), and all had tried some form of treatment for Achilles tendinopathy symptoms (**TABLE 3**). Of participants with Achilles tendinopathy, 70% had unilateral pain (**TABLE 4**). Insertional Achilles tendinopathy (70%) was more frequent in this sample than midportion Achilles tendinopathy (30%). The majority of participants had signs of tendinosis, and participants with insertional Achilles tendinopathy often had enthesophytes and/or bursitis on ultrasound imaging (**TABLE 4**).

Achilles Tendinopathy Pain

Prior to the anesthetic injection, all participants with Achilles tendinopathy reported movement-evoked pain (**TABLE 5**). After the injection, movement-evoked

TABLE 2 Baseline Characteristics of the Control and Achilles Tendinopathy Groups[a]

	Controls (n = 23)	AT (n = 23)	Group Comparison[b]	*P* Value
Age, y	49.2 ± 10.6	49.5 ± 10.3	0.3 (−5.9, 6.6)	.930
Sex (female), n (%)	15 (65)	15 (65)	...	1.000
Body mass index, kg/m^2	31.3 ± 5.7	33.7 ± 7.8	2.5 (−1.6, 6.5)	.229
PROMIS-depression	46.4 ± 7.6	46.7 ± 8.2	0.2 (−4.6, 5.1)	.921
BPI-intensity	0.1 (0.0-0.8)[c]	2.5 (1.7-3.6)[c]	2.1 (1.5, 2.8)[d]	<.001
BPI-interference	0.0 (0.0-1.0)[c]	1.9 (1.1-3.7)[c]	1.6 (0.7, 2.4)[d]	.002
VISA-A	100 (100-100)[c]	39.0 (33.0-59.0)[c]	−61.0 (−64.0, −54.0)[d]	<.001
IPAQ-total physical activity, MET-min/wk	2508 (759-3984)[c]	2220 (798-3920)[c]	53 (−1110, 1112)[d]	.910

Abbreviations: AT, Achilles tendinopathy; BPI, Brief Pain Inventory; IPAQ, International Physical Activity Questionnaire; MET, metabolic equivalent; PROMIS, Patient-Reported Outcomes Measurement Information System; VISA-A, Victorian Institute of Sport Assessment-Achilles.
[a]*Values are mean ± SD unless otherwise indicated.*
[b]*Values are mean difference (95% confidence interval) unless otherwise indicated. Sample characteristics were compared between groups using independent-samples t tests for parametric data, the Mann-Whitney U test for nonparametric data, or the chi-square test for categorical data.*
[c]*Values are median (interquartile range).*
[d]*Values are median group difference (Hodges-Lehmann statistic).*

pain reduced ($P<.01$ for all comparisons), although some participants reported a mild sensation of discomfort during activity. One participant had increased pain after the injection due to pressure in retrocalcaneal space, and 2 participants had partial pain relief (movement-evoked pain of at least 1/10). The Achilles tendinopathy group reported no injection-related adverse events.

Motor Control Performance Measures

Prior to the anesthetic injection, the Achilles tendinopathy group performed fewer heel raises than controls (post hoc group effect at time 1, $P = .006$). After the anesthetic injection, the Achilles tendinopathy group was able to complete a similar number of heel raises to that completed by controls (group-by-time effect, $P = .036$; post hoc group effect at time 2, $P = .272$) (**TABLE 6**). A sensitivity analysis indicated a consistent improvement in heel-raise number for all Achilles tendinopathy subgroups (insertional, midportion, unilateral, bilateral) after the anesthetic injection compared to controls (group-by-time effect, $P<.05$) (**APPENDIX TABLES 2** through **5**). Although the sensitivity analysis also indicated an effect of group, this was driven by between-group differences prior to the injection (control versus insertional, $P = .018$ and versus unilateral, $P = .012$), not after the injection (control versus insertional, $P = .09$ and versus unilateral, $P = .200$). There were no differences between groups (Achilles tendinopathy versus control) and no effect of injection in the Achilles tendinopathy group on motor performance in the low-level activities of stair ascent and the waltz ($P>.05$ for all group, time, and group-by-time effects) (**TABLE 6**).

TABLE 3 Types of Treatment and Treatment Provider[a]

	Sample, %
Treatment provider	
Physical therapist	52
Other care provider (chiropractor, massage therapist, orthopaedic surgeon, podiatrist, primary care provider, sports medicine physician)	57
Treatment	
Stretching	70
Tendon-loading exercise	61
Shoe insert (eg, heel lift, arch support)	57
Night splints	39
Pain medication (NSAID, acetaminophen)	26
Modalities (ice, heat)	22
Corticosteroid injection	13
Nitroglycerine patch over Achilles tendon	7
Iontophoresis	7
Soft tissue instrument-assisted mobilization	4

Abbreviation: NSAID, nonsteroidal anti-inflammatory drug.
[a]*All participants had seen a care provider and/or tried at least 1 form of treatment. Many participants had seen multiple care providers and tried multiple treatments for Achilles tendinopathy pain.*

TABLE 4 Frequency of Pathology Assessed Using Ultrasound Imaging in Participants With Achilles Tendinopathy, by Subtype

Type/Laterality	Tendinosis	Enthesophytes	Bursitis
Insertional (n = 16)			
Unilateral (n = 11)	8/11 (73%)	9/11 (82%)	8/11 (73%)
Bilateral (n = 5)	5/5 (100%)	5/5 (100%)	5/5 (100%)
Midportion (n = 7)			
Unilateral (n = 5)	4/5 (80%)	0/5 (0%)	0/5 (0%)
Bilateral (n = 2)	2/2 (100%)	0/2 (0%)	0/2 (0%)

Pain Psychology Questionnaires

The Achilles tendinopathy group had higher TSK and PCS scores than controls (group effect, $P<.001$ for both comparisons) (**TABLE 6**). The anesthetic injection had no effect on TSK score (group-by-time interaction effect, $P = .450$), and the TSK score was slightly lower in both groups with repeat testing (time effect, $P = .012$) (**TABLE 6**). The anesthetic injection lowered the PCS score in participants with Achilles tendinopathy to levels similar to those of controls. Participants with Achilles tendinopathy had a higher PCS score prior to the anesthetic injection ($P<.001$) and at 1 week ($P<.001$) than that of controls, but there was no difference between groups immediately after the injection (post hoc testing, $P = .582$). The sensitivity analysis yielded the same results for all subgroups (**APPENDIX TABLES 2** through **5**).

Quantitative Sensory Testing

Localized The Achilles tendinopathy group had a lower Achilles tendon PPT than that of controls (Achilles tendinopathy, 423.0 ± 196.1; control, 645.1 ± 250.3; mean difference, 222.1; 95% confidence interval: 88.5, 355.7; $P<.01$).

Widespread The PPTs on the contralateral heel and hamstring increased during CPM, and there were increases in pain over time during TS in both groups (time effect, $P<.001$) (**TABLE 6**). There were no differences between groups for any of the indicators of nociplastic pain (group effect and group-by-time effect, $P>.05$ for

all comparisons) (**TABLE 6**). The sensitivity analysis yielded the same group and group-by-time effects for all subgroups (**APPENDIX TABLES 2** through **5**). There was a reduction of less than 30 kPa between the first and second repetitions of PPT at the elbow for certain subgroups (control versus insertional, $P = .016$ and control versus unilateral, $P = .045$) (**APPENDIX TABLES 2** and **4**). The sensitivity analysis also detected a group-by-time interaction ($P = .046$) for TS, where participants with midportion Achilles tendinopathy (n = 7) had a smaller increase in pain rating prior to the injection (1.5-point increase in numeric pain-rating scale) compared to after (2.2-point increase) and to the control group (2- to 2.7-point increase) (**APPENDIX TABLE 3**).

Relationship Between Motor Control, Pain, and Pain Psychology

In the Achilles tendinopathy group, there were correlations between improved heel-raise performance and reduced TSK score ($r = -0.57$, $P = .01$) and decreased pain ($r = -0.46$, $P = .04$) (**FIGURE 3**). Reduction in pain was not significantly correlated with a reduction in TSK score ($r = 0.32$, $P = .16$). Change in PCS score was not correlated with heel-raise performance, pain, or TSK score ($r<0.2$, $P>.05$). To fulfill the assumptions of parametric testing, 2 outliers (increases of 18 and 25) for the change in the maximum number of heel raises after an anesthetic injection were capped at the third highest value in the sample (increase of 9).

DISCUSSION

We detected motor dysfunction and elevated pain catastrophizing and fear of movement in participants with Achilles tendinopathy. We did not detect nociplastic pain with measures of widespread sensitivity, TS, and CPM. An anesthetic injection at the site of Achilles tendon pain immediately improved heel-raise performance and reduced pain catastrophizing, yet kinesiophobia remained elevated.

Altered Processing in the Central Nervous System of Participants With Achilles Tendinopathy

Participants with Achilles tendinopathy, compared to controls, had altered central processing on some indicators, including motor dysfunction with single-limb heel raises, higher pain catastrophizing, and higher kinesiophobia. Consistent with Plinsinga et al,[33] who showed no alterations in pain thresholds outside the Achilles tendinopathy site, we failed to detect signs of nociplastic pain. The lack of widespread reductions in PPT

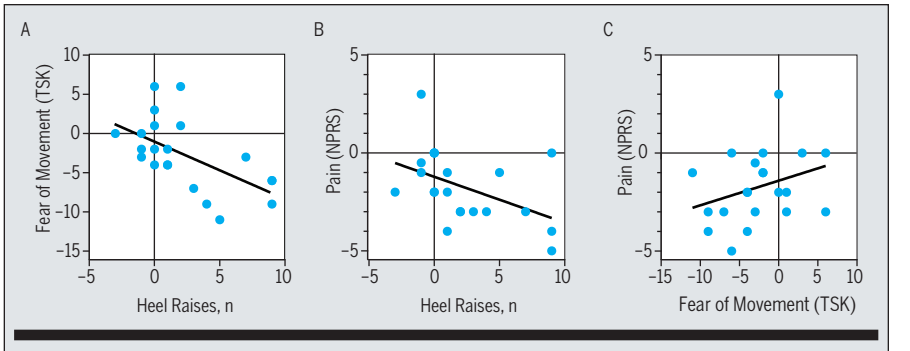

FIGURE 3. Pearson correlations between (A) an indicator of altered central processing (motor dysfunction using the number of heel raises) and heightened pain psychology (using the TSK) ($r = -0.57$, $P = .01$), (B) number of heel raises and changes in pain (reported during the single-limb heel raise using the NPRS) ($r = -0.46$, $P = .04$), and (C) heightened pain psychology and changes in pain ($r = 0.32$, $P = .16$) after an anesthetic injection in participants with Achilles tendinopathy. Abbreviations: NPRS, numeric pain-rating scale; TSK, Tampa Scale of Kinesiophobia.

TABLE 5 Achilles Tendinopathy Pain Ratings on a 0-to-10 Verbal Numeric Pain-Rating Scale[a]

Pain Rating	Total AT (n = 23)	Insertional AT (n = 16)	Midportion AT (n = 7)	Unilateral AT (n = 16)	Bilateral AT (n = 7)
Highest in past week	7.0 (5.0-8.0)	8.0 (5.5-9.0)	5.0 (4.0-6.0)	5.5 (4.3-8.0)	8.0 (7.0-9.0)
Lowest in past week	0.0 (0.0-1.0)	0.0 (0.0-1.0)	1.0 (0.0-1.0)	0.0 (0.0-1.0)	0.0 (0.0-1.0)
Standing, time 1	1.0 (0.0-2.0)	0.5 (0.0-1.0)	1.0 (0.5-3.0)	1.0 (0.5-2.0)	0.3 (0.0-1.8)
Standing, time 2	0.0 (0.0-0.1)	0.0 (0.0-0.4)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.1 (0.0-1.0)
Stairs, time 1	2.0 (1.0-3.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	2.0 (1.0-2.8)	3.0 (1.5-4.0)
Stairs, time 2	0.0 (0.0-1.0)	0.0 (0.0-1.0)	0.0 (0.0-0.5)	0.0 (0.0-0.9)	0.0 (0.0-1.0)
Waltz, time 1	1.8 (1.0-2.3)	1.5 (1.0-3.0)	2.0 (1.0-2.0)	1.3 (1.0-2.0)	2.5 (1.1-3.5)
Waltz, time 2	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	0.0 (0.0-1.3)
Heel raise, time 1	2.0 (0.3-4.0)	2.5 (0.8-4.0)	2.0 (0.0-5.0)	2.0 (0.0-3.0)	4.0 (1.5-5.5)
Heel raise, time 2	0.0 (0.0-0.5)	0.0 (0.0-1.5)	0.0 (0.0-0.0)	0.0 (0.0-0.0)	1.5 (0.0-3.3)

Abbreviation: AT, Achilles tendinopathy.
[a]*Values are median (interquartile range). Participants rated their AT pain over the past week, pain during standing, and movement-evoked pain (stairs, waltz, heel raise). For the last 4 activities, participants rated their pain at 2 time points: prior to the anesthetic injection (time 1) and after the anesthetic injection (time 2).*

TABLE 6 Measures of Altered Central Processing, Including Motor Dysfunction, Heightened Pain Psychology Factors, and Nociplastic Pain, in Participants With Achilles Teninopathy

Domain/Test/Time Point[a]	AT Group[b]	Control Group[b]	Bonferroni-Adjusted *P* Value: Group	Time	Group by Time
Motor performance					
Maximum single-limb HRs, n			.054	.708	.036
Time 1	13.5 (9.4, 17.6)	22.5 (18.5, 26.6)			
Time 2	17.0 (12.8, 21.1)	21.3 (17.3, 25.3)			
Peak plantar flexor power during stair ascent, W/kg			1.000	1.000	.369
Time 1	2.7 (2.3, 3.0)	3.0 (2.6, 3.3)			
Time 2	2.8 (2.4, 3.2)	2.8 (2.4, 3.2)			
Peak plantar flexor power during the waltz, W/kg			1.000	.327	1.000
Time 1	0.8 (0.6, 1.0)	0.7 (0.5, 0.9)			
Time 2	0.7 (0.5, 0.9)	0.6 (0.5, 0.8)			
Pain psychology questionnaires					
Tampa Scale of Kinesiophobia			<.001	.012	.450
Time 1	37.2 (34.7, 39.7)	29.6 (27.1, 32.1)			
Time 2	34.9 (32.5, 37.3)	28.7 (26.2, 31.1)			
Pain Catastrophizing Scale			<.001	<.001	<.001
Time 1	12.6 (9.2, 15.9)	1.9 (−1.5, 5.2)			
Time 2	2.5 (1.2, 3.7)	1.3 (0.0, 2.6)			
Time 3	8.3 (5.5, 11.2)	0.9 (−1.9, 3.7)			
Quantitative sensory testing					
PPT at the wrist extensors, kPa[c]			1.000	.136	1.000
Time 1	330.6 (270.9, 390.4)	303.2 (243.4, 362.9)			
Time 2	314.8 (260.6, 368.9)	280.3 (226.1, 334.5)			
CPM: PPT at hamstrings contralateral to AT pain, kPa			.664	<.001	1.000
Before CPM: time 1	463.5 (375.2, 551.8)	383.6 (297.4, 469.8)			
During CPM: time 1	596.5 (475.5, 717.5)	501.0 (382.9, 619.1)			
Before CPM: time 2	425.7 (345.3, 506.0)	358.0 (280.0, 436.4)			
During CPM: time 2	530.3 (448.7, 611.8)	432.0 (352.3, 511.6)			
CPM: PPT at heel contralateral to AT pain, kPa			1.000	<.001	1.000
Before CPM: time 1	789.6 (650.2, 929.1)	729.4 (597.9, 860.9)			
During CPM: time 1	960.3 (804.2, 1116.4)	842.9 (695.8, 990.1)			
Before CPM: time 2	731.3 (609.3, 853.3)	653.5 (538.5, 768.5)			
During CPM: time 2	837.0 (707.0, 967.1)	766.5 (643.9, 889.2)			
Temporal summation: verbal numeric pain rating during ice bath of the hand			1.000	<.001	.418
5 s: time 1	3.2 (2.5, 3.9)	2.9 (2.2, 3.6)			
20 s: time 1	5.2 (4.2, 6.1)	4.9 (4.1, 5.8)			
5 s: time 2	3.1 (2.2, 3.9)	3.1 (2.3, 3.9)			
20 s: time 2	5.3 (4.3, 6.2)	5.8 (4.9, 6.7)			

Abbreviations: AT, Achilles tendinopathy; CPM, conditioned pain modulation; HR, heel raise; PPT, pressure pain threshold.
[a]*Time point 1, prior to the anesthetic injection/first repetition (controls); time point 2, after the anesthetic injection/second repetition (controls); time point 3, at 1-week follow-up (Pain Catastrophizing Scale only).*
[b]*Values are mean (95% confidence interval).*
[c]*Measured bilaterally as the average of the left and right sides.*

or enhanced TS suggests that there was not a general increase in central excitability. However, the enhanced pain catastrophizing and motor dysfunction, reversed by local anesthetic, suggests enhanced central excitability. However, it was localized and maintained by continued nociceptive input. There may be a localized, not widespread, loss of central inhibition in individuals with Achilles tendinopathy.[41]

Nociceptive Input Drives Movement Pain, Motor Dysfunction, and Pain Catastrophizing

Eliminating nociceptive input nearly eliminated movement-evoked pain, motor dysfunction, and pain catastrophizing. Our findings suggest that heel-raise performance was impaired by peripheral nociceptive input, yet expectation of pain relief could influence outcomes.[8] Also, it remains unknown whether motor dysfunction with high-level plyometric tasks (eg, running, jumping) would similarly resolve with pain relief. Interpretation of clinical examination findings in some individuals could be altered if Achilles tendinopathy pain provokes motor dysfunction and/or elevates pain psychological factors, rather than the reverse. Future studies should consider the potential interplay of pain, motor function, and psychological factors identified in this study with other factors such as tendon pathology, altered mechanical properties of the tendon, and neuromuscular control measures.[10,48]

Kinesiophobia Was Linked to Motor Dysfunction and Was Independent of Nociceptive Input

Unlike pain catastrophizing, kinesiophobia did not resolve with an anesthetic injection. Severity might explain the differential effect on psychological factors. Participants with Achilles tendinopathy had elevated kinesiophobia (37.2 ± 6.2; high TSK score, 37 or greater[44]), while pain catastrophizing was well below the clinical cutoff (12.6 ± 10.6; high PCS score, 30 or greater[39]). In patients with knee pain, interventions that reduce pain can also greatly reduce catastrophizing, indicating that the PCS may reflect a more dynamic state than a stable trait.[15,45] Our data suggest that pain relief alone may be sufficient to address low levels of pain catastrophizing in patients with chronic Achilles tendinopathy—but not kinesiophobia, at least acutely.

Improvement in motor dysfunction (heel-raise performance) was moderately associated with pain relief and reduced kinesiophobia. Absence of a significant correlation between changes in pain and kinesiophobia indicates that peripheral nociceptive input and kinesiophobia may both independently contribute to motor dysfunction in moderate-level tasks involving the foot and ankle. These findings underscore the importance of using psychologically informed physical therapy to evaluate any relationship between pain, motor dysfunction, and kinesiophobia.

Limitations

This mechanistic study modeled the immediate effect of a treatment targeting peripheral nociceptive input, which was confirmed by an absence of sensation to pressure in the Achilles tendinopathy group. An injection can also have central effects that reduce pain, such as the expectation of pain relief.[38,42,43] Yet prior studies support anesthetic injection to reduce pain ratings more than saline injection when the pain condition is localized.[9,38,50] More research is needed to understand how pain mechanisms may differ in acute Achilles tendinopathy and subtypes of Achilles tendinopathy (insertional, midportion, unilateral, bilateral).

CONCLUSION

Participants with Achilles tendinopathy had signs of altered central processing, including motor dysfunction and pain psychology (elevated pain catastrophizing and kinesiophobia). We did not detect other signs of nociplastic pain, like widespread sensitivity, enhanced TS, or reduced CPM. Heel-raise performance immediately improved with pain relief. Elevated kinesiophobia did not resolve with removal of nociceptive input. ◉

KEY POINTS

FINDINGS: People with chronic Achilles tendinopathy had movement-evoked pain, motor dysfunction, elevated pain catastrophizing, and elevated fear of movement. A local anesthetic injection eliminated pain and normalized the observed deficits in motor performance and pain catastrophizing, but not in fear of movement.

IMPLICATIONS: Peripheral nociceptive input drives localized movement-evoked pain and some signs of altered central processing (motor dysfunction, pain catastrophizing), but not fear of movement. To address all Achilles tendinopathy–associated deficits identified in this study, patients may benefit from psychologically informed physical therapy to evaluate any relationship between pain, motor dysfunction, and kinesiophobia.

CAUTION: Although we found that peripheral nociceptive input was a mechanism for motor dysfunction, evaluation of all factors contributing to motor dysfunction is needed to tailor care to the individual.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Dr Chimenti prepared the first draft of the manuscript, and all authors contributed to the revision and final approval.

DATA SHARING: Individual participant data that underlie the results reported in this article, after deidentification, will be available immediately following publication and up to 5 years following publication. These data will be shared with researchers who provide a methodologically sound proposal and will use the data to achieve aims specified in the proposal. Proposals should be directed to the corresponding author. To gain access, data requestors will need to sign a data-access agreement.

PATIENT AND PUBLIC INVOLVEMENT: There was no patient or public involvement in this study.

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APPENDIX

Table 1. Within-Session Test-Retest Reliability in Controls, Who Did Not Receive an Anesthetic Injection Between Repeat Tests

	ICC[a]
Motor performance measures	
Plantar flexor endurance: maximum number of single-limb heel raises	0.83 (0.63, 0.92)
Stair ascent biomechanics, peak motion, and plantar flexor kinetics	
Dorsiflexion	0.82 (0.57, 0.92)
Moment	0.91 (0.78, 0.96)
Power	0.83 (0.61, 0.93)
Waltz biomechanics, peak motion, and plantar flexor kinetics	
Dorsiflexion	0.91 (0.79, 0.96)
Moment	0.93 (0.84, 0.97)
Power	0.97 (0.92, 0.99)
Pain psychology questionnaires	
Tampa Scale of Kinesiophobia	0.89 (0.75, 0.95)
Pain Catastrophizing Scale	0.90 (0.78, 0.96)
Quantitative sensory testing	
Pressure pain threshold	
Heel	0.93 (0.79, 0.97)
Hamstring	0.95 (0.89, 0.98)
Elbow	0.93 (0.81, 0.97)
Conditioned pain modulation	
Hamstring pressure pain threshold	0.86 (0.65, 0.94)
Heel pressure pain threshold	0.93 (0.78, 0.97)
Temporal summation with constant cold stimulus (NPRS)	
Hand: 5 s	0.76 (0.52, 0.89)
Hand: 20 s	0.71 (0.29, 0.88)
Heat pain threshold	
Hand	0.80 (0.64, 0.89)
Temporal summation with constant heat stimulus (NPRS)[b]	
Hand: first repetition	0.43 (0.11, 0.66)
Hand: fifth repetition	0.72 (0.50, 0.85)
Hand: 10th repetition	0.58 (0.32, 0.77)

Abbreviations: ICC, intraclass correlation coefficient; NPRS, numeric pain-rating scale.

[a]*Values in parentheses are 95% confidence interval. The ICC estimates were calculated based on absolute agreement with a 2-way mixed-effects model. The ICCs for ankle biomechanics and pressure pain thresholds were based on a mean rating (k = 3); those for heel raises, pain psychology questionnaires, and temporal summation were based on a single measure.*

[b]*Due to poor reliability, temporal summation to a constant heat stimulus was not further analyzed. For temporal summation to heat, the stimulus intensity was the temperature that the participant rated 4/10 from a series of 10 randomly ordered pulses from 40°C to 49°C (TSA 2 neurosensory analyzer; Medoc Ltd, Ramat Yishai, Israel). A 4/10 pain stimulus was delivered 10 times to the thenar eminence. The temperature started at 2°C below the 4/10 pain intensity stimulus and increased at a rate of 8°C/s; there were 2.5 seconds between stimuli. Pain was reported after the first, fifth, and 10th repetitions. Temporal summation was defined as the peak pain rating minus the initial pain rating. For test-retest reliability, the ICCs were examined in the control group.*

APPENDIX

Table 2. Measures of Altered Central Processing, Including Motor Dysfunction, Heightened Pain Psychology Factors, and Nociplastic Pain, in Participants With Insertional AT

Domain/Test/Time Point[a]	Insertional AT Group[b]	Control Group[b]	*P* Value		
			Group	Time	Group by Time
Motor performance					
Maximum single-limb HRs, n			.027[c]	.734	.049
Time 1	14.2 (9.2, 19.2)	22.5 (18.5, 26.6)			
Time 2	16.0 (11.4, 20.6)	21.3 (17.3, 25.3)			
Peak plantar flexor power during stair ascent, W/kg			.804	.637	.264
Time 1	2.8 (2.4, 3.2)	3.0 (2.6, 3.3)			
Time 2	2.9 (2.4, 3.3)	2.8 (2.4, 3.2)			
Peak plantar flexor power during the waltz, W/kg			.816	.019[c]	.13
Time 1	0.8 (0.6, 1.0)	0.7 (0.5, 0.9)			
Time 2	0.6 (0.4, 0.8)	0.6 (0.5, 0.8)			
Pain psychology questionnaires					
Tampa Scale of Kinesiophobia			.001	.030	.484
Time 1	36.5 (33.8, 39.2)	29.6 (27.1, 32.1)			
Time 2	34.8 (31.8, 37.7)	28.7 (26.2, 31.1)			
Pain Catastrophizing Scale			<.001	<.001	.001
Time 1	13.1 (8.9, 17.2)	1.9 (0.0, 5.2)			
Time 2	2.8 (1.2, 4.4)	1.3 (0.0, 2.6)			
Time 3	7.4 (4.6, 10.3)	0.9 (0.0, 3.7)			
Quantitative sensory testing					
PPT at the wrist extensors, kPa[d]			.502	.016[c]	.881
Time 1	333.9 (260.7, 407.2)	303.2 (242.1, 364.3)			
Time 2	308.2 (243.9, 372.5)	280.3 (226.7, 334.0)			
CPM: PPT at hamstrings contralateral to AT pain, kPa			.435	<.001	.388
Before CPM: time 1	422.8 (318.9, 526.6)	383.6 (297.4, 469.8)			
During CPM: time 1	579.1 (427.2, 731.1)	501.0 (382.9, 619.1)			
Before CPM: time 2	379.0 (285.9, 472.0)	358.0 (280.0, 436.4)			
During CPM: time 2	503.2 (401.5, 604.9)	432.0 (352.3, 511.6)			
CPM: PPT at heel on side contralateral to AT pain, kPa			.861	<.001	.811
Before CPM: time 1	710.0 (535.6, 884.3)	729.4 (597.9, 860.9)			
During CPM: time 1	903.0 (700.3, 1105.7)	842.9 (695.8, 990.1)			
Before CPM: time 2	648.6 (496.0, 801.2)	653.5 (538.5, 768.5)			
During CPM: time 2	800.1 (627.0, 973.2)	766.5 (643.9, 889.2)			
Temporal summation: verbal numeric pain rating during ice bath of the hand			.84	<.001	.673
5 s: time 1	3.0 (2.1, 3.9)	2.9 (2.2, 3.6)			
20 s: time 1	5.2 (4.0, 6.3)	4.9 (4.1, 5.8)			
5 s: time 2	3.4 (2.3, 4.5)	3.1 (2.3, 3.9)			
20 s: time 2	5.6 (4.4, 6.8)	5.8 (4.9, 6.7)			

Abbreviations: AT, Achilles tendinopathy; CPM, conditioned pain modulation; HR, heel raise; PPT, pressure pain threshold.
[a]*Time point 1, prior to the anesthetic injection/first repetition (controls); time point 2, after the anesthetic injection/second repetition (controls); time point 3, at 1-week follow-up (Pain Catastrophizing Scale only).*
[b]*Values are mean (95% confidence interval).*
[c]*Change in statistical significance compared to the primary analysis.*
[d]*Measured bilaterally as the average of the left and right sides.*

APPENDIX

Table 3 . Measures of Altered Central Processing, Including Motor Dysfunction, Heightened Pain Psychology Factors, and Nociplastic Pain, in Participants With Midportion AT

			P Value		
Domain/Test/Time Point[a]	**Midportion AT Group[b]**	**Control Group[b]**	**Group**	**Time**	**Group by Time**
Motor performance					
Maximum single-limb HRs, n			.103	.067	.009
Time 1	12.1 (5.1, 19.1)	22.5 (18.6, 26.5)			
Time 2	18.9 (11.4, 26.3)	21.3 (17.6, 24.9)			
Peak plantar flexor power during stair ascent, W/kg			.374	.565	.096
Time 1	2.4 (1.8, 3.0)	3.0 (2.6, 3.3)			
Time 2	2.7 (2.0, 3.5)	2.8 (2.5, 3.1)			
Peak plantar flexor power during the waltz, W/kg			.673	.217	.022[c]
Time 1	0.7 (0.3, 1.0)	0.7 (0.5, 0.9)			
Time 2	0.8 (0.4, 1.2)	0.6 (0.5, 0.8)			
Pain psychology questionnaires					
Tampa Scale of Kinesiophobia			.004	.002	.061
Time 1	38.7 (33.7, 43.7)	29.6 (27.2, 31.9)			
Time 2	35.3 (31.1, 39.5)	28.7 (26.3, 31.0)			
Pain Catastrophizing Scale			<.001	<.001	<.001
Time 1	11.4 (7.9, 15.0)	1.9 (0.0, 5.0)			
Time 2	1.7 (0.0, 4.1)	1.3 (0.0, 2.7)			
Time 3	10.4 (6.2, 14.7)	0.9 (0.0, 3.6)			
Quantitative sensory testing					
PPT at the wrist extensors, kPa[d]			.568	.517	.242
Time 1	323.2 (212.1, 434.2)	303.2 (241.9, 364.4)			
Time 2	329.8 (220.7, 439.0)	280.3 (220.1, 340.5)			
CPM: PPT at hamstrings on contralateral AT pain side, kPa			.108	.001	.973
Before CPM: time 1	539.1 (385.6, 692.6)	383.6 (304.3, 463.0)			
During CPM: time 1	628.8 (415.0, 842.6)	501.0 (388.8, 613.2)			
Before CPM: time 2	512.3 (369.2, 655.5)	358.0 (280.7, 435.3)			
During CPM: time 2	580.6 (433.1, 728.1)	432.0 (345.2, 518.7)			
CPM: PPT at heel on side contralateral to AT pain, kPa			.147	.012	.607
Before CPM: time 1	922.4 (680.2, 1164.6)	729.4 (590.7, 868.1)			
During CPM: time 1	1055.9 (781.0, 1330.8)	842.9 (682.8, 1003.0)			
Before CPM: time 2	869.2 (656.2, 1082.1)	653.5 (521.8, 785.2)			
During CPM: time 2	898.5 (665.8, 1131.2)	766.5 (618.6, 914.5)			
Temporal summation: verbal numeric pain rating during ice bath of the hand			.734	<.001	.046[c]
5 s: time 1	3.6 (2.3, 4.8)	2.9 (2.2, 3.6)			
20 s: time 1	5.1 (3.7, 6.6)	4.9 (4.1, 5.8)			
5 s: time 2	2.4 (1.0, 3.9)	3.1 (2.3, 3.9)			
20 s: time 2	4.6 (3.2, 5.9)	5.8 (5.0, 6.5)			

Abbreviations: AT, Achilles tendinopathy; CPM, conditioned pain modulation; HR, heel raise; PPT, pressure pain threshold.
[a]*Time point 1, prior to the anesthetic injection/first repetition (controls); time point 2, after the anesthetic injection/second repetition (controls); time point 3, at 1-week follow-up (Pain Catastrophizing Scale only).*
[b]*Values are mean (95% confidence interval).*
[c]*Change in statistical significance compared to the primary analysis.*
[d]*Measured bilaterally as the average of the left and right sides.*

APPENDIX

Table 4. Measures of Altered Central Processing, Including Motor Dysfunction, Heightened Pain Psychology Factors, and Nociplastic Pain, in Participants With Unilateral AT

			P Value		
Domain/Test/Time Point[a]	**Unilateral AT Group[b]**	**Control Group[b]**	**Group**	**Time**	**Group by Time**
Motor performance					
Maximum single-limb HRs, n			.037[c]	.457	.047
Time 1	14.1 (9.3, 18.9)	22.5 (18.5, 26.6)			
Time 2	16.8 (11.8, 21.8)	21.3 (17.3, 25.3)			
Peak plantar flexor power during stair ascent, W/kg			.555	.837	.098
Time 1	2.6 (2.2, 3.0)	3.0 (2.6, 3.3)			
Time 2	2.8 (2.3, 3.3)	2.8 (2.4, 3.2)			
Peak plantar flexor power during the waltz, W/kg			.332	.142	.498
Time 1	0.9 (0.6, 1.1)	0.7 (0.5, 0.9)			
Time 2	0.7 (0.5, 1.0)	0.6 (0.5, 0.8)			
Pain psychology questionnaires					
Tampa Scale of Kinesiophobia			.005	.025	.544
Time 1	35.2 (32.3, 38.1)	29.6 (27.1, 32.1)			
Time 2	33.6 (30.8, 36.5)	28.7 (26.2, 31.1)			
Pain Catastrophizing Scale			<.001	<.001	<.001
Time 1	10.8 (7.6, 14.0)	1.9 (0.0, 5.2)			
Time 2	1.6 (0.2, 3.0)	1.3 (0.0, 2.6)			
Time 3	6.7 (4.3, 9.0)	0.9 (0.0, 3.7)			
Quantitative sensory testing					
PPT at the wrist extensors, kPa[d]			.406	.045[c]	.856
Time 1	338.9 (264.9, 413.0)	303.2 (242.1, 364.3)			
Time 2	319.8 (251.3, 388.2)	280.3 (226.7, 334.0)			
CPM: PPT at hamstrings on contralateral AT pain side, kPa			.053	<.001	.536
Before CPM: time 1	512.1 (400.2, 624.1)	383.6 (297.4, 469.8)			
During CPM: time 1	678.3 (523.0, 833.7)	501.0 (382.9, 619.1)			
Before CPM: time 2	462.9 (362.6, 563.2)	358.0 (280.0, 436.4)			
During CPM: time 2	573.3 (475.4, 671.2)	432.0 (352.3, 511.6)			
CPM: PPT at heel on side contralateral to AT pain, kPa			.172	<.001	.770
Before CPM: time 1	876.7 (712.9, 1040.5)	729.4 (597.9, 860.9)			
During CPM: time 1	1004.6 (811.7, 1197.5)	842.9 (695.8, 990.1)			
Before CPM: time 2	768.8 (625.7, 911.8)	653.5 (538.5, 768.5)			
During CPM: time 2	866.2 (715.6, 1016.7)	766.5 (643.9, 889.2)			
Temporal summation: verbal numeric pain rating during ice bath of the hand			.911	<.001	.440
5 s: time 1	3.5 (2.6, 4.4)	2.9 (2.2, 3.6)			
20 s: time 1	5.0 (3.9, 6.1)	4.9 (4.1, 5.8)			
5 s: time 2	3.2 (2.1, 4.4)	3.1 (2.3, 3.9)			
20 s: time 2	5.2 (4.0, 6.5)	5.8 (4.9, 6.7)			

Abbreviations: AT, Achilles tendinopathy; CPM, conditioned pain modulation; HR, heel raise; PPT, pressure pain threshold.
[a]*Time point 1, prior to the anesthetic injection/first repetition (controls); time point 2, after the anesthetic injection/second repetition (controls); time point 3, at 1-week follow-up (Pain Catastrophizing Scale only).*
[b]*Values are mean (95% confidence interval).*
[c]*Change in statistical significance compared to the primary analysis.*
[d]*Measured bilaterally as the average of the left and right sides.*

APPENDIX

Table 5. Measures of Altered Central Processing, Including Motor Dysfunction, Heightened Pain Psychology Factors, and Nociplastic Pain, in Participants With Bilateral AT

			P Value		
Domain/Test/Time Point[a]	**Bilateral AT Group[b]**	**Control Group[b]**	**Group**	**Time**	**Group by Time**
Motor performance					
Maximum single-limb HRs, n			.072	.121	.013
Time 1	12.2 (4.5, 19.8)	22.5 (18.6, 26.5)			
Time 2	17.3 (10.4, 24.3)	21.3 (17.6, 24.9)			
Peak plantar flexor power during stair ascent, W/kg			.810	.490	.545
Time 1	2.8 (2.2, 3.4)	3.0 (2.6, 3.3)			
Time 2	2.8 (2.2, 3.4)	2.8 (2.5, 3.1)			
Peak plantar flexor power during the waltz, W/kg			.453	.098	.695
Time 1	0.6 (0.2, 0.9)	0.7 (0.5, 0.9)			
Time 2	0.5 (0.1, 0.8)	0.6 (0.5, 0.8)			
Pain psychology questionnaires					
Tampa Scale of Kinesiophobia			<.001	.003	.058
Time 1	41.7 (37.5, 45.9)	29.6 (27.2, 31.9)			
Time 2	37.9 (33.7, 42.1)	28.7 (26.3, 31.0)			
Pain Catastrophizing Scale			<.001	<.001	<.001
Time 1	16.6 (10.9, 22.2)	1.9 (0.0, 5.0)			
Time 2	4.4 (1.9, 7.0)	1.3 (0.0, 2.7)			
Time 3	12.1 (7.3, 17.0)	0.9 (0.0, 3.6)			
Quantitative sensory testing					
PPT at the wrist extensors, kPa[c]			.786	.191	.542
Time 1	311.7 (202.6, 420.8)	303.2 (241.9, 364.4)			
Time 2	303.3 (202.2, 404.4)	280.3 (220.1, 340.5)			
CPM: PPT at hamstrings on contralateral AT pain side, kPa			.880	<.001	.747
Before CPM: time 1	373.2 (235.8, 510.7)	383.6 (304.3, 463.0)			
During CPM: time 1	444.7 (250.3, 639.0)	501.0 (388.8, 613.2)			
Before CPM: time 2	356.4 (222.6, 490.3)	358.0 (280.7, 435.3)			
During CPM: time 2	450.3 (300.1, 600.5)	432.0 (345.2, 518.7)			
CPM: PPT at heel on side contralateral to AT pain, kPa			.845	.015	.219
Before CPM: time 1	598.1 (335.0, 861.2)	729.4 (590.7, 868.1)			
During CPM: time 1	863.0 (559.2, 1166.8)	842.9 (682.8, 1003.0)			
Before CPM: time 2	648.9 (399.0, 898.7)	653.5 (521.8, 785.2)			
During CPM: time 2	772.9 (492.2, 1053.7)	766.5 (618.6, 914.5)			
Temporal summation: verbal numeric pain rating during ice bath of the hand			.859	<.001	.247
5 s: time 1	2.7 (1.5, 4.0)	2.9 (2.2, 3.6)			
20 s: time 1	5.4 (3.9, 7.0)	4.9 (4.1, 5.8)			
5 s: time 2	2.7 (1.3, 4.1)	3.1 (2.3, 3.9)			
20 s: time 2	5.3 (3.9, 6.7)	5.8 (5.0, 6.5)			

Abbreviations: AT, Achilles tendinopathy; CPM, conditioned pain modulation; HR, heel raise; PPT, pressure pain threshold.
[a]Time point 1, prior to the anesthetic injection/first repetition (controls); time point 2, after the anesthetic injection/second repetition (controls); time point 3, at 1-week follow-up (Pain Catastrophizing Scale only).
[b]Values are mean (95% confidence interval).
[c]Measured bilaterally as the average of the left and right sides.

APPENDIX

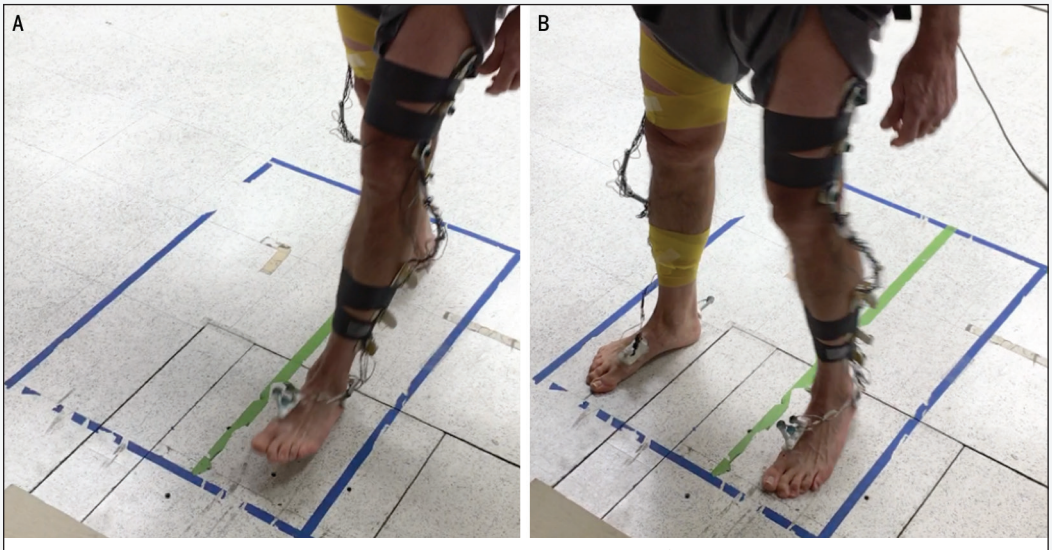

FIGURE. Participant with Achilles tendinopathy performing the waltz box step. A set of 3 infrared diodes on a thermoplastic molded platform were taped to the skin of each segment. The images demonstrate the participant stepping forward onto the left leg (A), and then pushing off from the left leg with a lateral sidestep onto the right leg (B). The ankle power generated by the left leg during the lateral sidestep was used for analysis.

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What Is the Personal Impact of Recurrences of Low Back Pain? Subanalysis of an Inception Cohort Study

OBJECTIVE: To investigate (1) the impact of low back pain (LBP) over the course of 1 year in people recently recovered from an episode of LBP, (2) whether the impact differs in people who do and do not experience a recurrence, and (3) the impact of LBP based on 3 definitions of a recurrence of LBP.

DESIGN: Cohort study.

METHODS: In 250 individuals recently recovered from LBP, the impact of LBP over the previous 3 months was assessed with the impact score, a multidimensional measure (range, 8-50), at 3, 6, 9, and 12 months. Recurrence of LBP was assessed monthly and defined as a recurrence of an episode of LBP, a recurrence of activity-limiting LBP, or a recurrence of LBP causing patients to seek care.

RESULTS: The median impact over 1 year was 11.5 points (interquartile range, 9.5-14.8). The impact was 15.2 points (95% confidence interval [CI]: 13.9, 16.3) for those who reported any recurrence and 11.1 points (95% CI: 10.6, 11.5) for those who did not. When comparing definitions of recurrence, those who had a recurrence that did not cause moderate activity limitation or result in care seeking had an overall impact of 12.7 points (95% CI: 11.6, 13.8). Participants who had recurrences of activity-limiting LBP but did not seek care, had an overall impact of 15.5 points (95% CI: 13.5, 17.6), and those who had recurrences of LBP for which health care was sought had an overall impact of 16.9 points (95% CI: 15.3, 18.4).

CONCLUSION: The average impact due to recurrence of LBP was low and dependent on the definition of recurrence. *J Orthop Sports Phys Ther 2020;50(6):294-300. Epub 16 Apr 2020. doi:10.2519/jospt.2020.9345*

KEY WORDS: *impact, inception cohort, low back pain, recurrences*

The initial prognosis for low back pain (LBP) is favorable, and most patients recover quickly.[4] However, recurrence is common and may be responsible for much of the cost and disability associated with LBP.[11,18] It is unclear whether recurrence has a substantial impact (eg, ongoing pain interference and physical function limitations) or little to no impact.

Although back pain and disability (function) are the most common constructs measured by clinicians and researchers, they may miss outcomes of importance for patients.[1,2] Next-generation outcome measures for research and clinical use should emphasize patient importance.[2,9] The National Institutes of Health Task Force on research standards for chronic LBP recently proposed the multidimensional impact score.[6] The measure was developed to classify patients with LBP according to the impact of back pain, rather than according to causes of pain.

The multidimensional measure is well suited to investigate the impact associated with recurrence of LBP. The measure covers the domains of pain intensity, pain interference with normal activities, and functional status, and might be superior to pain or disability alone for the measurement of patient-important outcomes.[6] Previous research demonstrated the discriminatory and prognostic importance of these items,[3,8,12,15,20] and described the psychometric properties of the instrument as good to excellent.[7]

Impact associated with recurrences of LBP will likely be influenced by how recurrence is defined. A recent consensus defined recurrence as "a return of LBP lasting at least 24 hours with a pain intensity of >2 on an 11-point numerical rating scale."[19] However, the validity of this definition is unknown, and it is unclear whether or not people experiencing a recurrence according to this definition experience substantial impact. Recurrence accompanied by activity limitation, or for which health care was sought, may have greater impact. Using a multidimensional measure of impact can help to describe the impact associated with recurrences of

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LBP, and how impact varies depending on the definition of recurrence.

We aimed to:

1. Investigate the impact of LBP over a 1-year period in people recently recovered from an episode of LBP
2. Investigate whether the impact of LBP is different in people who do and do not experience a recurrence during the first year after recovering from a previous episode of LBP
3. Investigate the impact of LBP in participants who met 3 different definitions of a recurrence of LBP

METHODS

Design

This study was a preplanned subanalysis using data from a cohort study[5] that investigated estimates of recurrences of LBP and related prognostic factors in people recently recovered from an episode of LBP.

Participants

The prospective inception cohort study recruited 250 patients, aged over 18 years, who were discharged from primary care practices (physical therapy and chiropractic) after recovery from an episode of nonspecific LBP within the previous month. Nonspecific LBP was pain in the area between the 12th rib and buttock crease not attributed to a specific diagnosis (eg, ankylosing spondylitis, vertebral fracture).[21] Recovery was defined as a score of 0 or 1 on an 11-point numeric rating scale for at least 7 consecutive days. Exclusion criteria were previous spinal surgery and/or inadequate English comprehension to complete outcome measures. Ethical clearance was granted by the Human Research Ethics Committee (Medical Sciences) of Macquarie University (5201500494). Informed consent was received and the rights of the participants were protected.

Study Variables

Outcome: Impact Score The impact score measure covers the domains of pain intensity, pain interference with normal activities, and functional status.[6] Pain intensity was assessed on an 11-point numeric rating scale, and pain interference with normal activities and functional status were each assessed by 4 items answered on a 5-option Likert scale ranging from 1 (not at all) to 5 (very much). The final score was the sum of the item scores and ranged from 8 (least impact) to 50 (greatest impact).

Previous research[7] on the impact score has reported mean ± SD impact scores in older adults with chronic musculoskeletal pain of 27.2 ± 7.8 points at baseline and 26.6 ± 8.8 points at 3 months.[7] The psychometric properties of the impact score were good to excellent, with a Cronbach alpha of 0.91[7] and a test-retest score at 3 months of 0.73 (95% confidence interval [CI]: 0.62, 0.82) among patients who rated their pain as stable.[7] The minimal clinically important difference of the impact score was considered to be 3 points on the 8-to-50 scale.[7]

The questionnaire was administered at baseline and at 3-, 6-, 9-, and 12-month follow-ups through a telephone interview, and the questions were related to the previous 3 months. Participants could also complete the questionnaire online if they preferred.

Recurrence Definitions There were 3 definitions of recurrence: (1) recurrence of an episode of LBP, (2) recurrence of activity-limiting LBP, and (3) recurrence of LBP for which health care was sought. Recurrence of an episode of LBP was defined according to expert consensus as "a return of LBP lasting at least 24 hours with a pain intensity of >2 on an 11-point numerical rating scale."[19] Recurrence of activity-limiting LBP was defined as a recurrence of an episode of LBP with moderate or greater activity limitation, measured using an adaptation of item 8 of the Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36): "During the recurrence, how much did LBP interfere with your normal work, including work both outside the home and housework?"[22] Recurrence of LBP for which health care was sought was defined as a recurrence of an episode of LBP resulting in consultation with a health care provider.

Participants were contacted every month by e-mail or text message (based on the participant's preference) for 12 months to determine whether a recurrence had occurred. Participants were asked whether they had a recurrence of an episode of LBP lasting at least 24 hours, with a pain intensity of greater than 2 on an 11-point numeric rating scale, where zero was no pain and 10 was the worst possible pain, within the last month (first definition). When participants reported a recurrence, they were contacted by telephone to obtain a detailed description of the episode, including whether the recurrence met the criteria for recurrence of activity-limiting LBP (second definition) and recurrence of LBP for which health care was sought (third definition). Participants who did not respond to e-mail or text messages within 48 hours were contacted by telephone.

Sample-Size Calculation

We did not complete a formal power calculation, as this was not the primary purpose of this cohort study. However, sample size was most critical for aims 2 and 3, and the sample size of 250 participants was expected to produce relatively precise estimates of the association between recurrences and impact, given that the outcome variable was continuous and we expected at least 20% of the sample to be in the smallest group (eg, recurrence of an episode of LBP, or recurrence of activity-limiting LBP, or recurrence of LBP for which health care was sought). In our model, we adjusted for 11 baseline covariates and had more than 20 participants per variable, exceeding common recommendations.[16,17]

Statistical Analysis

The impact of LBP over the course of 1 year for each participant, regardless of recurrence (aim 1), was assessed by taking a mean of the 4 measures of impact from

the 3-, 6-, 9-, and 12-month follow-ups. Participants missing 2 or more measures from the 4 time points were excluded from the analysis. When participants had LBP impact scores for 3 out of the 4 time points, the mean was taken from only 3 measures. We did not impute data, because few cases had missing data. Medians and interquartile ranges (IQRs) were used to describe the impact of LBP over the course of 1 year and for each time point.

To investigate whether the impact of LBP was different in people who experienced a recurrence compared to those who did not (aim 2), and the impact of LBP in participants who met any of the 3 definitions of a recurrence of LBP (aim 3), we used generalized estimating equations (GEEs) with an autoregressive correlation structure and robust assumptions. These analyses were conducted for each participant for the 4 epochs between assessment times: (1) baseline to 3 months, (2) 3 to 6 months, (3) 6 to 9 months, and (4) 9 to 12 months.

To assess whether the impact of LBP was different in people who experienced a recurrence compared to those who did not, we coded each participant based on the dichotomous option (no recurrence or any recurrence) within each epoch. When a recurrence spanned more than 1 epoch, it was coded as a recurrence in all relevant epochs. We considered only the first 2 recurrences reported by any participant within the 12 months, as data about duration of recurrence were not available for any additional recurrences. Epochs following the first 2 recurrences for an individual were not used in the analysis.

Two GEE analyses for aim 2 were conducted. The first GEE analysis investigated the association between the definitions of recurrence (eg, no recurrence or any recurrence) and the impact score, without any covariates. The second GEE analysis was an adjusted analysis investigating whether the relationship was influenced by baseline covariates. The following variables measured at baseline were considered to be potential confounders: age, sex, exposure to heavy loads, exposure to awkward posture, physical activity, number of previous episodes, duration of previous episode, general health, depression, anxiety, and stress.

To investigate the impact of LBP for the 3 definitions of recurrence (aim 3), we coded each participant based on a categorical option within each epoch. Participants who did not experience a recurrence were the reference group. Participants who experienced a recurrence were coded so that they could only meet 1 of the 3 recurrence definitions: (1) recurrence of LBP[19] when they had a recurrence but did not report it as meeting the definition of recurrence of activity-limiting LBP or recurrence of LBP for which health care was sought, (2) recurrence of activity-limiting LBP[22] when they met the recurrence definition but did not seek care, and (3) recurrence of LBP for which health care was sought when they reported a recurrence of LBP for which health care was sought, regardless of the degree of activity limitation reported. All epochs after the first 2 recurrences were considered to be missing values in the analysis.

Two GEE analyses for aim 3 were conducted. The first GEE investigated the unadjusted association between the definitions of recurrence and the impact score, and the second GEE was an adjusted analysis that investigated whether this relationship was influenced by baseline covariates.

All analyses were performed with SPSS Statistics for Windows Version 22.0 (IBM Corporation, Armonk, NY).[14]

RESULTS

The mean ± SD age of participants was 49.7 ± 15.1 years; 50% were men, and 79.2% were referred from a physical therapist (**TABLE 1**). The median duration of recovery at the time of study entry was 14 days (IQR, 7.0-27.5). The median number of previous episodes was 5 (IQR, 2.0-18.5), and the median duration of the previous episode was 14 days (IQR, 5.0-40.5). The median impact of LBP during the previous 3 months at baseline was 19 points (range, 8-49). Of the 250 participants, 68% had a recurrence of LBP and 32% had no recurrence over the 12-month period.

Impact of LBP in People Who Had Recently Recovered From an Episode of LBP

The average impact of LBP over the 1-year period in people who had recently recovered from an episode of LBP was based on 238 participants, as there were 12 participants with missing data for the outcome at more than 1 time point. The median impact of LBP over the course of 1 year in people who had recently recovered from an episode of LBP (regardless of having a recurrence) was 11.5 points (IQR, 9.5-14.8). Throughout the study period, the median and IQR for the impact of LBP were stable (**FIGURE 1**).

Impact of LBP in People Who Did and Did Not Experience a Recurrence

For the GEE analyses, the percentage of missing data across the 4 follow-up time points for the outcome of impact of LBP was very low (4.9%), and the rate of missing data for the variable of recurrence was about 13%, regardless of the definition of recurrence used (approximately 10% related to data considered as missing after 2 recurrences). As a result, of the 1000 possible assessment epochs (250 participants with 4 epochs each), we included 846 (84.6%) in the analysis.

The estimate of the impact of LBP over the 1-year period for people who had no recurrence was 11.1 points (95% CI: 10.6, 11.5) (**TABLE 2**). Overall, recurrence increased the impact of LBP by 4.1 points (95% CI: 3.3, 4.8) compared to no recurrence. Over a 3-month period, the impact for people who experienced a recurrence of LBP was 15.2 points (95% CI: 13.9, 16.3). The results of the adjusted model were similar to those of the unadjusted model (having a recur-

rence increased the impact of LBP by 4.0 points; 95% CI: 3.3, 4.8).

Impact of LBP Associated With 3 Definitions of Recurrence

Of the 68% of participants who had a recurrence of LBP, 14.4% had only a recurrence of an episode of LBP (definition 1), 14.0% had a recurrence of activity-limiting LBP but no recurrence of LBP for which health care was sought (definition 2), and 39.6% had a recurrence of LBP for which health care was sought (definition 3). Having a recurrence of an episode of LBP (definition 1) increased the impact of LBP by 1.6 points (95% CI: 0.9, 2.3), having a recurrence of activity-limiting LBP (definition 2) increased the impact of LBP by 4.4 points (95% CI: 2.8, 6.1), and having a recurrence of LBP for which health care was sought (definition 3) increased the impact of LBP by 5.8 points (95% CI: 4.6, 6.9), when compared to having no recurrence (**TABLE 3**). Over a 3-month period, the impact for people who experienced a recurrence of an episode of LBP (definition 1) was 12.7 points (95% CI: 11.6, 13.8), for people who experienced a recurrence of activity-limiting LBP (definition 2) was 15.5 points (95% CI: 13.5, 17.6), and for people who experienced a recurrence of LBP for which health care was sought (definition 3) was 16.9 points (95% CI: 15.3, 18.4). The results from the adjusted model were similar to those from the unadjusted model (**TABLE 3**). **FIGURE 2** presents the estimates of the impact over each 3-month period for each definition.

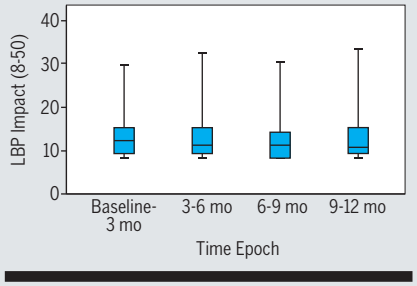

FIGURE 1. Impact of LBP over 1 year at each time epoch in people recently recovered from an episode of LBP. Values are median and interquartile range. Abbreviation: LBP, low back pain.

TABLE 1 Baseline Characteristics of the Study Participants[a]

Variable	Participants (n = 250)
Mean ± SD age, y	49.7 ± 15.1
Sex (male)	125 (50.0)
Manual task involving heavy loads	
Rarely (rarely, very rarely, or never)	100 (40.0)
Occasionally	84 (33.6)
Frequently (frequently or very frequently)	66 (26.4)
Manual task involving awkward posture	
Rarely (rarely, very rarely, or never)	110 (44.0)
Occasionally	74 (29.6)
Frequently (frequently or very frequently)	66 (26.4)
Physical activity[b]	
Vigorous	124 (49.6)
Moderate	56 (22.4)
Low	70 (28.0)
General health[c]	
Excellent (excellent or very good)	128 (51.2)
Good	99 (39.6)
Poor (fair or poor)	23 (9.2)
Number of previous episodes	
1-2	70 (28.0)
3-10	93 (37.2)
>10	87 (34.8)
Duration of last episode, wk	
<2	146 (58.4)
2-6	51 (20.4)
>6	53 (21.2)
Perceived risk of recurrence	
0-5 points	125 (50.0)
>5 points	125 (50.0)
Depression[d]	
Normal (normal or mild)	215 (86.0)
Moderate or worse (moderate, severe, or extremely severe)	35 (14.0)
Anxiety[d]	
Normal (normal or mild)	206 (82.4)
Moderate or worse (moderate, severe, or extremely severe)	44 (17.6)
Stress[d]	
Normal (normal or mild)	204 (81.6)
Moderate or worse (moderate, severe, or extremely severe)	46 (18.4)
Recurrence of low back pain	
Yes	170 (68.0)
No	80 (32.0)

[a] *Values are n (percent) unless otherwise indicated. Data were measured at the baseline assessment.*
[b] *Physical activity was assessed via The Active Australia Survey.*
[c] *General health was assessed via the question, "In general, would you say your health is excellent, very good, good, fair, or poor?"*
[d] *Depression, anxiety, and stress were assessed via the Depression Anxiety Stress Scales-21.*

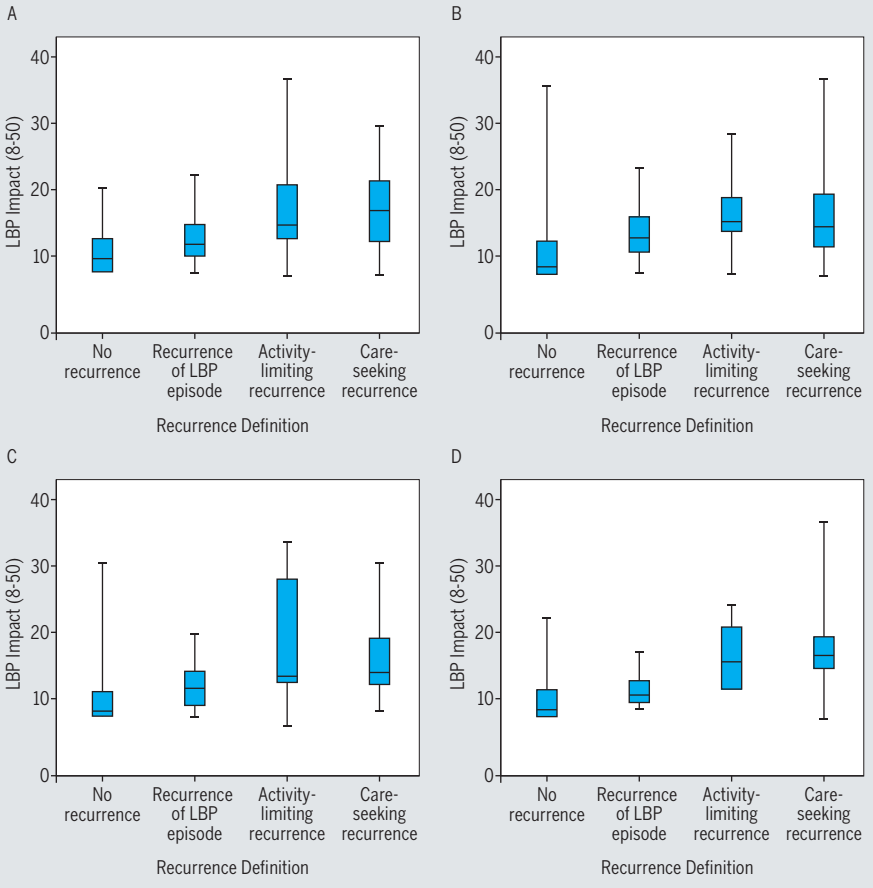

FIGURE 2. Impact of LBP for participants meeting each definition over 1 year. Graphs are based on raw data. Abbreviation: LBP, low back pain.

TABLE 2 Effect of LBP Recurrence on Impact Score: Comparing No Recurrence to Recurrence

	β Coefficient[a]
No recurrence compared to recurrence (unadjusted)[b]	
No recurrence	Reference
Recurrence of an episode of LBP	4.1 (3.3, 4.8)
Intercept (mean of reference group)	11.1 (10.6, 11.5)
No recurrence compared to recurrence (adjusted)[c]	
No recurrence	Reference
Recurrence of an episode of LBP	4.0 (3.3, 4.8)
Intercept (mean of reference group)	8.0 (6.5, 9.4)

Abbreviations: GEE, generalized estimating equation; LBP, low back pain.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Dependent variable: impact of LBP; independent variable: recurrence definition (no recurrence or recurrence of LBP).*
[c]*Dependent variable: impact of LBP; independent variables: recurrence definition, age, sex, exposure to heavy loads, exposure to awkward posture, physical activity level, general health, number of previous episodes, duration of previous episode, depression, anxiety, and stress.*

DISCUSSION

Participants who had recently recovered from an episode of LBP, on average, experienced minimal impact due to LBP over the following year. This is important new information, considering that recurrences are common.[5] The personal impact due to LBP was higher in those who had experienced a recurrence, but the magnitude was relatively small on average and dependent on the definition of recurrence used. Those who had a recurrence but did not report it as meeting definitions of recurrence of activity-limiting LBP or recurrence of LBP for which health care was sought had only minor increases in impact. People having a recurrence of LBP for which health care was sought reported the greatest personal impact (16.9 points on a scale ranging between 8 and 50) due to LBP.

Strengths and Weaknesses of the Study

Our study provides the first evaluation of the influence of recurrences of LBP on the average impact of LBP. The data are from a large inception cohort of consecutive patients recently recovered from an episode of LBP. We investigated the influence of 3 different definitions of recurrence on the impact of LBP using the impact score, a multidimensional measure of the impact of LBP recently recommended by the National Institutes of Health Task Force on research standards for chronic LBP.[6] The measure covers the important domains of pain intensity, pain interference, and physical function, and has good to excellent psychometric properties.[7] Our study provides some important data on this new measure.

Our study also has some limitations. We collected the measure of impact as it related to the previous 3 months. We acknowledge that the results may be affected by recall bias. However, previous studies investigating recall over 3 months in working-age adults with musculoskeletal complaints indicate that patients are able to accurately recall specific measures for up to 3 months.[10,13] Additionally, we collected the average impact over 3

months, which may obscure some shorter periods (eg, 1 week) with higher impact.

The impact score is relatively new and lacks established thresholds for low, moderate, or high impact; however, this measure includes well-established items and is recommended by the National Institutes of Health Task Force on research standards for chronic LBP.[6] Given that the previous literature suggests 3 points as the minimal clinically important difference, we feel that it was appropriate to describe the average levels of impact as low.

For the analysis investigating different definitions of a recurrence, we considered only the first 2 recurrences reported by any participant within the 12 months. This decision was made because data about the start and end dates of additional recurrences were not collected.

Implications for Clinicians and Future Directions

While it remains appropriate for clinicians to educate patients about the high likelihood of recurrences, they should also reassure patients that many recurrences will have little impact. Despite recurrences being very common in the first year after recovering from an episode of LBP, the average impact was low, even in patients who reported recurrence.[7] Because we also found that impact scores were only slightly higher in those who sought care, further research is needed to understand the drivers of care seeking in patients who have a recurrence of LBP.

Our findings suggest that the consensus definition of a recurrence[19] includes recurrences that may have little impact. One might question whether this definition of a recurrence is ideal for assessing the effect of interventions aiming to prevent recurrences. While it would be ideal to prevent all recurrences, this is probably unrealistic, and our results provide some support for using a definition such as recurrence causing at least moderate impact on activities of daily living. Future studies need to investigate possible thresholds describing the levels of impact (eg, low, moderate, or high impact).

TABLE 3 Effect of LBP Recurrence on Impact Score: Comparing No Recurrence to Recurrence of an Episode of LBP, Recurrence of Activity-Limiting LBP, and Recurrence of LBP for Which Health Care Was Sought

	β Coefficient[a]
No recurrence compared to different recurrence definitions (unadjusted)[b]	
No recurrence	Reference
Recurrence of an episode of LBP	1.6 (0.9, 2.3)
Recurrence of activity-limiting LBP	4.4 (2.8, 6.1)
Recurrence of LBP for which health care was sought	5.8 (4.6, 6.9)
Intercept (mean of reference group)	11.1 (10.7, 11.5)
No recurrence compared to different recurrence definitions (adjusted)[c]	
No recurrence	Reference
Recurrence of an episode of LBP	1.5 (0.8, 2.3)
Recurrence of activity-limiting LBP	4.4 (2.8, 6.0)
Recurrence of LBP for which health care was sought	5.7 (4.6, 6.8)
Intercept (mean of reference group)	8.1 (6.7, 9.5)

Abbreviations: GEE, generalized estimating equation; LBP, low back pain.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Dependent variable: impact of LBP; independent variable: recurrence definition (no recurrence, recurrence of an episode of LBP, recurrence of activity-limiting LBP, and recurrence of care seeking).*
[c]*Dependent variable: impact of LBP; independent variables: recurrence definition, age, sex, exposure to heavy loads, exposure to awkward posture, physical activity level, general health, number of previous episodes, duration of previous episode, depression, anxiety, and stress.*

CONCLUSION

Despite recurrences of LBP being common, on average, people had minimal impact due to LBP over the subsequent year. The impact due to LBP was higher in those who experienced a recurrence of moderate, activity-limiting LBP or a recurrence for which health care was sought. ◉

KEY POINTS

FINDINGS: People experienced minimal impact due to low back pain (LBP) over the following year. The impact due to LBP is higher in those who experience a recurrence of moderate, activity-limiting LBP or a recurrence of LBP for which health care was sought.

IMPLICATIONS: While clinicians should educate patients about the likelihood of recurrences, they should also reassure them that many recurrences will have little impact.

CAUTION: There are no studies describing thresholds of low, moderate, or high impact.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: All authors were involved in developing the design of the study. Dr da Silva was involved in the recruitment of participants, data collection, and data entry. Dr da Silva did the statistical analysis in consultation with Drs Hancock, Mills, and Kongsted. Drs da Silva, Mills, and Hancock wrote the first draft. All authors also contributed by reviewing previous versions of the manuscript and improving the final version. Drs da Silva and Hancock had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

DATA SHARING: Data are available on request.

PATIENT AND PUBLIC INVOLVEMENT: Patients were not involved in the design, conduct, interpretation, and/or translation of the study.

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From Childbirth to the Starting Blocks: Are We Providing the Best Care to Our Postpartum Athletes?

A professional distance runner presents to your clinic 4 weeks after having her first child. Her sponsors require her to rapidly regain her prepregnancy level of competitive performance. Although she ran right up to delivery, she is anxious about making it to the start line of the New York City Marathon in 2 months. She has questions about topics unique to her postpartum state, which are not typically addressed by her usual athletic support team, including breastfeeding, pumping, strength training, injury risk following childbirth—the list goes on. You seek evidence to guide your recommendations but quickly realize there is a huge problem . . . there is no evidence.

Exercise is important to maternal health and well-being, yet there is little evidence to guide a mother's return to exercise.[3] Standard postpartum medical care is continuously evolving. The American College of Obstetricians and Gynecologists (ACOG) recently advocated for earlier and more frequent health care contact in the first 12 weeks after childbirth (often called the "fourth trimester") to better address medical issues (eg, hypertension, infection, pain) and maternal mental health.[7] While this is important progress in postpartum care, the musculoskeletal system (excluding the pelvic floor) continues to be largely ignored.

Evidence related to musculoskeletal health and safe return to exercise after childbirth is limited, with an even greater dearth of knowledge regarding safe return to high-intensity exercise and competitive sport.[3] This Viewpoint, which is intended for clinicians who treat postpartum athletes, will (1) explore possible reasons for this gap and (2) propose a model for comprehensive postpartum care for the athlete, including members of the care team and progression of care.

SYNOPSIS: There is minimal evidence to guide return to exercise after pregnancy and childbirth, and even less information on safe return to competitive sport. The International Olympic Committee has suggested a 3-phase approach to postpartum recovery in athletes. This Viewpoint expands on that 3-phase model and incorporates a multidisciplinary approach to ensure comprehensive care of postpartum athletes to facilitate safe return to sport with optimal health and performance outcomes. Adopting a multidisciplinary approach may also open new research avenues to ameliorate the dearth of knowledge regarding musculoskeletal recovery and facilitate the development of guidelines to inform clinicians and postpartum women about safe return to exercise, particularly, high-intensity or high-impact activities. *J Orthop Sports Phys Ther 2020;50(6):281-284. doi:10.2519/jospt.2020.0607*

KEY WORDS: *multidisciplinary treatment, pregnancy, sports*

Why Are Postpartum Exercise Recommendations So Ambiguous?

Lack of Standardized Terminology The meaning of certain words varies depending on profession or source, which can lead to confusion across health care providers and patients. For example:

- "Postpartum" can mean anything from the post-birth hospital stay to the time from delivery of the placenta to the cessation of breastfeeding.[10] Given the profound physiological and psychosocial differences between a woman who has given birth 2 days prior and a woman who is still breastfeeding 2 years later, recommendations for physical activity and exercise will, and should, be different. It is imperative that researchers and health care providers be explicit about how they define the postpartum period.
- Physical activity/exercise definitions are vague and inconsistent. For example, ACOG Committee Opinion 804 states, "Some women are capable of resuming physical activities within days of delivery."[2] But "physical activities" is not defined and could mean anything from a comfortable stroll to resistance training and distance running. Lack of clarity leaves well-intentioned recommendations vulnerable to misunderstanding and risks compromising the mother's outcomes.

Lack of Quality Evidence The International Olympic Committee published a

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5-part summary of evidence on exercise and pregnancy in athletes. The summary highlighted important topics for the postpartum athlete, including return to sport and musculoskeletal complaints, and found no studies involving elite athletes in most areas of the report.[3]

Lack of quality evidence may be due to the following:

1. The (erroneous) claim that musculoskeletal dysfunction is normal: women are often told that pain, incontinence, and impaired movement and exercise tolerance are "normal" during and after pregnancy, and therefore do not warrant further examination or treatment.[10] However, while musculoskeletal dysfunction (such as lumbopelvic pain) is common during and after pregnancy,[4] several conditions (eg, pelvic girdle pain and incontinence) can be effectively treated and sometimes prevented.[8,9]
2. Difficulty obtaining research funding for postpartum musculoskeletal disorders: the dismissal of pregnancy- and childbirth-related musculoskeletal dysfunction as "normal" likely reduces the perceived significance of the issue by research funding bodies. The limited available support makes it difficult to conduct adequately powered clinical trials to evaluate exercise prescription and progression in the general postpartum population, as well as in athletes who wish to return to sport after having children.
3. Lack of a structured interdisciplinary care model, which in some countries places the burden of care on the birth provider to address all aspects of postpartum recovery. Thus, other disciplines extensively rely on referral from the birth provider to establish clinical data sets, or must independently recruit postpartum women to participate in research studies outside of their normal medical care. This approach to recruitment can be logistically burdensome, may introduce selection bias, and may ultimately create a barrier to advancing research in this population.

Proposed Model of Care

A multidisciplinary treatment approach has been beneficial in the treatment of chronic low back pain[6]; therefore, we propose an interprofessional team approach to maximize recovery following childbirth, particularly in athletes. Care for the postpartum athlete should be comprehensive and tailored to the individual, based on her specific recovery (including musculoskeletal impairments), sport demands, and performance goals (**FIGURE 1**). Consistent with the recent International Olympic Committee statement, we recommend viewing the journey from childbirth to return to sport as having 3 phases[3]: recovery, rehabilitation/training, and competition (**TABLE 2**).

The athlete will have different needs at each phase. Each member of the care team will have a different role during each phase, while working in an integrated manner. To ensure continuity of care, all providers should be aware of evaluation and treatment recommendations of other specialists, through review of the medical record, telecommunications, or team meetings.

The Recovery Phase The needs of the recovering athlete include relative rest while physiological homeostasis is restored, support while transitioning to motherhood and bonding with her infant (including addressing lactation concerns), and management of pregnancy- and birth-related musculoskeletal concerns. Consistent with musculoskeletal literature on other conditions,[10] recovery typically encompasses the first 12 weeks after childbirth. However, following an uncomplicated pregnancy, childbirth, and recovery, women may progress to the next phase in less than 12 weeks. In contrast, women who experience complications may be in the recovery phase longer than 12 weeks.

The birth provider (physician), the primary health care contact, has the role of assessing gynecologic recovery, wound healing, and cardiovascular health and screening for issues with maternal-infant bonding/maternal mental health.[3] The birth provider will refer the athlete to other disciplines, as needed. However, due to the unique musculoskeletal implications of pregnancy and childbirth, a women's health physical therapist should be involved in this phase to address topics such as interrecti distance, childcare body mechanics (car seats, cribs, infant feeding), management of cesarean incision site and/or perineal tearing (to facilitate healing and manage pain and movement restrictions), lumbopelvic pain, and pel-

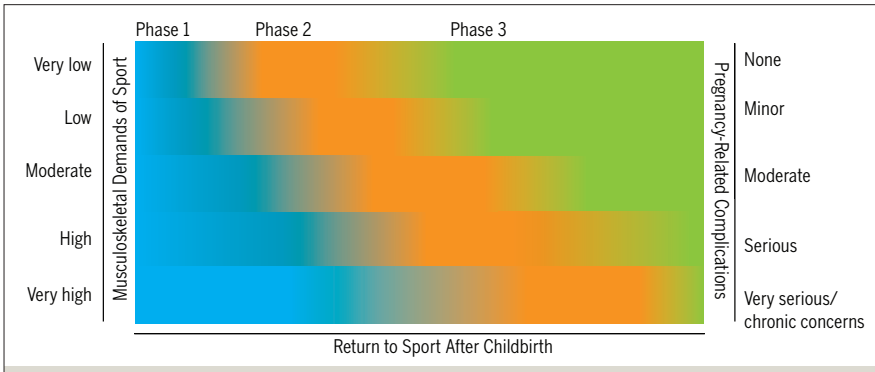

FIGURE 1. Return-to-sport timelines will vary and be heavily influenced by the interaction of a woman's individual recovery from the physiological and musculoskeletal complications associated with pregnancy and childbirth with the musculoskeletal demands of her sport. A woman who has little to no health or musculoskeletal concerns following childbirth but participates in a very demanding sport, such as running or gymnastics, may take longer to return to sport than a woman who is a competitive archer. Conversely, a competitive archer who experiences severe pregnancy-related complications, such as sepsis due to a retained placenta, may spend substantially longer in the recovery phase than a woman in the same sport who had an uncomplicated recovery. It is important not to tie progression to specific time frames, but rather to specific health and musculoskeletal parameters in the context of the demands of the sport.

vic floor dysfunction (including pelvic organ prolapse).[3,10]

The Rehabilitation/Training Phase The athlete's needs in this phase are restoration of musculoskeletal function and cardiovascular endurance, and gradual reintroduction of sport-specific tasks once medically cleared to begin training. Postpartum women are more susceptible to neuromuscular fatigue and demonstrate impaired motor control.[5] Interrecti distance has been associated with strength and fatigability of the abdominal muscles,[5] and postpartum urinary incontinence commonly interferes with exercise.[8]

The athlete's primary health care contact is the physical therapist, who, ideally, will have expertise in both women's health and sports physical therapy. However, this combination of training is quite rare and may necessitate 2 individuals to ensure appropriate biomechanical analysis of movement (particularly during sport-specific activities), while continuing to address pregnancy- and childbirth-related musculoskeletal disorders and general orthopaedic concerns.[10] Mental health should continue to be screened and referral to specialists made as appropriate, as incidence of posttraumatic stress disorder is higher at 6 months than at 6 weeks after childbirth,[1] and because injury, medical complications, or slower-than-expected progress may negatively impact mood. For elite athletes, the coach is closely involved, guiding training and performance goals of the athlete. The physician will be consulted as needed.

The Competition Phase When the athlete has returned to full participation in her sport, she transitions to the competition phase. The rehabilitation/training and competition phases are somewhat fluid—the athlete may be competing below her prepregnancy level while still in the rehabilitation/training phase, and may re-enter that phase between competitive events or as a result of injury. The primary goal of the competition phase is athletic performance. The athlete may be navigating this phase independently or collaboratively with her coach. Explicit education should be provided to the athlete (and coach) on when and how to involve the health care team in the event of injury or performance concerns.

Summary

Our model is intended as a first step to comprehensive care, and should evolve

FIGURE 2. Progression of care for the postpartum athlete in a 3-phase model. Phase 1 prioritizes medical status and initial recovery from childbirth. If no major concerns regarding postpartum healing are present, rehabilitation and sport-specific training can begin. Rehabilitation and training will continue until the athlete has reached the desired level of athletic performance. The athlete may re-enter phase 2 between competitive events or when injury occurs or performance issues arise. Abbreviations: BP, blood pressure; HR, heart rate; LBP, low back pain; PGP, pelvic girdle pain.

as new evidence emerges and health care practices continue to progress. Research is sorely needed to determine the best way to provide comprehensive postpartum care in an effective and fiscally responsible manner. An interdisciplinary approach may open new research avenues for competitive funding opportunities, thus helping to ameliorate the lack of high-quality evidence and improve best-practice recommendations. We hope an integrated care model can improve the postpartum experience of female athletes and facilitate advances in evidence-based care.

Key Points

- Return to exercise and competitive sport after childbirth should be based on specific health and musculoskeletal parameters in the context of the demands of the sport, not on arbitrary time frames.
- A comprehensive team approach to postpartum care may improve mothers' outcomes and open doors for research opportunities.
- More research is needed to identify best-practice guidelines for return to exercise and competitive sport following pregnancy and childbirth. ◉

STUDY DETAILS

AUTHOR CONTRIBUTIONS: All authors contributed to concept development, writing of the manuscript, and development of the figures.

DATA SHARING: There are no data in this manuscript.

PATIENT AND PUBLIC INVOLVEMENT: There was no patient/public involvement in the development of this Viewpoint.

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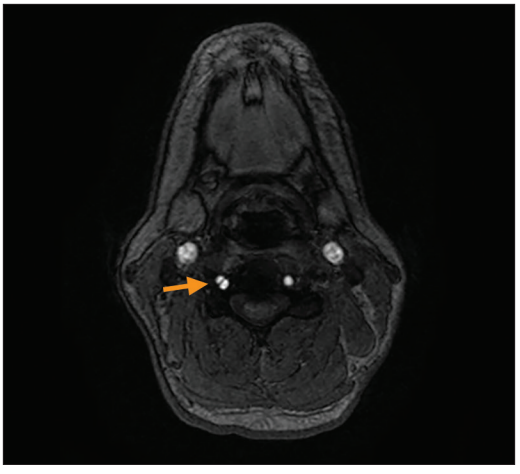

FIGURE 1. Axial time-of-flight (noncontrast) magnetic resonance angiograph at the C3-4 level. A linear defect (orange arrow) is visible in the right vertebral artery, consistent with an intimal flap projecting into the lumen, representing a focal dissection.

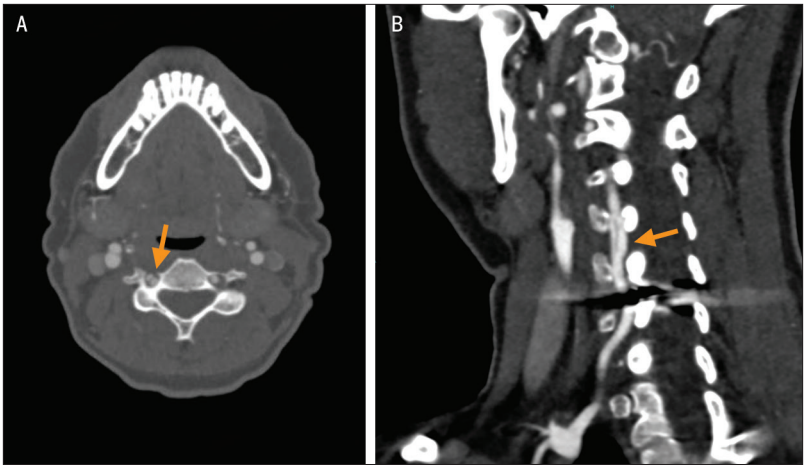

FIGURE 2. Axial (A) and oblique sagittal reformatted (B) computed tomography angiograms demonstrating a vertical linear filling defect in the contrast column within the right vertebral artery at C4 through C5 (orange arrows). This is consistent with focal dissection of the vertebral artery. The artifact at the C5-6 level is from a disc prosthesis.

Vertebral Artery Dissection

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A 40-year-old woman was referred to physical therapy with complaints of headaches. She reported that her headaches started after a neck injury from a trampoline accident 6 years prior, at a frequency of 1 per month. She also reported a C5-6 discectomy 3 years ago, and a motor vehicle collision 5 months prior, after which her headaches increased in frequency to 1 per day. She underwent a 2-month course of physical therapy at another clinic, with minimal improvement of her symptoms.

She reported that her headaches typically started posteriorly and radiated anteriorly, with a severity ranging from 5/10 to 9/10 on a numeric pain-rating scale, and that her most painful headaches were associated with orgasm. Examination revealed negative Sharp-Purser and alar ligament testing, a normal cranial nerve screen, and normal deep tendon reflexes. Cervical active range-of-motion testing revealed limitations in bilateral lateral flexion and rotation and did not reproduce her symptoms.

Severe headache pain, escalating within seconds and exacerbated by vasodilation, raised suspicion of a "thunderclap headache," a condition characterized by sudden, intense headaches correlated with bleeding in and around the brain.[1] The patient was referred to a neurologist, who ordered magnetic resonance angiography of the head and neck, which identified a partial dissection of the right vertebral artery (**FIGURE 1**). A subsequent computed tomography angiogram confirmed the dissection (**FIGURE 2**). Magnetic resonance imaging of the brain was negative for hemorrhage.

The vascular neurologist prescribed a 3-month course of clopidogrel and aspirin. Physical therapy interventions included cervical spine and peri-scapular strengthening, with emphasis on maintaining neutral posture and avoiding end-range positions of the cervical spine. At her 3-month follow-up with the vascular neurologist, the patient reported improved headache symptoms. Repeat imaging was unchanged, and medications were continued. ◉ *J Orthop Sports Phys Ther 2020;50(6):344. doi:10.2519/jospt.2020.8858*

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Seven Key Themes in Physical Therapy Advice for Patients Living With Subacromial Shoulder Pain: A Scoping Review

OBJECTIVE: To systematically scope the reported advice and education in physical therapy management of patients with subacromial shoulder pain, and to define key themes of the advice and education.

DESIGN: Scoping review.

LITERATURE SEARCH: We searched MEDLINE, Scopus, Web of Science, and CINAHL, with publication dates from 2007 to September 2019.

STUDY SELECTION CRITERIA: We included quantitative and qualitative research that reported on physical therapy interventions for subacromial shoulder pain.

DATA SYNTHESIS: We performed a qualitative synthesis that identified items included in patient advice and education.

RESULTS: Of 89 original studies included, there were 61 randomized controlled trials; 5 prospective studies; 16 nonrandomized observational intervention studies or case series; and 7 surveys, audits of physical therapy patient records, and focus groups with physical therapists. We identified 7 key themes for advice and education: exercise intensity and pain response, activity modification advice, posture advice, pain self-management advice, pathoanatomical and diagnosis information, behavioral approaches, and pain biology advice.

CONCLUSION: While advice focused predominantly on the local tissue pathology model, 10% of studies included information about pain neuroscience education, psychosocial factors, motor imagery, or behavior change. *J Orthop Sports Phys Ther 2020;50(6):285-293. doi:10.2519/jospt.2020.9152*

KEY WORDS: *advice, patient education, rotator cuff, shoulder pain*

Patient education is an important component of managing persistent musculoskeletal pain.[38,79,90] The health literacy, expectations of treatment, and personal attributes (such as self-efficacy) of patients may have an important influence on treatment outcomes.[19,94] Patients who understand their health condition are empowered to share in the decision-making process and take greater responsibility for the self-management of their condition,[87] and show improvements in health status, well-being, quality of life, and satisfaction with health care.[88,93,94] Patients with poor understanding of their condition and how to self-manage it (poor health literacy) may have poorer health outcomes, increased emergency care use, and lower use of preventive health care.[6,13,94] Failing to provide applicable advice and education may facilitate dependence on the clinician, reduce self-efficacy or compliance with rehabilitation, and increase fear and anxiety.

Shoulder pain is the third most common musculoskeletal disorder seen in primary care physical therapy.[59] Subacromial shoulder pain, the largest contributor to cases of shoulder pain, encompasses a variety of conditions and symptoms, including partial and full rotator cuff tears, inflammation of the rotator cuff tendons and bursa, and subacromial impingement syndrome.[22] Subacromial shoulder pain can affect sleep, movement, participation in activities of daily living, and employment.[32,62] The person-related burden of potentially decreased quality of life and increased suffering adds to the overall costs of subacromial shoulder pain.[92]

To address central mechanisms and psychosocial influences that may be associated with persistent shoulder pain, a management approach with a wider focus than physical symptom modification is indicated. This wider approach may include techniques to boost patient understanding and beliefs about persistent shoulder pain, or "cognitive training."

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Such techniques may be part of an overall approach that includes pain education; self-management strategies to improve self-efficacy, coping, and resilience; and exercises and physical activity to decrease nervous system sensitivity.[51,52,67,68,88]

Effective self-management strategies may help reverse the escalating health- and person-related costs of subacromial shoulder pain. Advice and education as part of a biopsychosocial approach may contribute to effective self-management.[50,51] Advice and education may overlap with the behavioral or psychosocial approach of physical therapy and enhance the patient's understanding of pain neurophysiology, address potential fear-avoidance behavior, and modify general health behavior. Although patient education is widely accepted as part of management of persistent musculoskeletal pain,[51] the content and mode of delivery of such patient education for subacromial shoulder pain, as reported in clinical research studies, are unclear.

We aimed (1) to systematically scope the reported content of advice and education in physical therapy management for patients with subacromial shoulder pain and (2) to define key themes of the advice and education.

METHODS

Design

We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) extension for Scoping Reviews[89] for the design and reporting of the review. A scoping review explores available evidence, allows a broad search and mapping of the literature, and clarifies working definitions of concepts.[89] Due to their exploratory nature, scoping reviews generally do not include a quality assessment of included studies.[33]

Search

The systematic search strategy was developed and refined by the research team. Appropriate search terms were identified and combined using Boolean operators. We searched 4 databases (MEDLINE, Scopus, Web of Science, and CINAHL). Prior to defining the final search strategy, pilot searches were conducted independently by 2 reviewers. We used an iterative process with several amendments until we agreed on the final search strategy (**TABLE 1**). Publication dates were limited from 2007 to 2019. We hand searched reference lists of appropriate primary articles that did not appear in the original search results. The first and final searches were undertaken on March 14, 2017 and September 19, 2019, respectively.

Screening

The results from the search strategy were imported into EndNote X8 (Clarivate Analytics, Philadelphia, PA) and duplicates were removed. One reviewer screened all titles of the initial search. A second reviewer independently screened 25% of excluded articles to verify judgment of the first assessor, and verified all included articles. The titles of 32 articles were discussed by the 2 reviewers, who decided by consensus whether to review the article abstracts. The 2 reviewers independently reviewed the abstracts of the included titles, applying selection criteria. Articles that could not be included or excluded based on their abstract and methods were assessed in full text.

Selection Criteria Studies that met the following criteria were included:

- Patients of any age diagnosed with subacromial shoulder pain or unspecified shoulder pain
- Treatment delivered by a physical therapist
- Published in the English language from January 2007 to September 2019
- Research designs: quantitative research studies—randomized clinical trials, prospective cohort studies, pre-post study designs (including case series), and surveys—and qualitative studies with focus groups or interviews

We focused on studies published between 2007 and 2019, as the role of patient education in the physical therapy management of persistent pain has advanced during this period.

Studies that met the following criteria were excluded:

- A diagnosis of adhesive capsulitis (frozen shoulder), fracture, dislocation, rheumatoid arthritis, or primary osteoarthritis
- Treatment, surgery, or postsurgery follow-up that was only medical
- Study of the immediate effects of interventions on biomechanical variables (such as advanced kinematic analysis or muscle activity)
- Shoulder pain associated with cerebral vascular accident or other neurological disorders

TABLE 1 Search Parameters[a]

Concept 1	Concept 2	Concept 3	Concept 4
• Rotator cuff injuries	• Physical therapy modalities	• Advice	• Adhesive capsulitis
• Rotator cuff		• Education (health)	• Fracture dislocation
• Shoulder impingement syndrome		• Education/patient education	• Fracture
• Shoulder pain		• Handout/patient education	• Shoulder dislocation
		• Pain education	• Dislocation
		• Exercise	• Rheumatoid arthritis
		• Motivation	• General surgery
		• Mindfulness	• Postsurgical
		• Relax*	• Postoperative pain
		• Musculoskeletal manipulations	

[a]*OR within each concept; AND concepts 1, 2, and 3; NOT concept 4.*

- Shoulder pain associated with diabetes or nonspecific neck/shoulder pain that could not be differentiated from neck pain
- Review article, expert opinion, clinical commentary, or case report

Data Extraction

Data were extracted in Microsoft Word (Microsoft Corporation, Redmond, WA), using an iterative process between K.M. and G.S., and exported to Microsoft Excel (Microsoft Corporation) for analysis. The author, title, year of publication and geographical area, inclusion criteria, whether patient advice or education was given, and type of advice or education were extracted from each article. When a pilot study, protocol, or follow-up study was published in addition to a main article, the details of all publications were combined. A qualitative synthesis of the evidence was undertaken. Items included in patient advice and education were categorized into key themes via consensus.

RESULTS

Our search identified 1193 studies, of which 104 met the inclusion criteria (**FIGURE**). Fifteen of the 104 included studies were pilot studies, protocols, or follow-up studies[4,5,7,9,20,41-43,46-48,53,54,61,83] of published main studies. Finally, out of 89 independent, original studies (**APPENDIX**, available at www.jospt.org) identified, 82 were classified as "patient-focused" studies (61 randomized clinical trials; 5 prospective cohort studies; and 16 nonrandomized or retrospective studies, case series, or qualitative interviews). The remaining 7 were classified as "physical therapist–focused" studies and included surveys, audits, guideline implementation studies, and focus groups with physical therapists. Studies reported using advice and education in combination with exercise, manual therapy, acupuncture, electrotherapies, and taping.

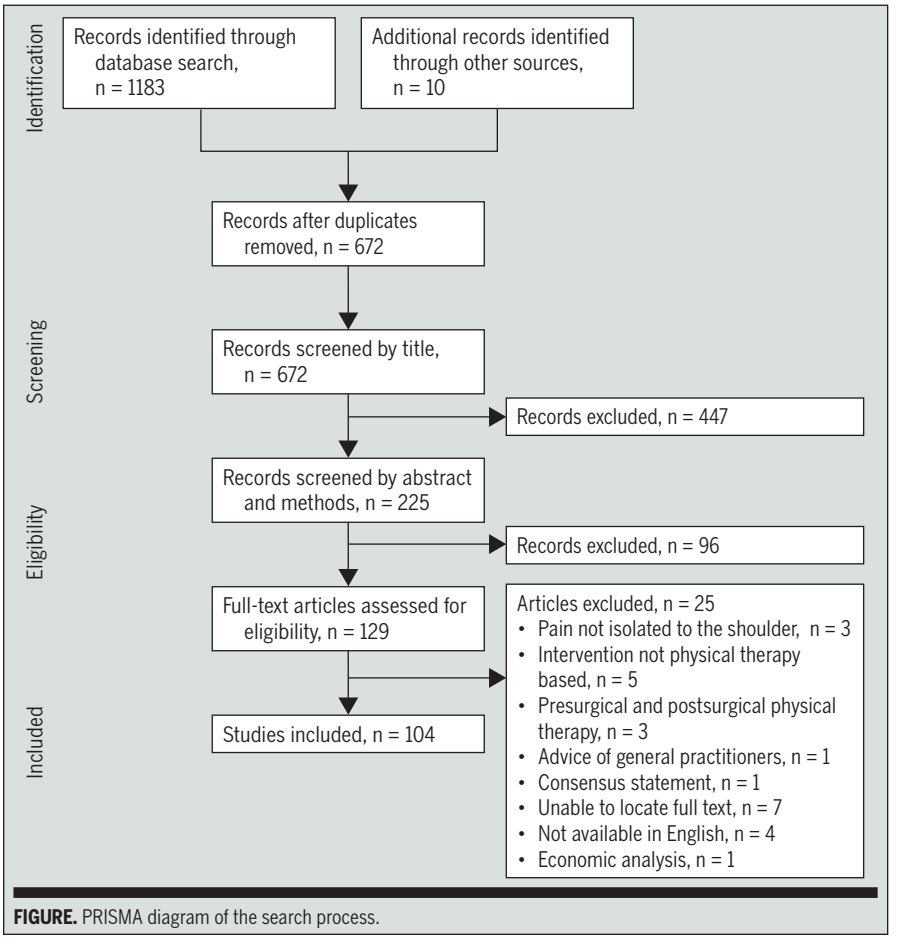

FIGURE. PRISMA diagram of the search process.

Key Themes for Advice and Education in the Patient-Focused Studies

Of the 82 intervention/prospective studies, 52 (63%) specified that participants were provided with advice or education, 7 (9%) indicated that advice was provided but did not specify that advice, and 1[71] stated that advice was not provided.

We categorized the items included in education and advice into 7 themes (**TABLE 2**): exercise intensity and pain response (n = 32, 39%); activity modification advice (n = 17, 21%); posture advice (n = 15, 18%); pain self-management advice; pathoanatomical and diagnosis information; behavioral approaches; and pain biology advice. Of 82 studies, 9 (11%) provided written instructions or booklets. One protocol paper[37] reported the use of multimedia to cater to patient health literacy and preferences.

Exercise Intensity and Pain Response In nearly 40% of studies, exercise-related advice supplemented prescribed shoulder exercises (stretching and/or strengthening for the rotator cuff, glenohumeral joint, or scapular thoracic muscle groups). Specific guidelines for progression of exercises were outlined in 3 studies.[1,8,37] A protocol provided a detailed outline for patients regarding acceptable pain levels during and following exercises, without focusing on specific intensity of pain.[37] One study[21] provided information that pain levels should drop to the pre-exercise level after 30 minutes of rest. Two studies specified that pain during exercises should not exceed the numeric pain-rating scale level of 3/10, or should not last longer than 30 seconds after exercise.[1,47]

Activity Modification Advice Patients were advised to avoid painful movements,[16,24,27,31,40,85,97,98] overhead sports- or

work-related movements,[81] or all sporting activities during the course of treatment or the clinical trial.[82] Yiasemides et al[97] included a focus on scapular movement within the pain-free range of motion, also encouraging preferential use of the unaffected arm. One study specified encouraging return to "normal" activity following cessation of the program.[81]

Posture Advice Some studies included detailed instructions regarding movements and postures at work[17] and postures associated with lower loads on the rotator cuff or decreased compression on the shoulder[80] (referred to as "proper" posture[40] or "postural hygiene"[3]), and other studies did not specify the type of advice.[24,35,72,76] Specific advice regarding "centering of the humerus" and scapular position was defined by Vas et al.[91] Four studies provided advice regarding sleeping positions.[1,8,27,37]

Pain Self-management Advice Pain management included advice regarding use of analgesia,[55] nonsteroidal anti-inflammatory drugs, taping,[28] heat,[14] or ice[15]; accessing treatment from other health care professionals, if needed[37]; or was not further specified.[8,27] Littlewood et al[53] also included lifestyle changes in addition to self-management of shoulder symptoms.

Pathoanatomical and Diagnosis Information Information about the etiology and pathology of the underlying sources of symptoms was based on anatomy and biomechanics of the shoulder complex and on "impingement."[15,21,27,40,46,76] Kromer et al[46] provided information about possible contributing factors to shoulder pain. Specific information about "contributing factors" was not provided.

Behavioral Approaches Behavioral approaches or psychologically informed components were wide ranging and might have overlapped the nonphysical or cognitive treatment approaches specifically explored in the studies. This category included specifying goal setting,[9,46,54] motivation and positive reinforcement,[9] reassurance,[37] and the use of mental imagery while performing exercises as part of the study methods.[39] Analay Akbaba et al[2] explored whether patients' expectations of treatment outcomes (of Kinesio Taping) influenced outcomes.

Pain Biology Advice Two studies provided information about the neuroscience or biology of pain.[8,27] Detail of such information was not provided.

Advice and Education Reported by Physical Therapists: Surveys and Focus Groups

Of 5 surveys of physical therapists, 1[84] did not include patient education/advice and 1[42] did not specify the advice provided. Of 271 Swedish physical therapists in primary care, 85% provided advice about posture to patients with subacromial pain, 50% provided advice about staying active, and 10% provided advice regarding bed rest.[11] The most common modalities used by 13 physical therapists when managing shoulder pain in the United Kingdom were education (85/98 patients) and exercise prescription (87/98 patients).[29] Education focused on anatomical structure of the shoulder, describing why pain occurred, and encouragement to return to usual activity.[29] In the SUPPORT trial,[76] 88% of treatment sessions included advice/education of unspecified content.[83]

In the United Kingdom, 20 physical therapists used education about the etiology of shoulder impingement, the importance of posture to minimize risk of impingement, and strategies to minimize pain to promote self-management.[34] Of 505 physical therapists in Belgium and the Netherlands, three quarters provided advice based on self-management, posture, activity modification, work, and home exercises for rotator cuff disorders.[74] Approximately 70% of the physical therapists advised patients to undertake exercises with levels of pain "acceptable to the patient." Instructions regarding the behavior of pain during and following exercise varied.[74]

DISCUSSION

We reviewed the content of patient advice and education included in published physical therapy interventions for subacromial shoulder pain. The physical therapy–focused surveys and focus groups indicate that advice and education comprise a modality that, similar to exercise prescription, is frequently reported in the management of such patients. We identified 7 categories from the patient-focused studies that may provide a clinical structure for

TABLE 2 Key Themes for Advice and Education Specified in the Patient-Focused Studies (n = 82)

Theme	Advice Mentioned by Studies	Studies[a]
Exercise intensity and pain response	Home exercise program prescription: instruction about dosage, progression, and pain response to the exercises	32 (39)
Activity modification advice	Activity modification, rest, activity avoidance, advice to work within pain limits, guidelines for activities of daily living, encouraging physical activity	17 (21)
Posture advice	Posture, biomechanics, ergonomics, shoulder positioning, instruction to decrease load on the shoulder	15 (18)
Pain self-management advice	Use of nonsteroidal anti-inflammatory drugs or analgesics, application of heat/cold, application and use of taping	10 (12)
Pathoanatomical and diagnosis information	Information about etiology of diagnosis; anatomy and biomechanics of the shoulder complex	7 (9)
Behavioral approaches	Empowerment, goal setting, motor imagery, cognitive behavioral techniques, self-efficacy and self-management, reassurance, level of research evidence for the intervention used in the study	6 (7)
Pain biology advice	Information about the neuroscience or physiology of pain	2 (2)

[a] *Values are n (percent).*

individual-specific and tailored education for patients with subacromial shoulder pain. These categories address potential sources and mechanisms of pain; advice related to exercise, ergonomics, and general physical activity; and psychosocial factors.

Mechanisms of Pain

Reported advice and education were mostly based on anatomical and biomechanical factors related to the shoulder girdle. A mechanistic approach that focused on shoulder symptoms was thus most commonly included. This approach may apply, in particular, to patients with acute-onset pain, such as those with an acute injury, sudden onset after unaccustomed activity, or repetitive loading activities.

Patients with shoulder pain expect to be provided with a pathoanatomic diagnosis when seeking health care advice,[23] and providing pathoanatomic information may meet this expectation. However, the relationship between anatomical lesions or pathology and the presence of shoulder-related symptoms is unclear, especially in chronic pain states.[12,49] Further, peripheral influences and changes in central pathways, such as central sensitization or central motor reorganization, may also contribute to the experience of shoulder pain.[25,53,64,78] Such information should, therefore, aim to enhance patients' understanding of the multiple factors that can influence their pain.[57] Two intervention studies[8,27] explicitly reported education about the mechanisms of pain (neurophysiology/pain biology), indicating a potential new trend to include such information.

Given the individual and societal burden of shoulder pain,[63,86] management must focus on decreasing risk for chronicity. Patients who understand their condition and related pain often have enhanced clinical outcomes.[67,69] Treatment involving education and advice surrounding pain physiology/neuroscience can improve outcomes, supporting the inclusion of these "nonphysical" interventions in rehabilitation.[57] The impact of the content of information that is provided to patients with subacromial shoulder pain may also be important.[44,87] For example, the wording used by the clinician to the patient regarding imaging findings and implications for treatment and outcomes should be characterized by reassurance and avoid unnecessary cause for fear and anxiety.[44,87]

Advice Related to Exercise, Ergonomics, and Physical Activity

Evidence for exercise therapy for subacromial pain syndromes appears to be increasing,[73] and advice as an adjunct to exercise was the most frequent category (39%). Besides describing the exercises, few studies outlined guidelines for progression[1,8,37] or recommended pain response to the exercise.[1,21,47] Future studies should provide such details to allow replication of methods, comparison between exercise programs, and application to clinical practice. Other reported factors included postural or ergonomic advice and avoiding positions of potential impingement and/or pain.

Progressive return to activity and lifestyle factors are important considerations for patients with persistent musculoskeletal pain.[26] Shoulder-specific health-related quality of life measures are influenced by comorbidities.[95] There is increased awareness that chronic metabolic disorders, as well as increased body mass index,[75,96] may be associated with rotator cuff–related conditions. Only 1 protocol included in this review explicitly stated considering lifestyle factors as part of self-management for patients with subacromial shoulder pain.[53] While the factors were not further defined,[53] they may include considerations for sleep patterns, stress management, nutrition, and general physical activity. Lifestyle factors, as well as behavior change, may need to be considered in future studies as part of holistic management for patients with persistent shoulder pain.

Behavioral and Psychologically Informed Advice

There is growing evidence that psychological responses may be associated with self-reported shoulder pain and disability.[18,60] Psychologically informed treatment approaches, such as cognitive behavioral therapy, motor imagery, empowerment, and other behavioral techniques, are being explored and applied for the management of persistent musculoskeletal pain,[58] shoulder pain,[56] and lower back pain.[65,66,70] Such approaches include a substantial element of patient education and are reported in our scoping review. Psychologically informed approaches, particularly cognitive behavioral therapy, may be crucial for successful physical therapy management of pain conditions.[30,45,77]

Two surveys of Swedish physical therapists[10,11] found that 5% to 8% of the respondents reported using behavioral therapy. Furthermore, the low number of intervention studies[8,27] that explicitly reported inclusion of behavioral approaches (n = 6) to the management of subacromial shoulder pain indicates that this area should be explored more thoroughly. It is currently unknown whether such approaches are more effective than those focused on "local structures" specific to patients with persistent subacromial shoulder pain. The increasing health costs that appear to be associated with subacromial shoulder pain, in addition to personal costs, suggest that further investigations are warranted to determine whether the cost trajectory can be reversed.

Recommendations for Future Directions

None of the included studies compared different modes of advice/education or the effect of education versus that of other interventions. Physical therapists used a range of modes to deliver education, the content and delivery of which may change with increased clinical experience.[34] Future research is warranted to explore the content of advice and education as part of physical therapy management of persistent subacromial shoulder pain. Such advice may need to expand beyond the local tissue pathology model to include the neurosciences, physical activity, and lifestyle factors. As indicated

for all patients, the advice needs to be patient centered, considering their level of health literacy, goals, concerns, beliefs, social support, and other factors.[37,38,90]

Strengths and Limitations

We followed best-practice guidelines, with clearly reported and well-defined methods. Advice and education may be difficult to clearly differentiate from other modalities, as they are often interlinked, such as in the prescription of home-based exercises and self-management of pain.[34] The challenge of defining advice and education as an explicit modality of rehabilitation may help to explain why at least one third of the articles included in our scoping review did not specifically report providing advice. The authors may not have considered providing advice and education as an explicit modality, but rather as part of the conversation with the patient about the treatment intervention. Due to manuscript word count limits, authors may have prioritized information directly aligned with the aims of the individual study. Using reporting guidelines, for example, the Template for Intervention Description and Replication checklist,[36] would assist researchers to clearly define interventions in future trials.

Due to the scoping review design, we do not provide evidence for effectiveness of various items of advice/education for patients with subacromial shoulder pain. We used an iterative process to categorize patient education reported in studies of physical therapy management of subacromial shoulder pain. There may be other topics that physical therapists cover in clinical practice that are not reported in published research. Our results may not apply to surgical, medical, and other management contexts.

CONCLUSION

Physical therapy advice reported for subacromial shoulder pain in published research covered 7 key themes: exercise intensity and pain response, activity modification advice, posture advice, pain self-management advice, pathoanatomical and diagnosis information, behavioral approaches, and pain biology advice. While advice focused predominantly on the local tissue pathology model, 10% of studies included information about pain neuroscience education, psychosocial factors, motor imagery, or behavior change. ◉

KEY POINTS

FINDINGS: This scoping review provides a structured approach of themes for advice and education provided for patients with subacromial shoulder pain. Advice and education reported in included studies focused mainly on pathoanatomical and biomechanical factors.

IMPLICATIONS: Clinicians may need to consider integrating education about pain mechanisms and psychological factors into their management of patients with subacromial shoulder pain, tailoring these to patient-specific health literacy, goals, beliefs, and support systems.

CAUTION: A scoping review does not define the most effective patient education that should be provided to patients with subacromial shoulder pain.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Dr Sole and Karen Meehan conceived of and designed the study and collected the data. All authors analyzed and interpreted the data, drafted and revised the manuscript, and gave final approval of the manuscript.

DATA SHARING: Data are available on request.

PATIENT AND PUBLIC INVOLVEMENT: Patient and public partners were not involved in the design, conduct, interpretation, and/or translation of the review.

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APPENDIX

STUDIES INCLUDED IN THE REVIEW

Patient-Focused Studies

Randomized Clinical Trials

Study	Country	Participant Inclusion Criteria	Advice and Education
Ager et al[1]	Canada	Military personnel with clinical diagnosis of rotator cuff tendinopathy; DASH score >15%; reported shoulder pain; painful arc during flexion or abduction; positive Neer or Hawkins test; pain on resisted external rotation, abduction, or the empty-can test Age, 18-60 y Imaging: to exclude other conditions	Posture, relative rest, sleeping position, physical training; guidance for intensity of exercise and pain levels during exercise (3/10 on NPRS)
Ainsworth et al[2]	United Kingdom	Unilateral shoulder pain exacerbated by active or passive shoulder movement Age, ≥18 y Imaging: none	Advice sheet about shoulder pain and home exercise program
Al Dajah[3]	Saudi Arabia	Clear diagnosis of SIS; VAS, ≥5 Age, 40-60 y Imaging: none	No advice mentioned
Analay Akbaba et al[4]	Turkey	MRI-verified partial rotator cuff tear, shoulder pain for ≥3 mo, insufficient response to nonoperative management (local corticosteroid injection, NSAID, rest, and physical therapy) Imaging: MRI	Patients informed of effectiveness of Kinesio Taping. Group 1: there is no evidence that Kinesio Taping is effective; group 2: there is limited evidence that Kinesio Taping is effective; group 3: there is evidence that Kinesio Taping is effective
Apeldoorn et al,[6] Kalter et al[56]	the Netherlands	Two positive impingement tests indicating subacromial impingement Age, 18-65 y Imaging: X-ray, ultrasound	No advice mentioned
Asensio-García et al[7]	Spain	Patients with nontraumatic shoulder pain referred to physical therapy: nontraumatic rotator cuff tear, supraspinatus or infraspinatus tendinitis, SIS, partial or complete tendon tear, or capsulitis VAS, ≤8/10 Younger than 80 y of age	Group information sessions about "recommendations" and postural "hygiene," with description of exercises
Barra et al,[8] Barra López et al[9]	Spain	Referred to physical therapy if diagnosed with chronic (>3 mo) painful shoulder of peri-articular origin; some degree of pain and restricted movement in at least 1 of the shoulder movements analyzed in this study Age, ≥18 y Imaging: none	No advice mentioned
Beaudreuil et al[13,14]	France	SIS, pain duration >1 mo Total Constant score, <80 Age, ≥30 y At least 2 positive tests: Neer, Yocum, Hawkins-Kennedy Imaging: none	No advice mentioned
Belley et al[15]	Canada	Unilateral rotator cuff tendinopathy: a positive finding for 1 of the following: (1) painful arc movement, (2) positive Neer test or Hawkins-Kennedy test, and (3) pain on resisted isometric lateral rotation, abduction, or Jobe test Age, 18-65 y Imaging: none	Pain neuroscience, pain management, structures affected, rehabilitation stages, graded exposure to exercise, shoulder and body mechanics and posture, sleeping, activities, work, and sports

Table continues on page A2.

APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Bennell et al[16,17]	Australia	Shoulder pain for ≥3 mo; pain severity, at least 4/10 on movement; pain on active abduction or external rotation; positive shoulder impingement quick test Age, ≥18 y Imaging: X-ray	Unspecified "education"; cognitive behavioral strategies for the intervention group: education, goal setting, motivation, positive reinforcement; home exercise Placebo group: no advice/education
Bron et al[21]	the Netherlands	Unilateral nontraumatic shoulder pain for ≥6 mo Age, 18-65 y Imaging: none	Advice on the application of heat, advice on pain relief, ergonomic advice and instructions to assume and maintain good posture, relaxation exercises
Calis et al[22]	Turkey	SIS Age, 18-65 y Imaging: MRI	No advice mentioned
Chaconas et al[24]	United States	Shoulder pain for ≥3 mo; positive result on all of the following: Neer test, Hawkins-Kennedy test, empty-can test; pain with resisted external rotation; palpable tenderness at insertion of supraspinatus or infraspinatus; or painful arc from 60° to 120° of abduction Mean ± SD age, 46.9 ± 17.3 y Imaging: none	Home exercises
Chen et al[25]	Australia	Pain over the glenohumeral joint or in the proximal upper limb and reproduced with shoulder movement; duration, >1 mo; shoulder range of motion, ≤140° of flexion and abduction Imaging: none	Advice to avoid painful activity, advice to use pain-free methods to perform everyday activities, instruction to perform provided exercises in a pain-free manner
Cheng and Hung[26]	China	Work-related rotator cuff tendinitis, clinically diagnosed by a medical doctor Imaging: none	Ergonomic education: keeping the load close to the body, resting arm on support during extended reach, leaning forward or to the side to reduce arm extension, turning the upper body to bring in more shoulder muscles when making lateral movements, holding on to overhead support with one hand to reduce fatigue during overhead work, alternating hands for 1-handed tasks where arm is extended, holding on to vertical supports in front of a load when pushing it forward so the shoulders are stabilized
Cloke et al[31]	United Kingdom	Pain originating from the subacromial region during active arm abduction against gravity without added resistance (painful arc) Age, ≥18 y Imaging: none	No advice mentioned
de Oliveira et al[35]	Canada	Diagnosed with a rotator cuff tear: painful arc on movement during flexion or abduction; positive Neer or Hawkins-Kennedy impingement sign; pain during resisted external rotation, abduction, or empty-can test Age, 18-65 y Imaging: none specified	Guidance to improve patients' understanding of shoulder overload, pain neuroscience, pain management, posture, rehabilitation stages, graded exposure to exercise, shoulder and body mechanics and movements that provoke impingement, and preferred shoulder positioning during sleep, work, and daily sports activities
Dejaco et al[34]	the Netherlands	Unilateral subacromial pain for >3 mo; 2 of 3 positive impingement tests: empty-can test, Hawkins-Kennedy test, modified Neer test Age, 18-65 y Imaging: X-ray and ultrasound for exclusion criteria	Home exercises
Devereaux et al[38]	Canada	Primary complaint of anterolateral shoulder pain, subacute pain onset (<12 mo), painful arc (60°-120°), positive Hawkins-Kennedy test Age, ≥18 y Imaging: yes, but not specified	Exercise instruction and home exercise program, use of diary, instruction about use of tape and NSAIDs

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APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Elsodany et al[42]	Saudi Arabia	Rotator cuff tendinopathy diagnosed clinically with shoulder pain for >3 mo; limited shoulder abduction range and external and internal rotation range; positive diagnostic tests of Neer, Hawkins, Jobe, and external rotation lag sign	Home exercises
Engebretsen et al[43]	Norway	Subacromial shoulder pain (or rotator cuff rupture) lasting >3 mo, dysfunction/pain on abduction, normal passive glenohumeral range of motion, pain on 2 of 3 isometric tests (abduction, internal rotation, and external rotation), positive Hawkins-Kennedy test Age, 18-70 y Imaging: none	Postural awareness, avoid activities that elicit pain
Eslamian et al[44]	Iran	Rotator cuff tendinitis defined by 2 of the following tests: painful arc syndrome, positive impingement test, positive Hawkins-Kennedy test, sensitivity on palpation, positive supraspinatus test Inclusion age range not defined Imaging: none	No advice reported
de Paula Gomes et al[37]	Brazil	Patients on a waiting list for physical therapy with SIS and anterolateral and unilateral shoulder pain for >3 mo Orthopaedic doctor confirmed diagnosis with minimum score of 4/10 on the NPRS at rest and during shoulder movement and 2 of 3 positive tests: Neer, Hawkins, and Jobe Age, 18-60 y Imaging: none	No advice reported
de Paula Gomes et al[36]	Brazil	SIS and anterolateral and unilateral shoulder pain for >3 mo Orthopaedic doctor confirmed diagnosis with minimum score of 4/10 on the NPRS at rest and during shoulder movement and 2 of 3 positive tests: Neer, Hawkins, and Jobe Age, 18-60 y Imaging: none	No advice reported
Gutiérrez-Espinoza et al[46]	Chile	SIS with poor response to initial conservative treatment, under evaluation for surgery Orthopaedic surgeon to conduct assessment: pain located on the anterolateral side of the shoulder for >6 mo; painful arc during elevation; positive Neer or Hawkins-Kennedy test; pain with resisted external rotation, abduction, or empty-can test Age, >18 y Imaging: MRI	No advice reported
Haider et al[47]	Pakistan	SIS with pain for 2-3 mo; NPRS, ≥3/10 Age, 25-60 y	No advice reported
Haik et al[48]	Spain	Shoulder pain in the C5-6 dermatome region and 3 of the following tests positive for SIS: Neer, Hawkins, Jobe, pain during active elevation in the scapular or sagittal plane, and pain or weakness with resisted shoulder external rotation Age, 18-60 y Imaging: none	No advice reported
Hando et al[49]	United States	New episode of shoulder pain with at least 2 of the following positive signs: impingement tests, painful arc, pain with isometric resistance, rotator cuff weakness compared to opposite side Imaging: none	No advice reported

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APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Heredia-Rizo et al[51]	Spain	Impingement defined with positive results in at least 2 of 3 specific tests: Neer test, Jobe test, Yergason test; negative response to cervical compression test Age, ≥18 y Imaging: none	Postural advice
Heron et al[52]	United Kingdom	Shoulder pain for ≥3 mo No passive limitation of range-of-motion testing Pain on Hawkins-Kennedy or empty-can test Imaging: none	Home exercises
Hopewell et al[53]	United Kingdom	A new episode of shoulder pain (within last 6 mo) attributable to rotator cuff disorder using diagnostic criteria of the British Elbow and Shoulder Society guidelines Imaging: none	Assessment and advice: self-management leaflets, tailored education, reassurance and advice on pain management and activity modification Home exercises Behavioral change strategies
Hoyek et al[54]	France	Identified as stage II of SIS Age, 35-65 y Imaging: none	Motor imagery: requested to imagine the exercise/movement performed before performing it
Kachingwe et al[55]	United States	Superolateral shoulder pain with 2 of 4 tests: positive Neer test, positive Hawkins-Kennedy test, painful limitation of active shoulder elevation, pain or limitation with the functional movement patterns of hand behind back or hand behind head Imaging: X-ray to exclude calcific tendinitis	Instruction for home exercises Education on the etiology of SIS and the importance of proper posture Instructed to modify overhead activity
Kamali et al[57]	Iran	Overhead athletes with unilateral SIS: positive Neer and Hawkins tests, active muscle trigger points identified by palpation (taut band, tenderness that reproduced patient's familiar pain, pain intensity of at least 3/10 on a VAS) Age, 18-60 y Imaging: none	No advice reported
Kaya et al[62]	Turkey	Shoulder pain reproduced with empty-can test and Hawkins-Kennedy test, subjective complaint of difficulty performing ADL, pain before 150° of active shoulder elevation in any plane Age, 18-70 y Imaging: none	No advice reported
Kinsella et al[63]	Australia	Pain localized to the proximal anterolateral shoulder Positive for pain on at least 1 of the following: Hawkins-Kennedy, Neer, and Jobe impingement tests Positive for pain on at least 1 of the following: painful arc, drop-arm test, lift-off test, and resisted external rotation Age, 18-80 y	No advice reported, but exercise booklet will be provided
Kromer et al[64-67]	Germany	Main complaints in the glenohumeral joint region or the proximal arm for >4 wk; positive Neer or Hawkins-Kennedy test or painful arc with active abduction or flexion; pain with resisted external rotation, internal rotation, abduction, or flexion Age, 18-75 y Imaging: none	Information booklet: anatomy and biomechanics of the shoulder complex, etiology of SIS, pathology, brief overview about possible contributing factors, goals for treatment, general guidelines for behavior through daily living
Kukkonen et al[69]	Finland	Atraumatic supraspinatus tendon tear comprising <75% of the tendon insertion and documented with MRI, full range of motion in the shoulder Age, ≥55 y Imaging: MRI, X-ray	Written information for home exercises

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APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Kvalvaag et al[70]	Norway	Shoulder pain for ≥3 mo Pain on 1 of the following tests: isometric abduction in 45° or external rotation with arm at side, positive Hawkins-Kennedy impingement sign Normal passive glenohumeral range of motion Age, 25-70 y Imaging: none	Home exercises
Lewis et al[72]	United Kingdom	Unilateral shoulder pain in C5-6 dermatome Age, ≥18 y Imaging: none	Shoulder advice and exercise class
Littlewood et al[73-75]	United Kingdom	Primary complaint of shoulder pain with or without referral into the upper limb for >3 mo, no or minimal resting shoulder pain, range of motion largely preserved (>50% external rotation), shoulder pain provoked consistently with resisted muscle tests (abduction or external rotation) Age, ≥18 y Imaging: none	Pain education, explanation of the cause of the problem, enhancement of self-efficacy, encouragement of self-management
Lombardi et al[76]	Brazil	Shoulder pain, positive Neer and Hawkins-Kennedy tests, pain between 3 and 8 on the NPRS in the arc of movement that produced the greatest pain Imaging: none	Advice regarding analgesic usage
Mintken et al,[78] McDevitt et al[77]	United States	Shoulder pain (between neck and elbow at rest or during arm movements), baseline SPADI ≥20% Age, 18-65 y	Advised to maintain usual activities that did not increase symptoms and avoid exacerbating activities
Moosmayer et al[79]	Norway	Lateral shoulder pain at rest or with exercise, painful arc, positive impingement signs, passive range of motion of at least 140° for abduction and flexion Imaging: MRI; ultrasound finding of full-thickness tear, tear of <3 cm on the short and long axes; muscle atrophy on MRI not exceeding stage 2	No advice mentioned
Østerås and Torstensen[80]	Norway	Shoulder pain duration of >3 mo; positive subacromial impingement test Age, 18-60 y Imaging: none	Education surrounding muscle fatigue resulting from exercise
Pekyavas and Baltaci[81]	Turkey	Diagnosis of SIS by a physical medicine and rehabilitation doctor, symptoms for >3 mo Imaging: none	Written instruction for exercises provided
Pérez-Merino et al[82]	Spain	SIS diagnosed by ultrasound, with rotator cuff tendinitis or tendinosis, or partial tear of the cuff and/or brachial biceps Age, 36-70 y Imaging: ultrasound	No advice given
Perez-Palomares et al[83]	Spain	Diagnosis of rotator cuff tendinitis and/or SIS by general practitioner Functional limitation and pain above 50% of flexion, abduction, and elevation in the scapular plane Imaging: MRI, ultrasound	Postural re-education
Rhon et al[85]	United States	Primary symptom of unilateral shoulder pain Age, 18-65 y Imaging: none	No advice mentioned
Roddy et al[86]	United Kingdom	Clinical diagnosis of SIS, pain in deltoid insertion, positive Neer and Hawkins-Kennedy tests, pain on shoulder abduction Age, ≥18 y Imaging: none	Information leaflet: shoulder anatomy and SIS, simple messages about pain relief and activities

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APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Stevenson et al[92]	United Kingdom	Audit of treatment report form of physical therapists for patients with shoulder pain (661 treatments)	88% of sessions included education and advice, but not further specified
Salom-Moreno et al[87]	Spain	Unilateral shoulder pain for ≥6 mo, pain intensity >3 points on 11-point NPRS, positive painful arc test during abduction, at least 2 positive tests: Hawkins-Kennedy test, Neer sign, empty-can test, drop-arm test, or lift-off test Imaging: none	No advice mentioned
Santamato et al[88]	Italy	Subacromial impingement confirmed using ultrasound or MRI Shoulder pain for ≥4 wk, painful abduction of the shoulder with a painful arc, positive Hawkins-Kennedy test, pain relief within 15 min of injection of local anesthetic into the subacromial space Imaging: MRI, ultrasound	No advice mentioned
Senbursa et al[90]	Turkey	Shoulder pain, painful range of motion, no marked loss of active or passive range of motion Imaging: MRI	Advice to avoid overhead work and overhead sports, encouraged to use shoulder "normally without any limitation" after completion of the treatment Shoulder exercise brochures were provided
Senbursa et al[91]	Turkey	Presence of SIS or stage 1 rotator cuff tear diagnosed by clinical examination and MRI Imaging: MRI	Leaflet with instructions for exercises, avoidance of sports activities for 12 wk
Ucurum et al[97]	Turkey	SIS, unilateral shoulder pain for ≥4 wk, passive range of motion of the shoulder: restriction of <30% compared to opposite side	No advice reported
Vas et al[99]	Spain	Chronic symptoms of unilateral subacromial syndrome; duration, ≥3 mo Imaging: X-ray to exclude other conditions	A series of postural and ergonomic instructions (eg, centering the humeral head and scapula during movement)
Vallés-Carrascosa et al[98]	Spain	Diagnosis of subacromial syndrome by physician Painful arc between 60° and 120° of abduction Age, 25-70 y Imaging: none	No advice reported
Vinuesa-Montoya et al[100]	Spain	Unilateral shoulder pain compatible with medical diagnosis of SIS; duration, ≤12 mo; baseline pain, ≥2/10 on the VAS; pain or dysfunction with overhead activities; pain during active shoulder movements; positive Neer or Hawkins-Kennedy test Included age range not reported Imaging: none	Home exercises
Wright et al[101]	United States	Shoulder pain with 3 positive tests for the diagnosis of SIS: Hawkins-Kennedy test, painful arc sign, weakness in external rotation with arm at the side Age, ≤18 y Imaging: none	Home exercise
Yiasemides et al[102]	Australia	Painful active flexion or abduction for >1 mo; minimal shoulder movement restrictions; pain/tenderness or restriction during passive accessory movements at the glenohumeral joint, acromioclavicular joint, or sternoclavicular joint, or during passive scapular movements Included age range not reported Imaging: none	Advice on how to avoid/minimize painful movement during ADL: limiting movement to pain-free range of motion, maintaining normal scapulohumeral rhythm within pain-free range of motion, using the affected upper limb in a slow/careful manner, using techniques to minimize pain during activity, preferential use of nonaffected upper limb
Yildirim et al[103]	Turkey	Shoulder symptoms with findings compatible with shoulder impingement for >6 mo, passive range of motion less than 30% compared to the unaffected side Age, >40 y Imaging: MRI, X-ray	Advice not to use affected arm for ADL or overhead activity

APPENDIX

Prospective Cohort Studies

Study	Country	Participant Inclusion Criteria	Advice and Education
Braun et al[20]	Germany	Shoulder pain associated with nontraumatic partial-thickness rotator cuff tear Clinical signs of shoulder impingement Age, ≥18 y Imaging: ultrasound	No advice mentioned
Chester et al[27,28]	United Kingdom	Musculoskeletal shoulder pain of any duration, score of ≤8 on the SPADI or QuickDASH, reproduction of pain and/or restriction on active or passive movement in at least 1 direction Age, ≥18 y Imaging: none	Advice and exercise
Christiansen et al[30]	Denmark	Diagnosis of rotator cuff syndrome, bicipital tendinitis, calcific tendinitis, impingement syndrome, bursitis, other shoulder lesions, or unspecified shoulder lesions Age, 18-65 y Imaging: none	Advice on self-training
Cummins et al[33]	United States	Diagnosis of impingement syndrome using diagnostic subacromial injection Age, 35-65 y Imaging: none	Work within pain, only progress exercise as tolerated, posture
Karel et al[58]	the Netherlands	Shoulder pain (not further defined) Imaging: ultrasound imaging in 31% of 389 included patients	Informing, advising, counseling, and coaching were documented for 86% of patients

Nonrandomized or Retrospective Studies, Case Series, or Qualitative Interviews

Study	Country	Participant Inclusion Criteria	Advice and Education
Andrews et al[5]	United States	Overhead athletes (water polo, baseball, basketball, volleyball) with complaints of SIS Imaging: none	No advice mentioned
Barrett et al[10,11]	Ireland	Minimum 6-wk history of shoulder pain; aggravated by resisted shoulder flexion, abduction, or external rotation Age, ≥18 y	Encouraged to perform home exercises
Baydar et al[12]	Turkey	MRI-confirmed full-thickness rotator cuff tears	Activity modification
Camargo et al[23]	Brazil	Clinical diagnosis of SIS No evidence of rotator cuff or long head biceps tendon tear Imaging: ultrasound	Basic instruction about the anatomy and biomechanical factors related to SIS; advice surrounding arm and trunk positions that may lead to impingement; strategies to reduce load on the shoulder; instructions to use cryotherapy at home, as in sessions, if pain is present
Christensen et al[29]	Denmark	Experienced symptoms of rotator cuff rupture for ≥3 mo; rupture of at least the supraspinatus and infraspinatus, visualized by ultrasound or arthroscopy Imaging: ultrasound, MRI, or arthroscopy	Information on the diagnosis and rationale for exercise protocol, advice on how to manage pain related to exercise
Collin et al[32]	France	Full-thickness tears of at least 2 rotator cuff tendons, stage 3 or 4 fatty muscle degeneration in the affected muscles, pain score of ≤4 on the VAS, shoulder pseudo-paralysis: less than 90° of active elevation with full passive range of motion Imaging: none defined	No advice mentioned
Dickinson et al[39]	United States	Symptomatic rotator cuff tears, pain and decreased function for ≤4 wk Age, ≤45 y Imaging: MRI	No advice reported

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APPENDIX

Study	Country	Participant Inclusion Criteria	Advice and Education
Elkhadir et al[41]	Saudi Arabia	Rotator cuff tear, subacromial bursitis, subdeltoid bursitis, labral tears Imaging: MRI	Advice not specified
Garrison et al[45]	United States	Medically diagnosed with impingement syndrome with 1 or more of the following: dull ache at the anterolateral aspect of the shoulder, pain with overhead activity, pain with resisted abduction/external rotation, and pain with overhead positioning or direct pressure against the shoulder Imaging: none	No advice mentioned
Kuhn et al[68]	United States	MRI-documented atraumatic full-thickness rotator cuff tears Age, 18-100 y Imaging: MRI	Instructive rehabilitative booklets
Leffa et al[71]	Brazil	Clinical diagnosis of rotator cuff injury, pain for ≥3 mo Age, 18-70 y	No advice reported
Savoie et al[89]	Canada	Shoulder pain with painful arc of movement during flexion or abduction; positive Neer or Hawkins-Kennedy test; pain on resisted lateral rotation, abduction, or the empty-can test Age, 18-65 y Imaging: none	Education regarding posture and body mechanics; instructions around preferred shoulder positioning during sleep, activities, work, and sports
Su et al[94]	China	Pain or dysfunction for the shoulder for >3 mo Age, ≥18 y Imaging: MRI indicating rotator cuff tendinopathy	No advice reported
Tate et al[95]	United States	Shoulder pain: VAS, ≤7/10 at rest, positive Hawkins-Kennedy or Neer test, positive painful arc, pain or weakness with either the Jobe empty-can test or resisted shoulder external rotation Age, 14-80 y Imaging: none	Patient education: posture and body mechanics, avoidance of positions likely to provoke impingement
Tyler et al[96]	United States	Shoulder pain with posterior glenohumeral joint line tenderness, posterosuperior glenoid labral lesion on MRI, positive relocation test, positive posterior impingement sign Imaging: MRI	No advice mentioned
Yilmaz and Tuncer[104]	Turkey	Subacromial bursa and supraspinatus tendon pathology with or without restricted shoulder movement Imaging: X-ray	Home exercise program

Physical Therapist–Focused Studies

Surveys/Audits, Guidelines Implementation Studies, and Focus Groups With Physical Therapists

Study	Country	Participant Inclusion Criteria	Advice and Education
Bernhardsson et al[19]	Sweden	271 physical therapists in primary care (survey)	Advice on posture, 85%; advice to stay active, 50%; advice on bed rest, 10%; behavioral therapy, 5%
Bernhardsson and Larsson[18]	Sweden	Total of 256 physical therapists surveyed in primary care as part of an implementation study Intervention group: 168 physical therapists included in a program to implement clinical guidelines for subacromial pain Control group: 88 physical therapists	Advice on posture: intervention group, 95%; control group, 92% Advice to stay active: intervention group, 89%; control group, 87% Advice on bed rest: intervention group, 10%; control group, 10% Behavioral therapy: intervention group, 8%; control group, 5%
Dziedzic et al[40]	United Kingdom	Audit of physical therapy patient notes	Basic description of shoulder complex, what makes the shoulder painful, why movements may be stiff, how to ease discomfort, advice on when to move, encouragement to get back to daily routine
Hanratty et al[50]	United Kingdom	Physical therapists with ≥5 y of postgraduate experience working with musculoskeletal conditions, working on a daily basis in a musculoskeletal role (survey)	Patient education to improve "buy-in": SIS etiology, self-management through exercise, postural advice, pain management

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Study	Country	Participant Inclusion Criteria	Advice and Education
Karel et al[59-61]	the Netherlands	125 physical therapists participating in a prospective study, reporting their treatment interventions for patients with shoulder pain; 112 (48%) of the patients were diagnosed as having a subacromial impingement (survey)	Information/advice: 92% of patients with SIS, but not defined
Pieters et al[84]	Belgium and the Netherlands	505 physical therapists, comparing those who were members of a professional shoulder network group to those who were not members	Self-management of pain, posture, activity modification, work-related advice, options for exercise
Struyf et al[93]	Belgium	Dutch-speaking members of the Belgian physical therapist society who had the possibility of treating patients with shoulder pain (183 respondents) (survey)	Patient education/advice was not included

Abbreviations: ADL, activities of daily living; DASH, Disabilities of the Arm, Shoulder and Hand questionnaire; MRI, magnetic resonance imaging; NPRS, numeric pain-rating scale; NSAID, nonsteroidal anti-inflammatory drug; QuickDASH, shortened version of the Disabilities of the Arm, Shoulder and Hand questionnaire; SIS, subacromial impingement syndrome/shoulder impingement syndrome; SPADI, Shoulder Pain and Disability Index; VAS, visual analog scale.

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Are Changes in Fear-Avoidance Beliefs and Self-efficacy Mediators of Function and Pain at Discharge in Patients With Acute and Chronic Low Back Pain?

OBJECTIVE: To examine the mediating role of changes in fear-avoidance beliefs and self-efficacy on pain and physical functioning at discharge in patients with acute and chronic low back pain (LBP).

DESIGN: Retrospective study.

METHODS: Baseline and discharge data from 418 participants with acute and chronic LBP were analyzed. At discharge, functional status and pain intensity were analyzed to assess their role as a predictor of acute and chronic LBP status and as a mediator of fear-avoidance beliefs and self-efficacy from baseline to discharge.

RESULTS: In multivariable analyses, patients with chronic LBP had lower discharge functional status (β = −7.4; 95% confidence interval [CI]: −10.5, −4.3), lower self-efficacy for physical function (β = −5.3; 95% CI: −10.2, −0.4), higher pain intensity (β = 0.9; 95% CI: 0.3, 1.5), and no difference in discharge fear-avoidance beliefs compared to patients with acute LBP. Change in self-efficacy for physical function had a small indirect association (β = −1.1; 95% bias-corrected CI: −2.5, −0.004), mediating the relationship between chronic LBP and discharge functional status.

CONCLUSION: Fear-avoidance beliefs were not a mediator of pain or function at discharge in patients with chronic LBP. Self-efficacy may be an important mediating factor for function at discharge in patients with chronic LBP who receive physical therapy. *J Orthop Sports Phys Ther 2020;50(6):301-308. Epub 6 Jan 2020. doi:10.2519/jospt.2020.8982*

KEY WORDS: *chronic disease, fear, musculoskeletal pain, outcome assessment, physical therapy modalities, self-efficacy*

Low back pain (LBP) is among the leading reasons for visiting a health care provider and a major cause of disability worldwide.[21] Despite the favorable course of recovery for most patients, 10% of patients are at risk for developing chronic LBP.[12] This small percentage of patients accounts for a disproportionate amount of the costs associated with LBP.[22] Subsequently, clinical practice guidelines recommend preventing the progression of acute pain to chronic pain as a priority in managing individuals during an episode of LBP.[9]

The key to successfully preventing the progression of acute LBP to chronic LBP and effectively managing individuals with chronic LBP is a better understanding of modifiable treatment targets for secondary and tertiary prevention. Mediation analysis allows for the causal inference of a specific exposure to a given outcome, allowing identification of the mechanisms through which change occurs.[25] Psychological factors are influential in the transition from an episode of acute pain to the development of chronic pain as well as the maintenance of chronic pain conditions, thus represent important treatment targets.[8,37] Fear-avoidance beliefs and self-efficacy are key psychological constructs known to influence clinical outcomes in individuals with LBP.[7,11,24,42] For example, a study of 184 individuals with chronic LBP found that both fear-avoidance beliefs and self-efficacy mediated the relationship between baseline pain and disability, while only self-efficacy mediated 12-month changes in pain and disability.[7] Furthermore, a study of 701 individuals with LBP observed that changes in fear-avoidance beliefs and self-efficacy mediated 12-month outcomes of pain and disability following cognitive behavioral therapy.[11] In fact, systematic reviews support fear (standardized β = 0.08; 95% confidence interval [CI]: 0.01, 0.14) and self-efficacy (standardized β = 0.23; 95% CI: 0.10, 0.34) as mediating the relationship between pain and disability in individuals with LBP and have found moderate evidence for an association between changes in fear-avoidance beliefs and changes in clinical outcomes.[24,42] Collectively, these bodies of work support both fear-avoidance beliefs

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and self-efficacy as important mediators of LBP and disability.

Diagnostic criteria as well as recommended treatment strategies differ among individuals with acute and chronic pain conditions.[31,35,43] Subsequently, the mediators of clinical outcomes may differ between individuals with acute and chronic LBP, requiring different treatment targets for effective interventions. The relationship between fear-avoidance beliefs, self-efficacy, and clinical outcomes across individuals with acute and chronic LBP is not established. For example, differential changes are observed in fear-avoidance beliefs in individuals with acute LBP and those with chronic LBP.[17] Furthermore, fear of pain is more highly associated with disability in individuals with chronic LBP compared to individuals with acute LBP.[16] The predictive value of baseline fear for clinical outcomes differs between individuals with acute LBP and those with chronic LBP.[16,17,42] A stronger mediating effect has been reported for fear on clinical outcomes in individuals with LBP of less than 6 months in duration compared to those with LBP of greater than 6 months in duration.[42] Conversely, a meta-analysis of studies of participants with pain conditions observed a moderate to large relationship between pain-related fear and disability, independent of the duration of pain.[44] Collectively, this body of literature suggests that there may be a differential relationship between fear and clinical outcomes in individuals with acute LBP and those with chronic LBP, necessitating additional consideration.

To date, there have been few novel longitudinal examinations of the potential mediating role of fear-avoidance beliefs and self-efficacy in patients with acute and chronic LBP receiving physical therapy.[4] The objective of this study was to determine whether longitudinal changes in fear-avoidance beliefs and self-efficacy influence discharge pain and function over an episode of physical therapy in patients with chronic LBP and those with acute LBP. We hypothesized that changes in both fear-avoidance beliefs and self-efficacy would have a mediating role on discharge outcomes in patients with chronic LBP. The results of this study may help to identify meaningful differences in psychological factors between patients with acute LBP and those with chronic LBP that may lead to targeted rehabilitation strategies.

METHODS

Study Design

The study was a retrospective analysis of prospectively collected longitudinal data from outpatient physical therapy clinics participating in the Focus On Therapeutic Outcomes, Inc (FOTO) database. This study received approval from the Institutional Review Board of Sacred Heart University (approval number 180412A).

Data Source

The FOTO database collects standardized physical therapy outcome data, including sociodemographic variables, health characteristics, and patient-reported outcome measures, from consecutive patients presenting to participating physical therapy clinics and who are willing to provide clinical data.[34] The FOTO database includes additional data from optional forms collected at the discretion of participating physical therapy clinics. All data are self-reported by patients at initial evaluation (baseline) and after completing a physical therapy episode of care (discharge). Discharge outcomes are not standardized and reflect variation in length of routine physical therapy. Educational modules are provided to clinicians who collect FOTO data on how to administer patient-reported outcome measures in order to decrease the risk of systematic bias related to patient selection.[10]

Standardized sociodemographic variables included age, sex, body mass index, comorbidities (Functional Comorbidity Index[15]), and type of insurance (private, public, or other). Standardized clinical variables included pain duration, number of physical therapy visits, duration of episode of care, prescription medication use (yes/no), prior treatment (yes/no), the Fear-Avoidance Beliefs Questionnaire physical activity subscale (FABQ-PA), the lumbar computer adaptive test (LCAT), and pain intensity on the numeric pain-rating scale (NPRS). Optional psychological variables included the Chronic Pain Self-Efficacy Scale (CPSS) and the subscales related to pain management, physical function, and coping with symptoms that are included within this questionnaire.

Participants

To be included in the study, patients had to present to a clinic using the FOTO database and have complete data for baseline functional status (LCAT), pain intensity (NPRS), fear-avoidance beliefs (FABQ-PA), and self-efficacy (CPSS). Additionally, patients had to be 18 to 89 years of age, have a diagnosis of a lumbar spine disorder (eg, arthropathy, muscle/tendon disorder, osteochondral/chondral condition, spine pathology, sprain/strain, or not otherwise classified), and report a pain duration that was operationally defined as acute (21 days or less) or chronic (greater than 90 days). Patients who reported subacute pain duration (22-90 days), were receiving physical therapy interventions while on workers' compensation, or were involved in litigation were excluded.

Outcome Measures

Lumbar Computer Adaptive Test Self-reported lumbar functional status was assessed using the LCAT. The LCAT is a standardized scale that ranges from 0 (low functioning) to 100 (high functioning) points and has been reported to be precise, valid, sensitive to change, and responsive in patients with LBP.[19,40] Although the test-retest reliability of this instrument has not been reported, the LCAT has been reported to be internally consistent (α = .92).[18] The minimal clinically important difference (MCID) of 5 points has been reported for the LCAT.[19,40] Functional status

was measured at baseline and at discharge from physical therapy.

Numeric Pain-Rating Scale The NPRS is an 11-point scale on which respondents rate their pain intensity on a scale from 0 to 10, where 0 represents "no pain" and 10 represents pain "as bad as it can be." Test-retest reliability of the NPRS has been reported to be excellent (r = 0.92) in patients with LBP.[27] The MCID for patients with LBP has been reported to be 2 points.[5] Pain intensity was measured at baseline and at discharge from physical therapy.

Psychological Variables

Fear-Avoidance Beliefs Questionnaire Physical Activity Subscale The FABQ-PA consists of 4 questions related to fear associated with physical activity.[39] For each question, patients rate their agreement on a 7-point Likert scale, with 0 representing "completely disagree" and 6 representing "completely agree."[39] The FABQ-PA is scored by summing items 2 through 5 (range, 0-24). Higher FABQ-PA scores indicate higher fear-avoidance beliefs.[39] The FABQ-PA subscale test-retest reliability has been reported to have an intraclass correlation coefficient value of 0.90 (95% CI: 0.82, 0.94) in people with chronic LBP.[14] The standard error of measurement in patients with chronic LBP has been reported to be 5.4.[14] Scores on the FABQ-PA were assessed at baseline and at discharge from physical therapy.

Chronic Pain Self-Efficacy Scale The CPSS is a 22-item questionnaire that is designed to assess a patient's perceived self-efficacy in coping with chronic pain.[1] There are 3 subscales related to self-efficacy in pain management, physical function, and coping with symptoms.[1] Each question asks the patient, "How certain are you that you can…." Certainty is rated on a 10-point Likert scale, where 10 represents "very uncertain" and 100 represents "very certain." Higher scores on the subscales represent higher self-efficacy. The reliability values have been reported to be 0.88, 0.87, and 0.90, respectively, for the subscales of self-efficacy in pain management, physical function, and coping with symptoms.[1] The construct and content validity of these 3 self-efficacy subscales have been established by analyzing their relationship to the Beck Depression Inventory, Beck Hopelessness Scale, Body Parts Assessment, and West Haven-Yale Multidimensional Pain Inventory.[1,30] Self-efficacy was assessed at baseline and at discharge from physical therapy.

Data Analysis

All analyses were conducted using SPSS Statistics for Windows Version 24 (IBM Corporation, Armonk, NY). Descriptive statistics were computed for the total sample and by acute and chronic LBP status. Subgroup differences in baseline characteristics between patients with acute LBP and those with chronic LBP were examined with appropriate statistical tests for continuous (t test) or categorical (chi-square) data. Cohen's d was used as a measure of effect size for differences in psychological or outcome measures. The effect size was considered small (0.20), medium (0.50), or large (0.80).[6] To examine the associations of chronic LBP status with functional status, pain intensity, fear-avoidance beliefs, and self-efficacy at discharge, separate multivariable regressions were conducted, with subgroup status (acute versus chronic LBP) as a predictor. Covariates were informed based on prior evidence on prognostic factors in LBP,[2,32,33,36] and through significant univariable associations in the current sample between the covariate and (1) subgroup status and (2) discharge functional status and pain intensity. All models controlled for the baseline score of the dependent variable, baseline functional status, baseline pain intensity, depression, prior treatment, number of physical therapy visits, and duration of physical therapy.

Mediation analysis was conducted using the PROCESS macro for SPSS to assess direct and indirect associations with bootstrap procedures (5000 samples and bias-corrected 95% CIs).[20] Mediation analysis was conducted on outcomes of discharge functional status and pain intensity, with acute and chronic LBP status as the predictor, and the psychological variables shown to have been influenced by subgroup status as the mediator. Mediation analysis was not conducted if a psychological factor was not influenced by subgroup status. Change in the psychological factor from baseline to discharge was examined as the mediating variable. Change was computed by subtracting the baseline value from the discharge value. The indirect association and bias-corrected CIs of subgroup status with outcome when the mediator was included in the model were examined as an indicator for mediation, along with the results of the Sobel test. All coefficients were unstandardized and accounted for the covariates listed above.

RESULTS

Patient Characteristics

The FOTO database contained 606 618 enrolled patients with symptomatic complaints related to LBP. The sample size for these analyses was 737 patients who met baseline eligibility criteria (**TABLE 1**). Four hundred eighteen participants (56.7% of the sample) had complete outcome data at discharge and were included in the current analyses. Of the 418 analyzed participants, 95 participants reported acute LBP and 323 participants reported chronic LBP. Patients with chronic LBP were older, had more comorbidities, more often had depression, were less likely to have private insurance, and more often reported receiving prior treatment for the current episode. Additionally, participants with chronic LBP had higher functional status scores (d = 0.20) compared to patients with acute LBP, representing a small difference.[6] There were no differences between subgroups for fear-avoidance beliefs, self-efficacy, or pain intensity. At discharge, participants with chronic LBP attended more physical therapy visits (mean ± SD visits, 14.2 ± 6.7

compared to 11.4 ± 5.3) and had a longer episode of care (mean ± SD, 128.2 ± 76.9 days compared to 98.7 ± 77.0 days).

Association Between Chronic LBP and Discharge Outcomes

At discharge for the total sample, there were significant improvements in functional status (mean change, 12.2; 95% CI: 10.8, 13.5) and reductions in pain intensity (mean change, −2.0; 95% CI: −2.3, −1.8). Additionally, there were significant reductions in fear-avoidance beliefs (mean change, −1.2; 95% CI: −1.8, −0.5) and improvements in self-efficacy (range of mean change, 12.1; 95% CI: 9.6, 14.5 to 13.7; 95% CI: 11.2, 16.1).

Multivariable regression analysis showed a significant association between chronic LBP and discharge functional status (F = 48.3, adjusted R^2 = 0.44, β = −7.4; 95% CI: −10.5, −4.3) and pain intensity (F = 32.1, adjusted R^2 = 0.34, β = 0.9; 95% CI: 0.3, 1.5) (**TABLE 2**). After controlling for covariates, participants with chronic LBP had lower functional status and higher pain intensity ratings at physical therapy discharge. Additionally, there was a significant association between chronic LBP and discharge self-efficacy for physical functioning (F = 32.3, adjusted R^2 = 0.38, β = −5.3; 95% CI: −10.2, −0.4) (**TABLE 2**). After controlling for covariates, participants with chronic LBP had lower self-efficacy for physical function at physical therapy discharge compared to those with acute LBP. There was no association between chronic LBP and discharge fear-avoidance beliefs or with the other self-efficacy subscales. Thus, fear-avoidance beliefs were not considered a potential mediator of discharge functional status or pain intensity in this cohort.

TABLE 1 Baseline Characteristics of the Sample[a]

Baseline Variable	Eligible Sample (n = 737)	Analyzed Sample (n = 418)	Acute LBP (n = 95)	Chronic LBP (n = 323)
Sociodemographic				
Age, y	57.4 ± 14.9	59.1 ± 15.3	55.7 ± 16.4	60.1 ± 14.8
Sex (female), n (%)	453 (61.5)	252 (60.3)	50 (52.6)	202 (62.5)
BMI, kg/m^2	30.1 ± 7.0	29.9 ± 7.0	29.8 ± 7.3	29.9 ± 6.9
Comorbidities (FCI)	3.1 ± 2.0	3.1 ± 2.0	2.4 ± 1.8	3.4 ± 2.0
Depression (yes), n (%)	142 (19.3)	80 (19.1)	8 (8.4)	72 (22.3)
Insurance, n (%)				
Private	322 (43.7)	149 (35.6)	43 (45.3)	106 (32.8)
Public	238 (32.3)	157 (37.6)	26 (27.4)	131 (40.6)
Other	177 (24.0)	112 (26.8)	26 (27.4)	86 (26.6)
Clinical				
Prescription medication use (yes), n (%)	436 (59.2)	249 (59.6)	60 (63.2)	189 (58.5)
Prior treatment (yes), n (%)	377 (51.2)	221 (52.9)	38 (40.0)	183 (56.7)
Psychological				
FABQ-PA	12.6 ± 5.6	12.7 ± 5.5	12.8 ± 5.8	12.7 ± 5.4
Self-efficacy for pain management	58.1 ± 25.8	58.6 ± 26.4	62.0 ± 27.3	57.6 ± 28.3
Self-efficacy for physical function	60.3 ± 27.0	62.1 ± 27.1	57.6 ± 28.3	63.4 ± 26.7
Self-efficacy for coping skills	58.7 ± 24.1	59.2 ± 24.5	61.2 ± 23.1	58.7 ± 24.9
Outcome				
Functional status (LCAT)	48.2 ± 13.2	48.2 ± 13.7	45.4 ± 12.7	49.0 ± 13.8
Pain intensity (NPRS)	6.0 ± 2.5	5.8 ± 2.5	6.2 ± 2.4	5.7 ± 2.5

Abbreviations: BMI, body mass index; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; FCI, Functional Comorbidity Index; LBP, low back pain; LCAT, lumbar computer adaptive test; NPRS, numeric pain-rating scale.
[a]*Values are mean ± SD unless otherwise indicated.*

Mediation Analyses

Change in self-efficacy for physical function from baseline to discharge was examined as a mediator of the association between chronic LBP and discharge functional status and pain intensity. There was a significant indirect association between chronic LBP and functional status at discharge that was mediated by changes in self-efficacy for physical function (β = −1.1; 95% bias-corrected CI: −2.5, −0.004) (**FIGURE 1**). This corresponded with a small mediation effect (standardized β = −0.03; 95% bias-corrected CI: −0.1, 0.0002). **FIGURE 2** depicts the mediation model, showing a nonsignificant indirect association as mediated by fear-avoidance beliefs and functional status.

Changes in self-efficacy for physical function did not mediate the association between chronic LBP and pain intensity at discharge (β = 0.2; 95% bias-corrected CI: −0.001, 0.4).

DISCUSSION

This study examined the potential mediating role of change in fear-avoidance beliefs and in self-efficacy on function and pain at discharge between patients with acute LBP and those with chronic LBP who received physical therapy. At discharge, patients with chronic LBP reported lower self-efficacy for physical function and functional status and higher pain intensity ratings than patients with acute LBP. Change in self-efficacy for physical function was a significant mediator between chronic LBP status and functional status at discharge. Contrary to our hypotheses, fear-avoidance beliefs at discharge were not different between groups and not a mediator of outcomes at discharge. These findings may suggest that interventions to improve self-efficacy for physical function could contribute to greater functional status in patients with chronic LBP.

There were notable differences in outcomes between patients with acute LBP and those with chronic LBP after controlling for covariates, including baseline outcome scores for pain, function, and depression. Patients with chronic LBP did not improve to the same degree that patients with acute LBP did with regard to pain intensity, functional status, or self-efficacy for physical function. The observed difference in the outcome of pain intensity was not clinically meaningful (based on the MCID of 2 points). However, the observed difference in the outcome of functional status was clinically meaningful (based on the MCID of 5 points). This suggests that patients with chronic LBP had pain outcomes similar to those of patients with acute LBP, but functional improvements were less robust in patients with chronic LBP.

There was also an outcome difference between groups in self-efficacy for physical function, but not in the other self-efficacy subscales for coping or pain. Given the lack of psychometrics for this measure, it is not possible to determine whether this difference is clinically meaningful. There may be a need to better target improvement in self-efficacy for physical function in patients with chronic LBP. Wertli et al[41] sought to examine the comparative ability of self-efficacy versus negative psychological distress in predicting treatment outcome in patients with neck and back pain. In the longitudinal analysis by Wertli et al,[41] baseline self-efficacy, but not distress, was found to be a significant predictor of treatment outcome. Our mediation analyses advance these findings to suggest that change in a positive psychological characteristic (eg, self-efficacy) as opposed to change in a negative factor (eg, fear-avoidance beliefs) may be more meaningful for functional outcome. To date, a number of psychological mediators, including self-efficacy, have been examined in the literature for patients with back pain in response to psychology-based treatment.[25] However, no studies have sought to identify important mediators of outcomes in patients with chronic LBP versus those with acute LBP. Given the current findings, a more targeted approach that boosts self-efficacy for physical function may be needed for patients with chronic LBP.

Specific strategies to boost self-efficacy exist. For example, 4 strategies that have been identified in the literature to enhance self-efficacy for physical function are (1) performance accomplishments (ie, individuals' perception of improvement), (2) vicarious experience (ie, observing the accomplishments of others), (3) verbal encouragement (ie, positive feedback), and (4) perceiving physiological and affective responses related to an activity (ie, the patient is able

TABLE 2 Association Between Chronic LBP and Discharge Psychological Factors and Outcomes[a]

Discharge Variable	β Coefficient[b]	SE	Standardized β
Psychological			
FABQ-PA	0.05 (−1.3, 1.4)	0.70	0.003
Self-efficacy for pain management	−3.8 (−9.7, 2.2)	3.03	−0.06
Self-efficacy for physical function	−5.3 (−10.2, −0.4)	2.50	−0.09
Self-efficacy for coping skills	−3.0 (−8.3, 2.3)	2.71	−0.05
Outcome			
Functional status (LCAT)	−7.4 (−10.5, −4.3)	1.57	−0.18
Pain intensity (NPRS)	0.9 (0.3, 1.5)	0.28	0.12

Abbreviations: FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activity subscale; LBP, low back pain; LCAT, lumbar computer adaptive test; NPRS, numeric pain-rating scale; SE, standard error.
[a]*Multivariable models controlled for baseline score of the dependent variable, baseline functional status, baseline pain intensity, depression, prior treatment, number of physical therapy visits, and duration of physical therapy.*
[b]*Values in parentheses are 95% confidence interval. Acute LBP was the reference group.*

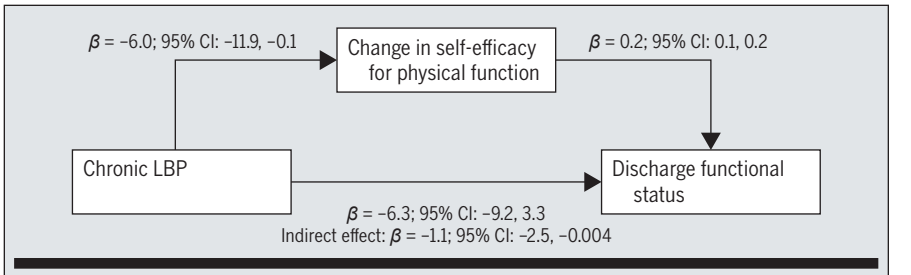

FIGURE 1. Mediation model showing a significant indirect association of chronic LBP with functional status at discharge as mediated by changes in self-efficacy for physical function. Abbreviations: CI, confidence interval; LBP, low back pain.

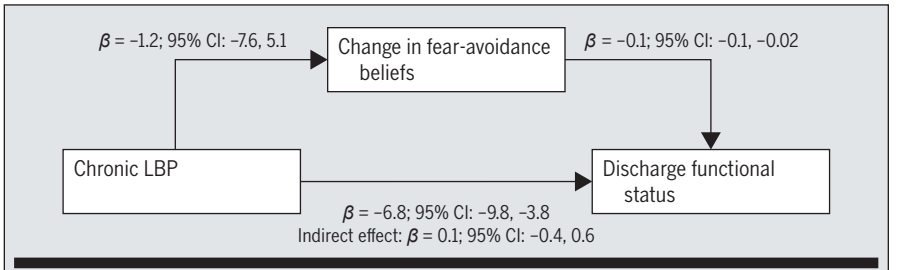

FIGURE 2. Mediation model showing a nonsignificant indirect association of chronic LBP with discharge functional status as mediated by changes in fear-avoidance beliefs. Abbreviations: CI, confidence interval; LBP, low back pain.

to see improvement).[3,25] The addition of motivational interventions to exercise and traditional physical therapy may improve self-efficacy.[28] Cognitive behavioral strategies encompass a range of techniques that can influence self-efficacy.[29,38] Although there have been recent calls for transforming care to a psychologically informed approach addressing negative beliefs,[26] there is a greater need for clarifying specific psychological strategies that should be integrated in physical therapy for targeting positive self-efficacy.[41]

Historically, clinical studies on LBP have primarily used physical function and pain measures to monitor treatment response, but have not often monitored change in psychological factors.[13] Beneciuk et al[4] found that a 4-week change in negatively oriented psychological measures, such as fear-avoidance beliefs and pain catastrophizing, improved the ability to predict disability outcomes in patients at high risk for developing chronic LBP. Similar to the current findings, Beneciuk et al[4] did not find an association between a change in negatively oriented psychological variables and pain intensity. While noteworthy, the unidimensional nature of many of these measures makes it challenging to comprehensively assess psychological risk within the constraints of physical therapy practice. Future studies examining the utility of composite psychological measures that include both positively and negatively oriented psychological constructs may be warranted.

There are limitations to consider in this study that primarily reflect the challenges of large clinical data collection. This study was a retrospective analysis of routinely collected clinical data. The sample meeting eligibility criteria was small (0.12%) in comparison to the total size of the cohort from which this sample was attained. Additionally, outcome data were not available for 43% of participants and thus were missing from the longitudinal analyses. This amount of missing data was considered too large for consideration of imputation methods. In addition, the current data did not include other potential psychological mediators such as pain catastrophizing or pathoanatomical factors. In addition, the use of the CPSS as a measure of self-efficacy makes the generalizability of our findings difficult due to its limited use in studies exploring positive psychological factors. This study cannot determine whether the changes are a result of physical therapy interventions or whether self-efficacy is an important mediator of physical therapy interventions. Mediators of an intervention require randomized trial designs. The mediation analysis conducted in this study used changes in mediators and outcomes that occurred at the same time point. One criterion advocated for determining causal mediation is the assessment of a mediator at an intermediate time point from the outcome.[23] Future work should establish the temporal sequence of changes in mediators and outcomes. Finally, the primary research question guiding this study pertained specifically to patients with acute LBP versus those with chronic LBP. As part of our approach, we dichotomized the predictor variable (pain duration) based on definitions of acute pain and chronic pain. A limitation of this study is the dichotomous categorization of the predictor variable, which may result in loss of information or power.

CONCLUSION

Changes in self-efficacy for physical function, but not in fear-avoidance beliefs, may be an important mediating variable for pain intensity and functional status in patients with chronic LBP. Further work is needed to identify optimal strategies for targeting self-efficacy in physical therapy for improving chronic pain management. ◉

KEY POINTS

FINDINGS: There were differences in discharge pain and physical function between patients with acute and those with chronic low back pain receiving physical therapy.

IMPLICATIONS: Difference in discharge physical function between patients with acute and those with chronic low back pain was mediated by changes in self-efficacy for physical function, but not fear-avoidance beliefs.

CAUTION: It may be important to assess psychological responses, specifically self-efficacy, within physical therapy for better tailoring of interventions for patients with chronic low back pain.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Drs Riley and Bialosky interpreted the data for the work, and Dr Coronado analyzed and interpreted the data for the work. Drs Riley and Coronado drafted the work and revised it critically for important intellectual content, and Dr Bialosky revised the work critically for important intellectual content. All authors agree to be accountable for all aspects of the work to ensure that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

DATA SHARING: Data are available on request through Focus On Therapeutic Outcomes, Inc.

PATIENT AND PUBLIC INVOLVEMENT: Patients were not involved in the design, methodological development, recruitment, data analysis, or the final written product of this research study.

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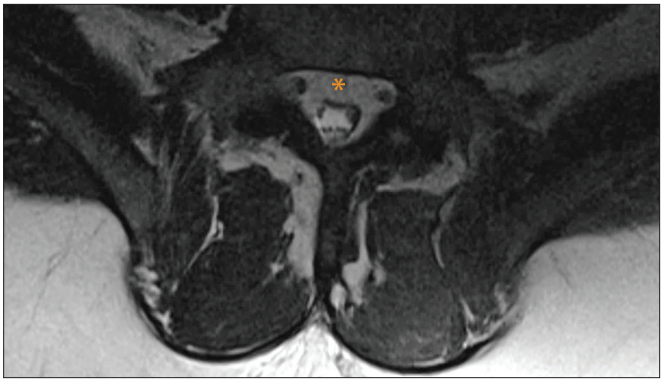

FIGURE 4. Axial T2-weighted magnetic resonance imaging at the L5 level. Excessive epidural fat (orange asterisk) is present in the anterior aspect of the spinal canal and encircling the thecal sac. Cauda equina is evident in the posterior aspect of the thecal sac.

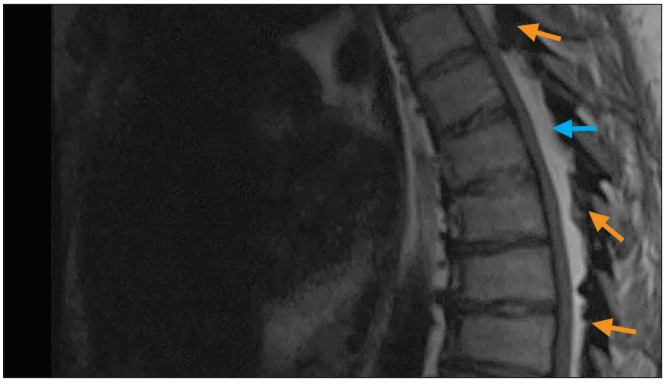

FIGURE 5. Sagittal T1-weighted magnetic resonance imaging of the thoracic spine. Excessive epidural fat (blue arrow) is visible in the upper portion of the thoracic spine. Bony encroachment of the spinal canal from facet arthrosis is present (orange arrows).

Facet Arthrosis and Spinal Lipomatosis–Related Spinal Canal Stenosis

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A 33-year-old man was referred to physical therapy by his primary care physician for low back pain (LBP) that had been present for 7 months. He noticed an increase in LBP with walking and gradually increasing lower extremity heaviness over the past 6 weeks. His past medical history and lumbar radiographs were noncontributory (**FIGURE 1**, available at www.jospt.org).

He had a body mass index of 46 kg/m^2 and an Oswestry Disability Index (ODI) score of 72%. Physical examination revealed decreased L4 and S1 reflexes bilaterally, as well as myotomal weakness of L2-S1 on the left and L4-S1 on the right lower extremity, with 3-beat clonus bilaterally. His blood pressure, heart rate, and oxygen levels were within normal ranges. He demonstrated neither peripheral edema nor trophic skin changes. His upper extremity myotomes, dermatomes, and reflexes were normal. He had no constitutional signs or symptoms and denied bowel or bladder changes.

The neurologic screen with mixed upper and lower motor neuron signs was of concern for spinal cord involvement. The primary care physician was contacted and magnetic resonance imaging ordered. Facet arthrosis and epidural lipomatosis were present, resulting in thoracic and lumbar spinal stenosis (**FIGURES 2** and **3**, available at www.jospt.org; **FIGURES 4** and **5**). While he was obese, he did not have other risk factors for epidural lipomatosis, such as chronic steroid use.[1,2] He underwent a T4-L3 laminectomy for spinal cord decompression. The excessive epidural fat was not removed during the procedure.

He resumed outpatient physical therapy 7 weeks following surgery. His LBP and lower extremity strength were unchanged immediately after surgery. However, his ODI score improved to 54% and his lower extremity reflexes were normal, with no clonus. Physical therapy focused on strengthening paraspinal and lower extremity musculature, along with improving cardiovascular endurance. His back pain was 2/10, his ODI score improved to 26%, and he returned to work as a laborer 17 weeks following surgery. ◉ *J Orthop Sports Phys Ther 2020;50(6):345. doi:10.2519/jospt.2020.9059*

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Effectiveness of Weight-Loss Interventions for Reducing Pain and Disability in People With Common Musculoskeletal Disorders: A Systematic Review With Meta-Analysis

OBJECTIVE: To assess the effectiveness of weight-loss interventions on pain and disability in people with knee and hip osteoarthritis (OA) and spinal pain.

DESIGN: Intervention systematic review.

LITERATURE SEARCH: Twelve online databases and clinical trial registries.

STUDY SELECTION CRITERIA: Randomized controlled trials of any weight-loss intervention (eg, diet, physical activity, surgical, pharmaceutical) that reported pain or disability outcomes in people with knee or hip OA or spinal pain.

DATA SYNTHESIS: We calculated mean differences or standardized mean differences (SMDs) and 95% confidence intervals (CIs). We used the Cochrane risk of bias tool to assess risk of bias and the Grading of Recommendations Assessment, Development, and Evaluation tool to judge credibility of evidence.

RESULTS: Twenty-two trials with 3602 participants were included. There was very low– to very low–credibility evidence for a moderate effect of weight-loss interventions on pain intensity (10 trials, n = 1806; SMD, −0.54; 95% CI: −0.86, −0.22; I^2 = 87%, P<.001) and a small effect on disability (11 trials, n = 1821; SMD, −0.32; 95% CI: −0.49, −0.14; I^2 = 58%, P<.001) compared to minimal care for people with OA. For knee OA, there was low- to moderate-credibility evidence that weight-loss interventions were not more effective than exercise only for pain intensity and disability, respectively (4 trials, n = 673; SMD, −0.13; 95% CI: −0.40, 0.14; I^2 = 55%; 5 trials, n = 737; SMD, −0.20; 95% CI: −0.41, 0.00; I^2 = 32%).

CONCLUSION: Weight-loss interventions may provide small to moderate improvements in pain and disability for OA compared to minimal care. There was limited and inconclusive evidence for weight-loss interventions targeting spinal pain.
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KEY WORDS: *management, musculoskeletal, obesity*

Musculoskeletal disorders are a leading cause of disability worldwide.[22] Hip and knee osteoarthritis (OA) and spinal pain (low back and neck pain) together have accounted for 75% of years lived with disability from musculoskeletal disorders in 2016.[22] Spinal pain has accounted for more disability than any other condition globally, totaling 86.5 million years lived with disability.[22] Hip and knee OA have accounted for over 16 million years lived with disability, and have been the 12th leading cause of disability.[22]

Up to 45% of the burden from OA and spinal pain has been attributed to overweight or obesity.[8] People with OA who are overweight or obese have 3 times increased odds of worsening knee OA.[44] People who are overweight or obese and have spinal pain have up to 1.4 times increased odds of persistent back pain[52] compared to those of normal weight. There is low-quality evidence that reducing body weight by 5% is associated with meaningful improvements in pain and disability in people who are overweight and have OA.[13] Weight loss is widely recommended as a treatment approach to improve pain and disability in people with OA and spinal pain who are overweight or obese.[29,40,47]

There are many weight-loss approaches for people who are overweight (including behavioral interventions targeting diet and/or physical activity and surgical and pharmaceutical interventions).

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However, systematic reviews of weight-loss interventions for people with musculoskeletal conditions have only included behavioral (diet and physical activity) interventions.[4,13,17] People with musculoskeletal conditions may face specific barriers to engaging in behavioral weight-loss interventions, including those targeting physical activity, due to obesity or pain that impacts everyday activity.[17,21] Comprehensive synthesis of all weight-loss interventions for people with musculoskeletal conditions is needed to help clinicians and patients make decisions about weight-loss treatment options.

The aim of this study was to assess the effectiveness of weight-loss interventions (including behavioral, pharmaceutical, surgical, and cognitive/psychological strategies) for reducing pain and disability in people with hip or knee OA or spinal pain.

METHODS

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[51] and was prospectively registered with PROSPERO (registration number CRD42016043134).

Data Sources and Searches

We searched MEDLINE, MEDLINE In-Process, AMED, CINAHL, the Cochrane NHS Economic Evaluation Database, the Cochrane Central Register of Controlled Trials, Embase, PsycINFO, and SPORTDiscus on February 5, 2019. The search strategy (**APPENDIX A**, available at www.jospt.org) was drafted in consultation with an information specialist and adapted for each database. We searched clinical trial registries in February 2019 (www.ClinicalTrials.gov, the Australian New Zealand Clinical Trials Registry, and the World Health Organization International Clinical Trials Registry Platform) to identify ongoing trials. We hand searched reference lists and contacted the authors of included studies to identify additional trials.

Trial Selection

We included randomized controlled trials (RCTs) and cluster randomized controlled trials (C-RCTs) with parallel groups. There was no restriction on language or publication date.

Participants

We included trials that recruited participants with a primary complaint of hip or knee OA or spinal pain (low back or neck pain). Diagnosis of hip or knee OA could be radiographic or clinical.[5,6,62] We excluded trials that recruited participants with hip or knee pain but no stated diagnosis of OA. We defined low back pain as pain located in the back between the 12th rib and buttock crease, with or without leg pain.[31] We defined neck pain as pain located in the cervical region of the spine.[16,27] We excluded trials with participants who had pain as a result of serious underlying conditions such as fracture, infectious disease, cancer, or systemic inflammatory conditions (eg, rheumatoid arthritis). We only included trials of mixed conditions when data were reported separately for OA and spinal pain. We placed no restriction on participant age.

Intervention

We included trials that assessed the effect of any intervention with a stated intention of reducing weight, regardless of the content, delivery methods, providers, intensity, or duration. This could include pharmacological, surgical, behavioral (diet and/or physical activity), or cognitive and psychological strategies. We excluded trials in which only a proportion of participants in an intervention arm were offered a weight-loss intervention. Trials that measured or reported on "weight" or "weight loss" but did not report weight loss as an intended treatment target were excluded, for example, therapeutic exercise interventions aiming to increase fitness or strength that did not explicitly aim to reduce weight.

Comparator

A comparison group could be any inactive or active control, including no care, wait list, minimal intervention, usual care, placebo or sham intervention, or an alternative intervention (eg, therapeutic exercise intervention).

Outcomes

We included a trial of OA (knee or hip) or spinal pain if it reported the effects of the intervention on pain intensity and disability outcomes, our primary outcomes of interest. When trials reported more than 1 pain or disability measure, we used the highest listed measure from a published hierarchy of patient-reported outcomes for meta-analyses, detailed for OA.[30] For spinal pain, we used the most valid and frequently used measure agreed on by consensus of the review authors.

Secondary outcomes captured for the review were weight, body mass index, physical performance measures, physical activity, dietary outcomes, mental health, and quality of life. We included physical performance outcomes measured by the 6-minute walk test or timed up-and-go test,[1] in line with the Osteoarthritis Research Society International recommendations[18] for assessing OA outcomes. We extracted both observer-rated and self-reported measures, prioritizing the former for extraction and inclusion in meta-analyses.

Data Extraction

Pairs of reviewers independently screened titles and abstracts, and then full texts, of potentially eligible papers. Reviewers resolved disagreements by consensus or a third reviewer when a consensus could not be reached. We contacted authors for translations of potentially eligible non-English trial reports and, when they did not reply, used Google Translate to screen the article against the eligibility criteria.

Two reviewers independently extracted data on trial design, participant characteristics, intervention description, outcome measures, and outcome data using a standardized data-extraction form. Discrepancies were resolved by consensus or, where necessary, by a third reviewer. We contacted trial authors where

important data were missing or information was required to determine eligibility.

Risk of Bias Across Trials

We used the Cochrane Collaboration risk of bias tool (Version 1) to assess random sequence generation, allocation concealment, blinding, incomplete data, selective reporting, and any other sources of bias such as contamination.[25] We additionally assessed C-RCTs for recruitment bias, baseline imbalance, loss of clusters, and incorrect analysis.[25] Two reviewers independently assessed each trial, with input from a third reviewer for unresolved differences. Trials were categorized as high risk of bias if they had high risk of bias in 3 or more of the 6 domains.

Data Synthesis and Analysis

We conducted meta-analysis based on condition (OA, including hip and knee, or spinal pain) when there were 2 or more trials for a condition, regardless of statistical heterogeneity. We performed separate meta-analyses for different comparators. We grouped trials with no- or low-intensity comparators as "minimal care." Minimal care could be usual care, attention or wait-list controls, placebo, a minimal intervention such as brief education or advice about self-management, or generic healthy lifestyle advice.

We grouped similar active comparators, irrespective of the dose or delivery (eg, exercise). When trials had more than 2 comparison arms, per Cochrane recommendations we combined similar intervention arms (active interventions) to form one comparison for the primary meta-analyses (eg, different types of exercise such as land-based and aquatic exercise weight-loss interventions). Where intervention arms were dissimilar (eg, dietary weight loss plus exercise versus dietary weight loss only), the number of participants in the control group was divided by the number of intervention arms to enable separate comparisons.[25] We used the first postintervention completion data point for synthesis in meta-analyses.

We calculated the mean difference and 95% confidence interval (CI) where trials reported the same outcome measure, and the standardized mean difference (SMD) where different outcome measures were reported. We used random-effects models, as we expected heterogeneity, and generic inverse variance methods to accommodate the inclusion of both RCTs and C-RCTs.[25] We assessed C-RCTs for unit-of-analysis errors. If clustering was not appropriately handled or intraclass correlation coefficients were not reported or supplied by the authors, then we adjusted for clustering.[25] We conducted meta-analyses using Review Manager Version 5.3.5 (The Nordic Cochrane Center, Copenhagen, Denmark).

We interpreted the effect size for the SMD according to Cohen's *d* (0.2, small effect; 0.5, moderate effect; greater than 0.8, large effect).[15] To facilitate interpretation, we transformed the SMD to provide an estimate of the mean difference for the primary outcomes (pain and disability) and weight outcomes. To do so, we used the most valid, widely used measurement tool of the included trials[25] and multiplied the SMD by the standard deviation of the combined groups at baseline of the trial that had the lowest risk of bias and used the tool. Data from trials not included in meta-analyses were presented separately.

We used the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) criteria to assess the credibility of evidence for each meta-analysis.[24] The credibility of evidence (categorized as "high," "moderate," "low," or "very low") was downgraded from high, based on limitations of the trial design, inconsistency of the results, imprecision, indirectness, or publication bias. Publication bias was assessed via visual inspection of funnel plots.

Subgroup and Sensitivity Analysis

We conducted subgroup analyses by intervention type and duration, where possible, for pain, disability, and weight outcomes. Intervention types were defined as multifocused interventions with weight loss, where weight loss was a component of a broader, pain-focused intervention (eg, with advice/education or cognitive or psychological pain management strategies), or weight loss–only interventions, where the entire intervention was focused on weight loss (eg, appetite suppressants, meal replacements, reduced-calorie diets with or without exercise) without any additional components. There were insufficient trials with similar comparison groups to conduct subgroup analyses by specific intervention type, such as pharmaceuticals, meal replacements, etc. Trials were defined as having a duration of less than 12 months or 12 months or greater.

We performed sensitivity analysis to explore the influence of bias by removing trials with an overall high risk of bias. We assessed statistical heterogeneity using the I^2 statistic, where a score greater than 75% was considered high.[26] We attempted to investigate the sources of high heterogeneity (greater than 75%) for primary outcomes by examining I^2 values in subgroup analyses by intervention type. Evidence credibility was downgraded for unexplained heterogeneity.

Protocol Deviations

We included only RCTs to ensure the highest-quality evidence. We added physical performance measures as an outcome. We presented a summary table of trials not included in the meta-analysis, instead of qualitative synthesis, due to the large number of outcomes.

RESULTS

We identified 8889 unique records, of which 268 full texts were reviewed and 22 trials (18 RCTs[10-12,14,23,28,33-39,41,45,46,53,54,56,59-61] and 4 C-RCTs[2,3,7,43,50] in 44 records) were included (**FIGURE 1**, **TABLE 1**; full details of interventions are presented in **APPENDIX B**, available at www.jospt.org). **TABLE 2** shows the results of the 16 trials included in meta-analyses, and the 6 trials that were not, and addi-

tional outcomes not included in the meta-analysis are provided in **APPENDIX B**.

Trial Characteristics

There were 19 trials that included 3310 participants with either knee OA (n = 17)[10-12,14,23,33-38,41,43,45,46,50,53,54,56,60,61] or knee and hip OA (n = 2),[2,3] and 3 trials that included 292 participants with chronic low back pain.[28,39,59] Intervention durations ranged from 6 weeks to 3 years. All but 1 trial reported follow-up immediately post intervention.[53] Only 2 trials collected long-term follow-up data (up to 11 months post intervention).[7,43,50] Seventeen trials (OA, n = 15; spinal pain, n = 2) examined weight loss–only interventions including diet-only interventions (reduced-calorie diets with or without meal replacements),[10,11,23,34,36,46,54,60] exercise interventions,[33,61] combined diet and exercise interventions,[23,28,34-36,38,41,53,60] and pharmaceutical interventions.[39,54,56] Six trials (OA, n = 5; spinal pain, n = 1) examined multifocused interventions with weight loss, including telephone coaching for weight loss combined with cognitive behavioral therapy, specialist referral,[2,3] or spinal pain education[59]; and diet and exercise interventions combined with OA education[43,50] or psychological pain-coping interventions.[53] Trial comparator groups included attention control, placebo, usual care, exercise only, diet only, therapeutic exercise, or brief lifestyle education.

Adherence to interventions (based on session attendance, calls completed, meal replacements consumed) ranged from 34% to 100% for weight loss–only interventions and from 45% to 95% for multifocused interventions. Interventions delivered via telephone had the lowest average adherence (34% to 46% of completed sessions). Interventions using diet and exercise approaches, either combined or independently, had average adherence rates between 70% and 73% of sessions completed. Only 1 of 3 pharmaceutical trials reported adherence, which was 100% of the prescribed medication.[54]

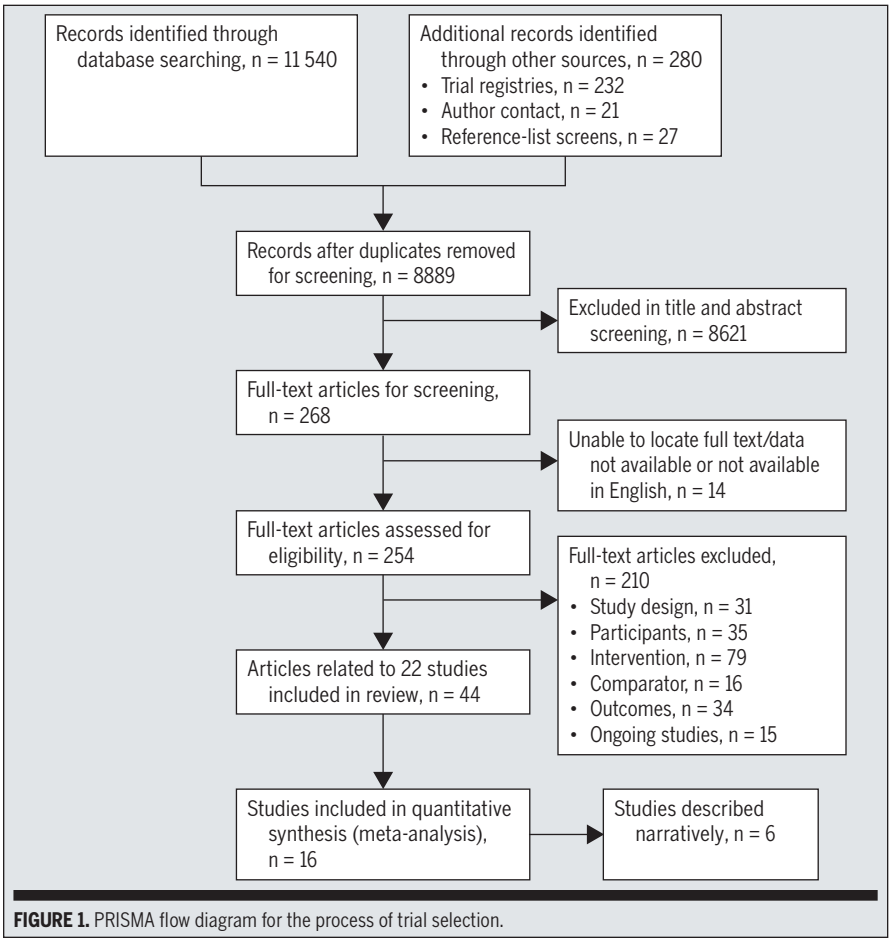


FIGURE 1. PRISMA flow diagram for the process of trial selection.

Risk of Bias Across Trials

We judged 7 trials as having a high overall risk of bias (**FIGURE 2**). Due to the nature of interventions and outcomes (self-report), almost all trials were at high risk of bias for blinding. Two trials had a high risk of bias for not randomizing group selection or selection bias, 2 for allocation concealment, and 7 for incomplete outcome data (attrition bias). Two trials were at high risk of recruitment bias or bias due to having no adjustment for clustering.

Results of Meta-Analyses

All meta-analyses, including primary and secondary outcomes, are reported in **TABLE 2** and **APPENDICES C**, **D**, and **E**.

Weight-Loss Interventions Versus Minimal Care (Hip and Knee OA) There was very low–credibility evidence from 10 trials[2,3,23,33,34,38,41,43,50,53] (n = 1806) for a moderate effect of weight-loss interventions (including diet and exercise, diet only, exercise only, and multifocused interventions) on pain intensity compared to minimal care (SMD, −0.54; 95% CI: −0.86, −0.22; I^2 = 87%) (**FIGURE 3**, **TABLE 2**). This equated to an estimated mean difference of −1.77 points on the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscale or of −1 points on a 0-to-10 numeric pain-rating scale. There was no effect on pain intensity when trials at high risk of bias were removed from the meta-analyses (SMD, −0.32; 95% CI: −0.68, 0.04) (**APPENDIX C**, available at www.jospt.org; **TABLE 2**).

Subgroup analysis showed a large effect of multifocused interventions (SMD, −0.81; 95% CI: −1.41, −0.21; I^2 = 94%) and a small effect of weight loss–only interventions (SMD, −0.36; 95% CI: −0.71, −0.01; I^2 = 72%) on pain (**FIGURE 3**, **TABLE 2**) compared to minimal care. The

interaction term for the subgroup analysis was not significant. Subgroup analysis showed a small effect of weight-loss interventions of less than 12 months' duration (SMD, −0.85; 95% CI: −1.39, −0.30; I^2 = 91%), and no effect of interventions lasting 12 months or longer (SMD, −0.13; 95% CI: −0.28, 0.02; I^2 = 0%) (**TABLE 2**). The interaction term for the subgroup analysis was significant.

There was low-credibility evidence from 11 trials[2,3,23,33,34,38,41,43,53,56,60] (n = 1821) for a small effect of weight-loss interventions (including diet and exercise, diet only, exercise only, multifocused, and pharmaceutical interventions) on disability compared to minimal care (SMD, −0.32; 95% CI: −0.49, −0.14; I^2 = 58%) (**FIGURE 3**, **TABLE 2**). This equated to an estimated mean difference of −3.7 points on the WOMAC function subscale. Effects were similar when trials at high risk of bias were removed from the analysis (**APPENDIX C**, **TABLE 2**).

Subgroup analysis showed small effects of weight loss–only interventions (SMD, −0.40; 95% CI: −0.69, −0.12; I^2

TABLE 1 Characteristics of Included Trials

Study/Type/Country/Trial	Condition/BMI/Arms	Length of Follow-up/Lost to Follow-up/ Intervention Adherence	Primary/Secondary Outcomes
Allen et al[3]	Knee/hip OA (n = 300)	12 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
C-RCT	>25 kg/m^2	9%	
United States	2 arms	NR	BMI, mental health (PHQ), physical activity (CHAMPS)
Allen et al[2]	Knee and/or hip OA (n = 537)	12 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
C-RCT	>25 kg/m^2	19.1%	
United States	4 arms	Patients, 43%; providers, 47% of calls completed	BMI, mental health (PHQ), physical activity (CHAMPS)
Bliddal et al,[10] Christensen et al[12]	Knee OA (n = 96)	12 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
RCT	>28 kg/m^2	41.7%	
Denmark	2 arms	58% completed	Weight (kilograms)
Christensen et al[11]	Knee OA (n = 153)	3 y	Pain (KOOS pain subscale) and disability (KOOS function in sport and recreation subscale)
RCT	>30 kg/m^2	29.5%	
Denmark	2 arms	70% of sessions completed	Weight (kilograms), KOOS knee-related QoL subscale
LIGHT			
Ghroubi et al[23]	Knee OA (n = 56)	8 wk	Pain (VAS) and disability (WOMAC)
RCT	>30 kg/m^2	19.7%	Weight (kilograms), physical performance (6MW)
France	4 arms	NR	
Irandoust et al[28]	LBP (n = 36)	4 mo	Pain (VAS)
RCT	NR	NR	Weight (kilograms)
Iran	2 arms	NR	
Lim et al[33]	Knee OA (n = 75)	8 wk	Pain (BPI, 0-11) and disability (WOMAC)
RCT	>25 kg/m^2	12%	Weight (kilograms), mental health (SF-36 MCS)
the Netherlands	3 arms	Aquatic, 92%; land, 88% of sessions completed	
Messier et al[35]	Knee OA (n = 24)	6 mo	Pain (knee pain scale, ambulation intensity of 0-6) and disability (FAST Functional Performance Inventory)
RCT	>28 kg/m^2	12.5%	
United States	2 arms	Diet plus exercise, 95% of sessions completed	Weight (kilograms), physical performance (6MW)
Messier et al,[34] Rejeski et al[45]	Knee OA (n = 316)	18 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
RCT	>28 kg/m^2	20.3%	
United States	4 arms	Diet, 72%; exercise, 60%; diet plus exercise, 64% of sessions completed	Weight (kilograms), physical performance (6MW), mental health (SF-36 MCS)
ADAPT			
Messier et al[36]	Knee OA (n = 454)	18 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
RCT	>27-41 kg/m^2	12.2%	
United States	3 arms	Diet, 61%; diet plus exercise, 63% of sessions completed	Weight (kilograms), physical performance (6MW), mental health (SF-36 MCS)
IDEA			
Miller et al [37,38]	Knee OA (n = 87)	6 mo	Pain (WOMAC pain subscale) and disability (WOMAC function subscale)
RCT	>30 kg/m^2	9.2%	
United States	2 arms	Intervention group, 77% of exercise and 75% of nutrition sessions completed	Weight (kilograms), physical performance (6MW)
Muehlbacher et al[39]	CLBP (n = 96)	10 wk	Pain (PRI of the MPQ, 0-40) and disability (ODQ)
RCT	NR	8.4%	Weight (kilograms), mental health (SF-36 MCS)
Germany	2 arms	NR	

Table continues on page 324.

TABLE 1 Characteristics of Included Trials (continued)

Study/Type/Country/Trial	Condition/BMI/Arms	Length of Follow-up/Lost to Follow-up/ Intervention Adherence	Primary/Secondary Outcomes
O'Brien et al[41] RCT Australia	Knee OA (n = 120) 27-40 kg/m^2 2 arms	6 mo 12% 34% completed ≥6 calls	Pain (NRS, 0-10) and disability (WOMAC function subscale) Weight (kilograms), mental health (SF-12 Version 2 MCS), physical activity (MVPA), dietary intake (FFQ)
Ravaud et al[43] C-RCT France ARTIST	Knee OA (n = 336) 25-35 kg/m^2 2 arms	4 mo 12.3% 95% attended 3 consultations	Pain (NRS, 0-10) and disability (WOMAC function subscale) Weight (kilograms), mental health (SF-12 MCS)
Riecke et al[46] RCT (phase 1 of 2) Christensen et al[14] RCT (phase 2 of 2) Denmark	Phases 1 and 2: knee OA (n = 192) NR Phase 1, 2 arms; phase 2, 3 arms	68 wk 12.7% 90% of sessions completed	Pain (OMERACT-OARSI VAS, 0-100) and disability (OMERACT-OARSI VAS, 0-100) Weight (kilograms), mental health (SF-36 MCS), KOOS knee-related QoL subscale
Aree-Ue et al,[7] Saraboon et al[50] C-RCT Thailand	Knee OA (n = 80) 23-29 kg/m^2 2 arms	8 wk NR NR	Pain (NRS, 0-10) Weight (kilograms), physical performance (TUG)
Somers et al[53] RCT United States	Knee OA (n = 232) 25-42 kg/m^2 4 arms	PTA, 24 wk plus 6 mo plus 12 mo 29.75% BWM, 65%; PCST plus BWM, 73% of sessions completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (pounds), mental health (AIMS psychological scale)
Strebkova and Alekseeva[54] RCT Russia	Knee OA (n = 50) >30 kg/m^2 2 arms	6 mo 0% 100% drug compliance	Pain (WOMAC pain VAS, 0-100) and disability (WOMAC function VAS, 0-100) Weight (kilograms)
Toda et al[56] RCT Japan	Knee OA (n = 40) >26.4 kg/m^2 2 arms	6 wk 7.5% NR	Disability (Lequesne index of severity) Weight (kilograms), physical activity (steps per day)
Williams et al[59] RCT Australia	CLBP (n = 160) 27-40 kg/m^2 2 arms	26 wk 21.8% 41% completed ≥6 calls	Pain (NRS, 0-10) and disability (RMDQ) Weight (kilograms), mental health (SF-12 Version 2 MCS), physical activity (MVPA), dietary intake (FFQ)
Wolf et al[60] RCT United States	Knee OA (n = 110) NR 4 arms	24 wk 22% NR	Disability (WOMAC function subscale) Weight (pounds), physical performance (6MW), mental health (SF-36 MCS)
Yázigi[61] RCT Portugal	Knee OA (n = 52) NR 2 arms	12 wk 7.7% NR	Pain (BPI) and disability (KOOS) Weight (kilograms), KOOS knee-related QoL subscale

Abbreviations: 6MW, 6-minute walk; ADAPT, Arthritis, Diet, and Activity Promotion Trial; AIMS, Arthritis Impact Measurement Scales; ARTIST, osteoarthritis intervention standardized; BMI, body mass index; BPI, Brief Pain Inventory; BWM, behavioral weight management; CHAMPS, Community Healthy Activities Model Program for Seniors; CLBP, chronic low back pain; C-RCT, cluster randomized controlled trial; FAST, Fitness Arthritis and Seniors Trial; FFQ, Food Frequency Questionnaire; IDEA, Intensive Diet and Exercise for Arthritis; KOOS, Knee injury and Osteoarthritis Outcome Score; LBP, low back pain; LIGHT, Long-term Intervention With Weight Loss in Patients With Concomitant Obesity and Knee Osteoarthritis; MCS, mental component summary; MPQ, McGill Pain Questionnaire; MVPA, moderate to vigorous physical activity; NR, not reported; NRS, numeric rating scale; OA, osteoarthritis; OARSI, Osteoarthritis Research Society International; ODQ, Oswestry Low Back Pain Disability Questionnaire; OMERACT, Outcome Measures in Rheumatology; PCST, pain coping skills training; PHQ, Patient Health Questionnaire; PRI, Pain Rating Index; PTA, posttreatment average; QoL, quality of life; RCT, randomized controlled trial; RMDQ, Roland-Morris Disability Questionnaire; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; TUG, timed up and go; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

= 64%) and multifocused interventions (SMD, −0.24; 95% CI: −0.42, −0.05; I^2 = 43%) on disability compared to minimal care (**FIGURE 3**, **TABLE 2**). The interaction term for the subgroup analysis was not significant. Subgroup analysis showed a small effect of weight-loss interventions of less than 12 months' duration (SMD, −0.46; 95% CI: −0.74, −0.18; I^2 = 91%) and no effect of interventions lasting 12 months or longer (SMD, −0.18; 95% CI: −0.33, −0.03; I^2 = 0%) (**TABLE 2**). The interaction term for the subgroup analysis was significant.

There was very low–credibility evidence from 12 trials[2,3,23,33,34,38,41,43,50,53,56,60] (n = 1903) for a small effect of weight-loss interventions (including diet and

exercise, diet only, exercise only, multifocused, and pharmaceutical interventions) on weight compared to minimal care (SMD, −0.42; 95% CI: −0.64, −0.19; I^2 = 77%) (**FIGURE 3**, **TABLE 2**). This equated to a mean difference of −5.6 kg.

Subgroup analysis found a moderate effect of weight loss–only interventions on weight (SMD, −0.56; 95% CI: −0.97, −0.15; I^2 = 83%) and a small effect of multifocused interventions (SMD, −0.21; 95% CI: −0.34, −0.08; I^2 = 1%) compared to minimal care (**FIGURE 3**, **TABLE 2**). The interaction term for the subgroup analysis was not significant.

Weight Loss–Focused Interventions Versus Exercise Only (Knee OA) There was low-credibility evidence from 4 trials[23,34-36] (n = 673) that weight-loss interventions had no effect on pain intensity compared to exercise-only interventions (SMD, −0.13; 95% CI: −0.40, 0.14; I^2 = 55%) (**APPENDIX D**, **TABLE 2**). There were no effects on pain intensity when trials at high risk of bias were removed from the analysis (**APPENDIX C**, **TABLE 2**).

There was moderate-credibility evidence from 5 trials[23,34-36,60] (n = 737) that weight-loss interventions had no effect on disability compared to exercise-only interventions (SMD, −0.20; 95% CI: −0.41, 0.00; I^2 = 32%) (**APPENDIX D**, **TABLE 2**). There were no effects on disability when trials at high risk of bias were removed from the analysis (**APPENDIX C**, **TABLE 2**).

There was low-credibility evidence from 5 trials[23,34-36,60] (n = 714) of a small effect of weight-loss interventions on weight compared to exercise only (SMD, −0.23; 95% CI: −0.39, −0.08; I^2 = 0%) (**APPENDIX D**, **TABLE 2**). This equated to an estimated mean difference of −3.5 kg.

Diet Plus Exercise Versus Diet Only (Knee OA) There was moderate-credibility evidence from 3 trials[23,34,36] (n = 435) of a small effect of combined diet (meal replacements and/or reduced-calorie diets) and exercise interventions on pain intensity compared to diet-only interventions (SMD, −0.48; 95% CI: −0.94, −0.03; I^2 = 75%) (**APPENDIX D**, **TABLE 2**). This equated to an estimated mean difference of −1.5 points on the WOMAC pain subscale.

There was moderate-credibility evidence from 4 trials[23,34,36,60] (n = 476) of a small effect of combined diet and exercise weight-loss interventions on disability compared to diet-only interventions (SMD, −0.38; 95% CI: −0.76, 0.00; I^2 = 67%) (**APPENDIX D**, **TABLE 2**). This equated to an estimated mean difference of −4.1 points on the WOMAC function subscale.

FIGURE 2. Summary of risk-of-bias assessment for included trials. 1, Random sequence generation (selection bias); 2, Allocation concealment (selection bias); 3, Blinding of participants and personnel (performance bias); 4, Blinding of outcome assessment (detection bias); 5, Incomplete outcome data (attrition bias); 6, Selective reporting (reporting bias); 7, Other bias.

TABLE 2 Summary of Meta-Analysis Results for Primary and Secondary Outcomes and of Subgroup and Sensitivity Analyses

Analysis	Patients (Trials), n	SMD[a]	Re-expression of SMD for Overall Result	GRADE
All Weight-Loss Interventions Versus Minimal Care for OA				
Pain	1806 (10)	−0.54 (−0.86, −0.22)	WOMAC pain subscale, −1.77 points; NRS (0-10), −1 points	Very low[b-d]
Weight loss only	614 (6)	−0.36 (−0.71, −0.01)		
Multifocused	1192 (5)	−0.81 (−1.41, −0.21)		
Excluding high ROB	925 (5)	−0.32 (−0.68, 0.04)		
<12 mo in duration	873 (7)	−0.85 (−1.39, −0.30)		
≥12 mo in duration	761 (3)	−0.13 (−0.28, 0.02)		
Disability	1821 (11)	−0.32 (−0.49, −0.14)	WOMAC function subscale, −3.7 points	Low[b,d]
Weight loss only	709 (8)	−0.40 (−0.69, −0.12)		
Multifocused	1112 (4)	−0.24 (−0.42, −0.05)		
Excluding high ROB	1020 (7)	−0.43 (−0.73 −0.13)		
<12 mo in duration	888 (8)	−0.46 (−0.74, −0.18)		
≥12 mo in duration	761 (3)	−0.18 (−0.33, −0.03)		
Weight	1903 (12)	−0.42 (−0.64, −0.19)	−5.6 kg	Very low[b-d]
Weight loss only	711 (8)	−0.56 (−0.97, −0.15)		
Multifocused	1192 (5)	−0.21 (−0.34, −0.08)		
<12 mo in duration	970 (9)	−0.57 (−0.91, −0.23)		
≥12 mo in duration	761 (3)	−0.13 (−0.27, 0.02)		
Physical performance	478 (5)	1.0 (0.44, 1.56)	...	Very low[b,c,e]
Mental health	1780 (8)	0.01 (−0.16, 0.18)	...	Moderate[b,e]
Physical activity	1221 (5)	1.11 (0.34, 1.88)	...	Very low[b-e]
Weight Loss–Focused Interventions Versus Exercise for Knee OA				
Pain	673 (4)	−0.13 (−0.40, 0.14)	No effect	Low[b,e]
Excluding high ROB	435 (3)	−0.04 (−0.48, 0.40)		
Disability	737 (5)	−0.20 (−0.41, 0.00)	No effect	Moderate[b]
Excluding high ROB	499 (4)	−0.18 (−0.49, 0.14)		
Weight	714 (5)	−0.23 (−0.39, −0.08)	−3.5 kg	Low[b,e]
Physical performance, m[f]	729 (5)	−10.47 (−32.2, 11.3)	...	Low[b,e]
Mental health[f]	673 (3)	0.20 (−0.84, 1.25)	...	Low[b,e]

Table continues on page 327.

There was low-credibility evidence from 4 trials[23,34,36,60] (n = 467) of no effect of combined diet and exercise interventions on reducing weight (mean difference, 0.46 kg; 95% CI: −2.55, 3.48; I^2 = 38%) (**APPENDIX D**, **TABLE 2**) compared to diet-only interventions.

Diet Plus Exercise Versus Exercise Only (Knee OA) There was moderate-credibility evidence from 4 trials[23,34-36] (n = 455) of a small effect of combined diet (meal replacements and/or reduced-calorie diets) and exercise interventions on pain intensity compared to exercise-only interventions (SMD, −0.29; 95% CI: −0.55, −0.03; I^2 = 30%) (**APPENDIX D**, **TABLE 2**). This equated to an estimated mean difference of −0.9 points on the WOMAC pain subscale.

There was moderate-credibility evidence from 5 trials[23,34-36,60] (n = 498) of a small effect of combined diet and exercise weight-loss interventions on disability compared to exercise-only interventions (SMD, −0.38; 95% CI: −0.55, −0.20; I^2 = 0%) (**APPENDIX D**, **TABLE 2**). This equated to an estimated mean difference of −4.1 points on the WOMAC function subscale.

There was moderate-credibility evidence from 5 trials[23,34-36,60] (n = 476) of no effect of combined diet and exercise interventions on reducing weight (SMD, −0.21 kg; 95% CI: −0.45, 0.02; I^2 = 25%) (**APPENDIX D**, **TABLE 2**) compared to exercise-only interventions.

Weight-Loss Interventions Versus Minimal Care (Chronic Low Back Pain) Meta-analyses of 2 trials[39,59] for chronic low back pain found no effects for pain intensity (low credibility of evidence), disability (low credibility of evidence), or weight (moderate credibility of evidence) compared to minimal care (**APPENDIX D**, **TABLE 2**). Based on the unusually large effect size for pain in the pharmaceutical trial[39] and the scale used for pain, we suspect that the reported standard deviation may be incorrect, but we were unable to confirm this with the study authors.

TABLE 2 Summary of Meta-Analysis Results for Primary and Secondary Outcomes and of Subgroup and Sensitivity Analyses (continued)

Analysis	Patients (Trials), n	SMD[a]	Re-expression of SMD for Overall Result	GRADE
Dietary Weight Loss and Exercise Versus Dietary Weight Loss Only for Knee OA				
Pain	435 (3)	−0.48 (−0.94, −0.03)	WOMAC pain subscale, −1.5 points	Moderate[b]
Disability	476 (4)	−0.38 (−0.76, 0.00)	WOMAC function subscale, −4.1 points	Moderate[b]
Weight, kg[f]	467 (4)	0.46 (−2.55, 3.48)	No effect	Low[b,e]
Physical performance, m[f]	448 (4)	51.83 (43.7, 59.95)	...	Low[b,e]
Mental health[f]	448 (3)	−0.02 (−1.36, 1.32)	...	Low[b,e]
Dietary Weight Loss and Exercise Versus Exercise Only for Knee OA				
Pain	455 (4)	−0.29 (−0.55, −0.03)	WOMAC pain subscale, −0.9 points	Moderate[b]
Disability	498 (5)	−0.38 (−0.55, −0.20)	WOMAC function subscale, −4.1 points	Moderate[b]
Weight	476 (5)	−0.21 (−0.45, 0.02)	No effect	Moderate[b]
Physical performance, m[f]	466 (5)	14.68 (6.70, 22.66)	...	Low[b,e]
Mental health[f]	446 (3)	0.04 (−0.14, 0.23)	No effect	Low[b,e]
Weight-Loss Interventions Versus Usual Care for Chronic Low Back Pain				
Pain	255 (2)	−3.05 (−8.68, 2.58)	No effect	Low[c,e]
Disability	189 (2)	−0.51 (−1.29, 0.27)	No effect	Low[c,e]
Weight[f]	213 (2)	−2.65 (−7.50, 2.20)	No effect	Moderate[e]
Mental health	200 (2)	−0.38 (−1.47, 0.70)	Not applicable	Low[c,e]

Abbreviations: GRADE, Grading of Recommendations Assessment, Development, and Evaluation; NRS, numeric rating scale; OA, osteoarthritis; ROB, risk of bias; SMD, standardized mean difference; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Downgraded due to limitations of trial design.*
[c]*Downgraded due to inconsistency of results.*
[d]*Downgraded due to high probability of publication bias due to visual inspection of the funnel plot.*
[e]*Downgraded due to imprecision of results.*
[f]*Values in the SMD column are mean difference.*

DISCUSSION

Weight-loss interventions were effective for reducing pain, disability, and weight in people with knee and hip OA. We found small to moderate effects on pain intensity and disability from very low– and low-credibility evidence, compared to minimal care, in people with knee and hip OA. Weight-loss interventions were not more effective than exercise-only interventions for people with knee OA (low- and moderate-credibility evidence). Combined diet and exercise weight-loss interventions had small to moderate effects on pain intensity and disability, compared to either diet-only or exercise-only interventions, in people with knee OA (low- to moderate-credibility evidence), but these interventions were not more effective for weight loss. Weight-loss interventions had small to moderate effects on weight reduction in people with knee and hip OA (mean difference between 5.6 kg and 3.5 kg). Weight-loss interventions may not influence pain intensity, disability, or weight in people with spinal pain (very low–credibility evidence). While the pharmaceutical weight-loss approach appeared to produce large effects, based on the implausible standard deviation reported in that trial, the result is questionable.

Overweight and obesity have been attributed as a determinant of OA onset and progression.[44] Weight-loss interventions had small to moderate effects on core OA outcomes. Improvements from weight-loss interventions were equivalent to a 1-point difference on a 0-to-10 numeric rating scale and a 3.7-point difference on the 0-to-68 WOMAC function (disability) subscale. These effects are at the low end of clinically meaningful effect sizes.[19,49] Given the complex interventions included in our review, it is unclear whether the effects may be attributed to reduced weight or to other mechanisms (eg, self-efficacy, strength, or other cognitive constructs).

The effects observed for weight-loss interventions in our review are similar to or smaller than those of OA interventions that do not include weight-loss components. For example, advice and education and interventions aiming to promote OA self-management produce similar effect sizes to our findings.[32] Exercise interventions may have larger effects on pain and disability than weight-loss interventions.[20] While many people with OA are overweight,[8] comparisons of our results to those of reviews of other interventions should be undertaken with caution, due to the potentially different populations of trials that do not focus on weight-loss inter-

ventions (ie, those including nonoverweight individuals).[20]

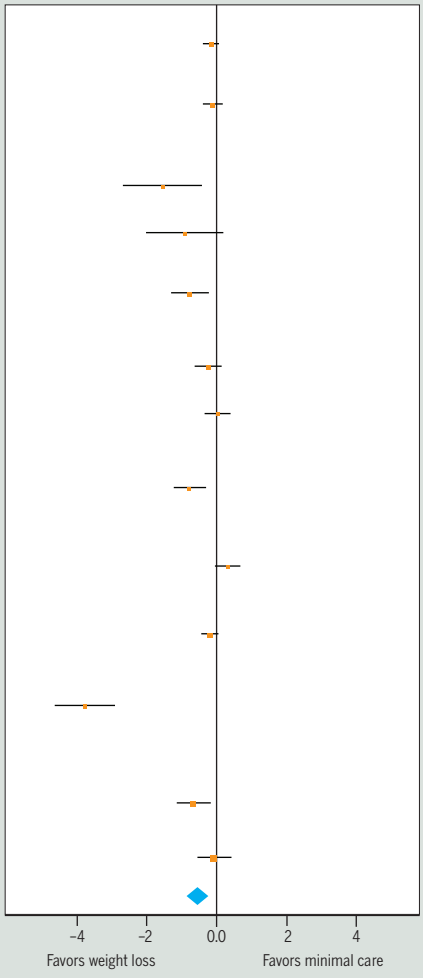
Strengths and Limitations in Relation to Other Studies

Our review was prospectively registered, conducted using best-practice Cochrane methods,[25] and reported according to the PRISMA guidelines.[51] We used a comprehensive search strategy, including trial registries. The scope of our review was wider than that of previous reviews in the field,[4,13,17] as it included 11 more trials and over 900 more participants. We also examined disability—an important outcome for people with OA and spinal pain that was omitted in previous reviews.[4,17] We calculated pooled intervention effects for a range of outcomes for specific conditions and conducted subgroup analysis by intervention type. Because the clinical interpretation of SMDs can be difficult, we re-expressed SMDs to provide effect estimates that can be more easily applied to clinical reasoning (**TABLE 2**).

We observed substantial statistical heterogeneity (I^2 greater than 50%) for some comparisons. We attempted to explore heterogeneity by subgroup analy-

Pain

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]					
Telephone coaching plus referral	−0.1613 ± 0.1157	151	149	9.3%	−0.16 (−0.39, 0.07)
Allen et al[2]					
Telephone coaching plus referral	−0.1101 ± 0.142	268	129	9.1%	−0.11 (−0.39, 0.17)
Ghroubi et al[23]					
Reduced-calorie diet plus exercise	−1.5539 ± 0.5795	12	6	4.4%	−1.55 (−2.69, −0.42)
Reduced-calorie diet	−0.9165 ± 0.5617	12	5	4.5%	−0.92 (−2.02, 0.18)
Lim et al[33]					
Exercise only	−0.7676 ± 0.2766	46	20	7.6%	−0.77 (−1.31, −0.23)
Messier et al[34]					
Reduced-calorie diet plus exercise	−0.2418 ± 0.1976	76	39	8.5%	−0.24 (−0.63, 0.15)
Reduced-calorie diet	0.04 ± 0.1945	82	39	8.6%	0.04 (−0.34, 0.42)
Miller et al[37]					
MR, reduced-calorie diet plus exercise	−0.7797 ± 0.242	39	35	8.0%	−0.78 (−1.25, −0.31)
O'Brien et al[41]					
Telephone coaching	0.3132 ± 0.1845	59	60	8.7%	0.31 (−0.05, 0.67)
Ravaud et al[43]					
Counseling plus education	−0.1897 ± 0.1196	146	181	9.3%	−0.19 (−0.42, 0.04)
Saraboon et al[50]					
Reduced-calorie diet plus exercise plus education	−3.7733 ± 0.4401	40	40	5.7%	−3.77 (−4.64, −2.91)
Somers et al[53]					
Reduced-calorie diet plus exercise plus PCS	−0.6855 ± 0.2396	62	26	8.1%	−0.69 (−1.16, −0.22)
Reduced-calorie diet plus exercise	−0.0861 ± 0.2387	59	25	8.1%	−0.09 (−0.55, 0.38)
Total[a]		1052	754	100.0%	−0.54 (−0.86, −0.22)



[a]*Heterogeneity: $\tau^2 = 0.27$, $\chi^2 = 95.97$, $df = 12$ ($P<.0001$), $I^2 = 87\%$. Test for overall effect: $z = 3.31$ ($P = .0009$).*
Abbreviations: IV, inverse variance; MR, meal replacement; PCS, pain coping skills; SE, standard error; SMD, standardized mean difference.

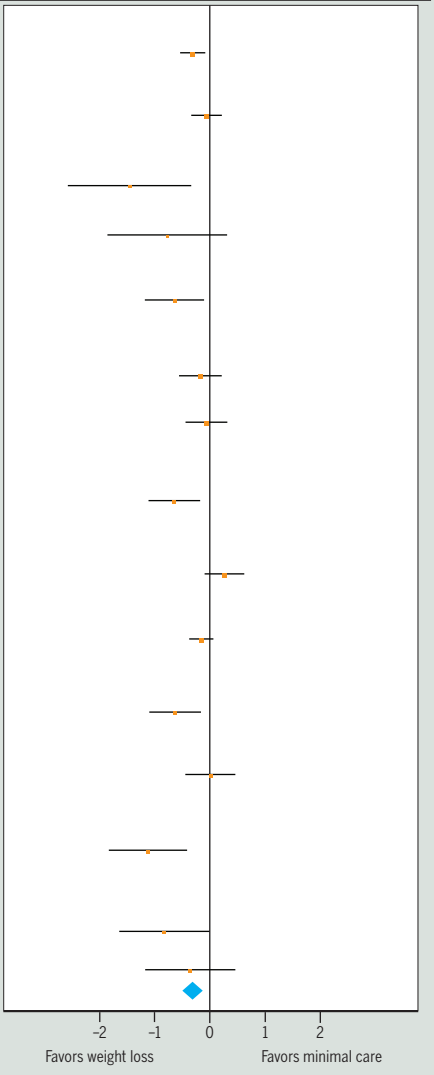
Figure continues on page 329.

FIGURE 3. Main meta-analyses of all weight-loss interventions versus minimal care for knee and hip OA for the outcomes of pain, disability, and weight. "Reduced-calorie diet plus exercise" is an intervention addressing weight loss via diet to reduce calorie intake, combined with an exercise program. The "MR" intervention addresses weight loss via diet using MRs, and the "education" intervention addresses weight loss via pain and condition-specific education. "Referral" is an intervention with specialist referral. Abbreviations: MR, meal replacement; OA, osteoarthritis.

sis based on intervention type, and downgraded the evidence credibility for inconsistency in GRADE assessments. We only found 3 trials of weight-loss interventions for spinal pain,[28,39,59] despite it being a leading cause of disability[22] with known impacts on co-occurring obesity.[52,57] We recommend caution when drawing conclusions from this limited number of trials with varied results, given the low credibility of evidence as assessed by GRADE and high heterogeneity for some analyses. We found few trials examining the impact of pharmacological weight-loss interventions overall (n = 3). We did not pool these trials due to differing comparison groups.[39,54,56] There were also no trials of other medical or surgical weight-loss interventions, and no trials reported on participants with hip OA

Disability

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]					
Telephone coaching plus referral	−0.3104 ± 0.1162	151	149	11.1%	−0.31 (−0.54, −0.08)
Allen et al[2]					
Telephone coaching plus referral	−0.0578 ± 0.1419	268	129	10.2%	−0.06 (−0.34, 0.22)
Ghroubi et al[23]					
Reduced-calorie diet plus exercise	−1.4544 ± 0.5703	12	6	2.1%	−1.45 (−2.57, −0.34)
Reduced-calorie diet	−0.7708 ± 0.5532	12	5	2.2%	−0.77 (−1.86, 0.31)
Lim et al[33]					
Exercise only	−0.6413 ± 0.274	46	20	6.0%	−0.64 (−1.18, −0.10)
Messier et al[34]					
Reduced-calorie diet plus exercise	−0.1732 ± 0.1973	76	39	8.2%	−0.17 (−0.56, 0.21)
Reduced-calorie diet	−0.062 ± 0.1946	82	39	8.3%	−0.06 (−0.44, 0.32)
Miller et al[37]					
MR, reduced-calorie diet plus exercise	−0.6445 ± 0.2391	39	35	6.9%	−0.64 (−1.11, −0.18)
O'Brien et al[41]					
Telephone coaching	0.2644 ± 0.1842	59	60	8.7%	0.26 (−0.10, 0.63)
Ravaud et al[43]					
Counseling plus education	−0.1543 ± 0.1127	146	181	11.2%	−0.15 (−0.38, 0.07)
Somers et al[53]					
Reduced-calorie diet plus exercise plus PCS	−0.6314 ± 0.2387	62	26	6.9%	−0.63 (−1.10, −0.16)
Reduced-calorie diet plus exercise	0.015 ± 0.2386	59	25	6.9%	0.01 (−0.45, 0.48)
Toda et al[56]					
Pharmacology plus MR	−1.122 ± 0.3622	22	15	4.2%	−1.12 (−1.83, −0.41)
Wolf et al[60]					
Reduced-calorie diet plus exercise	−0.8239 ± 0.4179	20	9	3.4%	−0.82 (−1.64, 0.00)
Reduced-calorie diet	−0.3599 ± 0.4186	21	8	3.4%	−0.36 (−1.18, 0.46)
Total[a]		1075	746	100.0%	−0.32 (−0.49, −0.14)



[a]*Heterogeneity: $\tau^2 = 0.06$, $\chi^2 = 33.30$, $df = 14$ ($P = .003$), $I^2 = 58\%$. Test for overall effect: $z = 3.52$ ($P = .0004$).*
Abbreviations: IV, inverse variance; MR, meal replacement; PCS, pain coping skills; SE, standard error; SMD, standardized mean difference.

Figure continues on page 330.

FIGURE 3 (CONTINUED). Main meta-analyses of all weight-loss interventions versus minimal care for knee and hip OA for the outcomes of pain, disability, and weight. "Reduced-calorie diet plus exercise" is an intervention addressing weight loss via diet to reduce calorie intake, combined with an exercise program. The "MR" intervention addresses weight loss via diet using MRs, and the "education" intervention addresses weight loss via pain and condition-specific education. "Referral" is an intervention with specialist referral. Abbreviations: MR, meal replacement; OA, osteoarthritis.

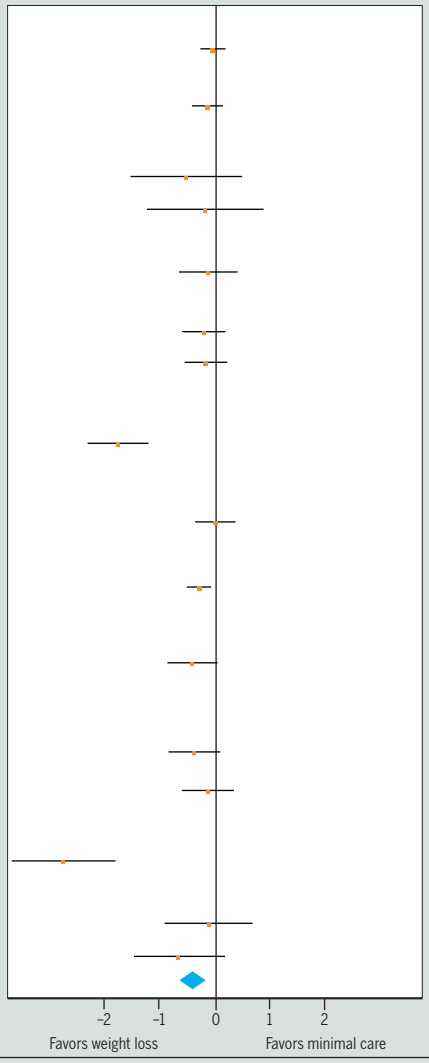
independent of knee OA. The subgroup analysis on the basis of intervention duration should be interpreted cautiously, because it did not account for intervention dose. Inconsistent information reported across trials precluded categorization by dose.

Implications for Practice and Policy

Current behavioral approaches might not consistently produce sufficient weight loss for meaningful effects on pain and disability.[9] Clinical practice guidelines suggest that people with overweight or obesity and OA require a weight loss of 5% to 7.5% of body weight for clinically meaningful improvements in pain and disability.[9,47] Behavioral approaches are recommended as the first line of care for weight loss.[47] We found that behavioral weight-loss interventions for knee and hip OA produced

Weight

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]					
Telephone coaching plus referral	−0.0564 ± 0.1155	151	149	8.7%	−0.06 (−0.28, 0.17)
Allen et al[2]					
Telephone coaching plus referral	−0.1526 ± 0.1421	268	129	8.3%	−0.15 (−0.43, 0.13)
Ghroubi et al[23]					
Reduced-calorie diet plus exercise	−0.5325 ± 0.51	12	6	3.4%	−0.53 (−1.53, 0.47)
Reduced-calorie diet	−0.1941 ± 0.5336	12	5	3.2%	−0.19 (−1.24, 0.85)
Lim et al[33]					
Exercise only	−0.1381 ± 0.2681	46	20	6.3%	−0.14 (−0.66, 0.39)
Messier et al[34]					
Reduced-calorie diet plus exercise	−0.2172 ± 0.1975	76	39	7.4%	−0.22 (−0.60, 0.17)
Reduced-calorie diet	−0.1844 ± 0.1949	82	39	7.5%	−0.18 (−0.57, 0.20)
Miller et al[37]					
MR, reduced-calorie diet plus exercise	−1.7559 ± 0.2786	40	33	6.1%	−1.76 (−2.30, −1.21)
O'Brien et al[41]					
Telephone coaching	−0.015 ± 0.1833	59	60	7.7%	−0.01 (−0.37, 0.34)
Ravaud et al[43]					
Counseling plus education	−0.3032 ± 0.1119	146	181	8.7%	−0.30 (−0.52, −0.08)
Saraboon et al[50]					
Reduced-calorie diet plus exercise plus education	−0.4221 ± 0.2291	40	40	6.9%	−0.42 (−0.87, 0.03)
Somers et al[53]					
Reduced-calorie diet plus exercise plus PCS	−0.3873 ± 0.2355	62	26	6.8%	−0.39 (−0.85, 0.07)
Reduced-calorie diet plus exercise	−0.145 ± 0.2389	59	25	6.8%	−0.14 (−0.61, 0.32)
Toda et al[56]					
Pharmacology plus MR	−2.7287 ± 0.4741	22	15	3.7%	−2.73 (−3.66, −1.80)
Wolf et al[60]					
Reduced-calorie diet plus exercise	−0.1344 ± 0.4018	20	9	4.4%	−0.13 (−0.92, 0.65)
Reduced-calorie diet	−0.6852 ± 0.4184	24	8	4.3%	−0.69 (−1.51, 0.13)
Total[a]		1119	784	100.0%	−0.42 (−0.64, −0.19)



[a]*Heterogeneity: $\tau^2 = 0.14$, $\chi^2 = 64.30$, $df = 15$ ($P<.0001$), $I^2 = 77\%$. Test for overall effect: $z = 3.58$ ($P = .0003$).*
Abbreviations: IV, inverse variance; MR, meal replacement; PCS, pain coping skills; SE, standard error; SMD, standardized mean difference.

FIGURE 3 (CONTINUED). Main meta-analyses of all weight-loss interventions versus minimal care for knee and hip OA for the outcomes of pain, disability, and weight. "Reduced-calorie diet plus exercise" is an intervention addressing weight loss via diet to reduce calorie intake, combined with an exercise program. The "MR" intervention addresses weight loss via diet using MRs, and the "education" intervention addresses weight loss via pain and condition-specific education. "Referral" is an intervention with specialist referral. Abbreviations: MR, meal replacement; OA, osteoarthritis.

weight loss between 3.5 and 5.6 kg. While our review supports weight loss as a generally effective treatment approach, behavioral interventions might not always be suitable as a first-line option, given their time-intensive nature, the resources they require, and their cost.

Although guidelines endorse weight loss as a core treatment for OA, our review suggests that exercise is a critical ingredient for managing OA. Weight loss might not contribute to greater effects on pain and disability. For example, we found that diet and exercise interventions led to greater improvements in pain and disability but no difference in weight loss. Causal mechanisms of weight-loss interventions may not be attributed to weight loss or changes to body mass index, but may be explained by other mediators.[48,58] Osteoarthritis management guidance should be cautious about overemphasizing the importance of weight loss for pain and disability, and instead focus on a comprehensive package of care, including exercise.

More research is needed to inform clinical practice decisions about weight loss for people with musculoskeletal conditions. Future research should focus on understanding whether weight loss is the mechanism of effect on pain and disability, and then how to maximize effects across the population. The 3 trials on pharmaceutical weight-loss interventions seem to report promising effects, but more research is needed to understand the effectiveness, safety, and applicability of these approaches. We identified an important evidence gap relating to spinal pain. As there is a high prevalence of overweight and obesity in people with spinal pain,[42,55] there is a need for more high-quality trials that investigate whether targeting weight loss is an important approach to care.

CONCLUSION

Compared to minimal care, weight-loss interventions reduced pain intensity and disability in people with knee and hip OA, but not in those with spinal pain. Weight-loss interventions were not more effective than exercise-only interventions for knee OA. There was limited evidence regarding the effect of weight-loss interventions for spinal pain. ◉

KEY POINTS

FINDINGS: There was low-credibility evidence that behavioral weight-loss interventions produced small to moderate improvements in pain intensity and disability in people with knee or hip osteoarthritis (OA) compared to minimal interventions. Weight-loss interventions were not more effective than exercise-only interventions for reducing pain or disability in people with knee OA. There was moderate-credibility evidence that combined diet and exercise weight-loss interventions improved pain intensity and disability compared to diet-only interventions for knee OA.

IMPLICATIONS: We found uncertainty in the evidence of effectiveness of weight-loss interventions for pain and disability in people with knee and hip OA. Guideline recommendations should be tempered to reflect uncertainty in effects of weight-loss interventions for pain intensity and disability. There was insufficient evidence of the effectiveness of pharmacological and other medical weight-loss interventions for patients with OA or spinal pain. More research is needed in these areas.

CAUTION: Most of the evidence was of low credibility and should be interpreted cautiously.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Drs Christopher Williams, John Wiggers, Serene Yoong, Luke Wolfenden, and Steven Kamper designed the review. Dr Christopher Williams, Emma Robson, and Debbie Booth developed the search strategy. Emma Robson and Drs Christopher Williams, Amanda Williams, Kate O'Brien, Rebecca Hodder, and Hopin Lee performed study selection and extracted data from included studies. Emma Robson and Drs Christopher Williams and Rebecca Hodder were involved in the data analysis. Emma Robson and Drs Christopher Williams, Steven Kamper, and Rebecca Hodder were involved in the interpretation and discussion of results. Emma Robson drafted the manuscript, and all authors revised it critically for important intellectual content and approved the final version of the article. All authors had access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Dr Christopher Williams is the guarantor.

DATA SHARING: All data relevant to the study are included in the article or are available as online appendices.

PATIENT AND PUBLIC INVOLVEMENT: There was no patient or public involvement in the completion of this study.

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APPENDIX A

SEARCH STRATEGY FOR MEDLINE (1946 TO PRESENT, WITH DAILY UPDATE)

	Search Term	Results, n
1	exp Obesity/	156932
2	Overweight/	14845
3	Weight Gain/	24699
4	Weight Loss/	27223
5	obes*.tw.	181310
6	(overweight or over weight or overeat* or over eat* or adipos*).tw.	105247
7	Body Mass Index/	91314
8	(weight adj3 (cycl* or reduc* or los* or maint* or decreas* or watch* or control* or gain* or chang* or increas* or diet*)).tw.	170762
9	((body mass index or bmi) adj3 (reduc* or maint* or decreas* or watch* or control* or gain* or chang* or increas* or diet*)).tw.	19367
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	452475
11	randomized controlled trial.pt.	411368
12	clinical trial/	505061
13	controlled clinical trial/	91657
14	Random Allocation/	86193
15	Double-Blind Method/	134958
16	Single-Blind Method/	21352
17	Placebos/	33996
18	Research Design/	84189
19	intervention studies/	8237
20	evaluation studies/	211418
21	Comparative Study/	1739732
22	Longitudinal Studies/	96307
23	cross-over studies/	37207
24	trial.tw.	374824
25	latin square.tw.	3449
26	(time adj series).tw.	15487
27	(before adj2 after adj3 (stud* or trial* or design*)).tw.	9322
28	((singl* or doubl* or trebl* or tripl*) adj5 (blind* or mask*)).tw.	133576
29	placebo*.tw.	162626
30	random*.tw.	716650
31	(matched adj (communit* or school* or population*)).tw.	1682
32	(comparison group* or control* group*).tw.	308309
33	matched pair*.tw.	6185
34	outcome stud*.tw.	5787
35	11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34	3272989
36	exp Osteoarthritis/	47218
37	exp Back Pain/	30960
38	Neck Pain/	4989
39	(backache or neckache).tw.	1951
40	exp Musculoskeletal Pain/	1690
41	Sciatica/	4419
42	Neuralgia/	9417
43	(dorsalgia or cervicalgia).tw.	124
44	((Cervical Vertebrae or back or knee* or neck or spin* or hip* or lumb* or joint* or musculoske*) adj3 (pain* or ache* or aching or complaint* or stiff* or dysfunction* or disabil* or trauma* or disorder* or injur*)).tw.	127932

Table continues on B2.

APPENDIX A

	Search Term	Results, n
45	(osteoarthr* or osteo arthr*).tw.	43713
46	Coxarthr*.tw.	1597
47	36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46	205106
48	10 and 35 and 47	1478
49	(animals not (humans and animals)).sh.	4022024
50	48 not 49	1383

INTERVENTION DETAILS OF INCLUDED TRIALS

Study/Type/ Country/Trial	Condition/BMI/ Arms	Intervention Group (Label Provided)/Duration, Content	Comparison Group (Label Provided)/Content	Length of Follow-up/Lost to Follow-up/Intervention Adherence	Primary/Secondary Outcomes
Allen et al[3] C-RCT United States	Knee/hip OA (n = 300) >25 kg/m^2 2 arms	Multifocused with weight loss (n = 151; telephone coaching for weight loss and primary care provider referrals) 12 mo. Patients received telephone counseling calls for weight management, physical activity, and cognitive behavioral strategies for managing pain. Primary care providers were trained to consider an algorithm-based referral method for OA treatments such as MOVE!, knee braces, injections, etc	Minimal care (n = 149; usual care) No description provided	12 mo 9% NR	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) BMI, mental health (PHQ), physical activity (CHAMPS)
Allen et al[2] C-RCT United States	Knee and/or hip OA (n = 537) >25 kg/m^2 4 arms	Multifocused with weight loss (n = 128; telephone weight management) 12 mo. Patients received telephone calls for weight management, physical activity, and cognitive behavioral strategies for managing pain Multifocused with weight loss (n = 140; telephone coaching for weight loss and primary care provider referrals) 12 mo. Combined patient and provider intervention	Minimal care (n = 129; usual care) No description provided	12 mo 19.1% Patients, 43%; providers, 47% of calls completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) BMI, mental health (PHQ), physical activity (CHAMPS)
Bliddal et al,[10] Christensen et al[12] RCT Denmark	Knee OA (n = 96) >28 kg/m^2 2 arms	Weight loss focused (n = 48; meal replacements and reduced-calorie diet) 12 mo. First 8 wk: meal replacement formula diet providing 810 kcal/d. In weeks 8-32, participants received weekly or second weekly nutrition sessions to achieve a 1200-kcal/d intake for weight loss. In weeks 32-36, patients used original meal replacements, and in weeks 36-52 nutrition sessions	Weight loss focused (n = 48; reduced-calorie diet) 2-h nutrition presentation at weeks 0, 8, 32, 36, and 52 to try to achieve caloric restriction of 1200 kcal/d	12 mo 41.7% 58% completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (kilograms)
Christensen et al[11] RCT Denmark LIGHT	Knee OA (n = 153) >30 kg/m^2 2 arms	Weight loss focused (n = 76; meal replacements and diet modification) 3 y. Three 5-wk weight-loss periods of consuming meal replacement products (totaling an intake of 810 kcal/d) and attending dietitian sessions for weight loss and maintenance advice. Participants were instructed to eat 1200 kcal/d between the 5-wk weight-loss periods	Weight loss focused (n = 77; meal replacements) 1-2 meal replacement products daily to reduce caloric intake. Group dietitian sessions 3 times weekly	3 y 29.5% 70% of sessions completed	Pain (KOOS pain subscale) and disability (KOOS function in sport and recreation subscale) Weight (kilograms), KOOS knee-related QoL subscale
Ghroubi et al[23] RCT France	Knee OA (n = 56) >30 kg/m^2 4 arms	Weight loss focused (n = 14; reduced-calorie diet) 8 wk. Diet prescription with 25%-30% reduction in calories Weight loss focused (n = 15; reduced-calorie diet and exercise) 8 wk. Dietary weight loss and exercise interventions combined	Minimal care (n = 14; control) Description not provided Exercise only (n = 13; exercise program) Aerobic and strength exercise for 60 min, 3 times per week	8 wk 19.7% NR	Pain (VAS) and disability (WOMAC) Weight (kilograms), physical performance (6MW)
Irandoust et al[28] RCT Iran	LBP (n = 36) NR 2 arms	Weight loss focused (n = 18; aquatic exercise program and diet modification) 4 mo. Water-based training for 60 min, 3 times per week. Diet adjusted based on calorie recommendations from nutritionist	Minimal care (n = 18; control) Description not provided	4 mo NR NR	Pain (VAS) Weight (kilograms)

Table continues on B4.

APPENDIX B

Study/Type/ Country/Trial	Condition/BMI/ Arms	Intervention Group (Label Provided)/Duration, Content	Comparison Group (Label Provided)/Content	Length of Follow-up/Lost to Follow-up/Intervention Adherence	Primary/Secondary Outcomes
Lim et al[33] RCT the Netherlands	Knee OA (n = 75) >25 kg/m^2 3 arms	Weight loss focused (n = 26; aquatic exercise program) 8 wk. Aquatic gym program for 40 min, 3 times per week Weight loss focused (n = 25; land-based exercise program) 8 wk. Land-based gym conditioning program for 40 min, 3 times per week	Minimal care (n = 24; home-based exercise) Advice for home-based exercise	8 wk 12% Aquatic, 92%; land, 88% of sessions completed	Pain (BPI, 0-11) and disability (WOMAC) Weight (kilograms), mental health (SF-36 MCS)
Messier et al[35] RCT United States	Knee OA (n = 24) >28 kg/m^2 2 arms	Weight loss focused (n = 13; reduced-calorie diet and exercise) 6 mo. Weekly 60-min nutrition classes for weight loss and an exercise program for 60 min, 3 times per week	Exercise only (n = 11; exercise program) Exercise program for 60 min, 3 times per week	6 mo 12.5% Diet plus exercise, 95% of sessions completed	Pain (knee pain scale, ambulation intensity of 0-6) and disability (FAST Functional Performance Inventory) Weight (kilograms), physical performance (6MW)
Messier et al,[34] Rejeski et al[45] RCT United States ADAPT	Knee OA (n = 316) >28 kg/m^2 4 arms	Weight loss focused (n = 82; reduced-calorie diet) 18 mo. 3-phase weight-loss program with weekly individual and group dietitian sessions, and phone counseling for weight loss. Goals were to produce and maintain an average weight loss of 5% Weight loss focused (n = 76; reduced-calorie diet and exercise) 18 mo. Dietary weight loss and exercise interventions combined	Minimal care (n = 78; healthy lifestyle education) Monthly 1-h meetings and calls for topics on OA, recommendations for exercise and weight Exercise only (n = 80; exercise program) Exercise program for 60 min, 3 times per week; facility-based transition or home based. Telephone contact	18 mo 20.3% Diet, 72%; exercise, 60%; diet plus exercise, 64% of sessions completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (kilograms), physical performance (6MW), mental health (SF-36 MCS)
Messier et al[36] RCT United States IDEA	Knee OA (n = 454) >27-41 kg/m^2 3 arms	Weight loss focused (n = 150; meal replacements and reduced-calorie diet) 18 mo. 2 meal replacement shakes per day and a calorie-controlled third meal. The diet plan provided for 1200 kcal/d. Participants also attended weekly nutrition education sessions Weight loss focused (n = 152; meal replacements, reduced-calorie diet, and exercise) 18 mo. Diet plus exercise intervention combined	Exercise only (n = 152; exercise program) Exercise program for 60 min, 3 times per week. Facility, then home based, and telephone contact	18 mo 12.2% Diet, 61%; diet plus exercise, 63% of sessions completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (kilograms), physical performance (6MW), mental health (SF-36 MCS)
Miller et al [37,38] RCT United States	Knee OA (n = 87) >30 kg/m^2 2 arms	Weight loss focused (n = 44; meal replacements, reduced-calorie diet, and exercise) 6 mo. Partial meal replacements, nutrition education, and behavioral and educational sessions. Dietary energy was 4600 kJ/d for women and 5022 kJ/d for men. Participants also attended exercise sessions in groups of 6-12, for 60 min, 3 times per week	Minimal care (n = 43; weight stable) Bimonthly meetings on OA general health and weight-maintenance content	6 mo 9.2% Intervention group, 77% of exercise and 75% of nutrition sessions completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (kilograms), physical performance (6MW)
Muehlbacher et al[39] RCT Germany	CLBP (n = 96) NR 2 arms	Weight loss focused (n = 48; pharmaceutical) 10 wk. Blinded medication of 50-mg topiramate titrated at 50 mg/wk to a dose of 200 mg/d in the sixth week, remaining constant	Minimal care (n = 48; placebo) Participants took blinded placebo drug	10 wk 8.4% NR	Pain (PRI of the MPQ, 0-40) and disability (ODQ) Weight (kilograms), mental health (SF-36 MCS)

Table continues on B5.

APPENDIX B

Study/Type/ Country/Trial	Condition/BMI/ Arms	Intervention Group (Label Provided)/Duration, Content	Comparison Group (Label Provided)/Content	Length of Follow-up/Lost to Follow-up/Intervention Adherence	Primary/Secondary Outcomes
O'Brien et al[41] RCT Australia	Knee OA (n = 120) 27-40 kg/m^2 2 arms	Weight loss focused (n = 60; telephone coaching for weight loss) 6 mo. Brief advice and referral to free telephone-based weight-loss coaching service	Minimal care (n = 60; usual care) Description not provided	6 mo 12% 34% completed ≥6 calls	Pain (NRS, 0-10) and disability (WOMAC function subscale) Weight (kilograms), mental health (SF-12 Version 2 MCS), physical activity (MVPA), dietary intake (FFQ)
Ravaud et al[43] C-RCT France ARTIST	Knee OA (n = 336) 25-35 kg/m^2 2 arms	Multifocused with weight loss (n = 154; goal-oriented OA consultations and weight-loss advice) 30 d. 3 goal-oriented rheumatologist visits. Each visit focused on 1 topic; the first visit provided OA education and advice and the next 2 visits focused on an exercise regime and weight loss, with tailored counseling	Minimal care (n = 182; usual care) 3 usual-care visits to rheumatologist	4 mo 12.3% 95% attended 3 consultations	Pain (NRS, 0-10) and disability (WOMAC function subscale) Weight (kilograms), mental health (SF-12 MCS)
Riecke et al[46] RCT (phase 1 of 2) Christensen et al[14] RCT (phase 2 of 2) Denmark	Phases 1 and 2: knee OA (n = 192) NR Phase 1, 2 arms; phase 2, 3 arms	Phase 1: weight loss focused (n = 96; meal replacements and reduced-calorie diet) 16 wk. 8 wk of a 415-kcal/d diet, followed by 8 wk of a hypoenergetic diet of normal foods, restricted to 1200 kcal/d. Patients attended 1.5-h weekly nutrition sessions to reinforce and encourage compliance Phase 2: weight loss focused (n = 64; meal replacements and reduced-calorie diet) 52 wk. Focus was on long-term lifestyle modifications to reach weight-loss goals. Weekly 60-min sessions where patients were provided with enough meal replacement formula products for 1 per day	Phase 1: weight loss focused (n = 96; meal replacements and reduced-calorie diet) Meal replacement formula: 810 kcal/wk for 8 wk and same hypoenergetic diet and nutrition sessions as the intervention group Phase 2: minimal care (n = 64; usual care) No attention provided Phase 2: exercise only (n = 64; exercise program) Participants completed 60-min exercise sessions 3 d/wk	68 wk 12.7% 90% of sessions completed	Pain (OMERACT-OARSI VAS, 0-100) and disability (OMERACT-OARSI VAS, 0-100) Weight (kilograms), mental health (SF-36 MCS), KOOS knee-related QoL subscale
Aree-Ue et al,[7] Saraboon et al[50] C-RCT Thailand	Knee OA (n = 80) 23-29 kg/m^2 2 arms	Multifocused with weight loss (n = 40; OA education, reduced-calorie diet, and exercise) 8 wk. 2-h workshops, 3 delivered in 1 wk. Education on knee OA and weight-reduction program, including information on food selection and an exercise regime. Home visits conducted at weeks 2, 4, and 6 following the workshops to support participants in healthy behavior change	Minimal care (n = 40; control) Booklet and DVD on OA	8 wk NR NR	Pain (NRS, 0-10) Weight (kilograms), physical performance (TUG)
Somers et al[53] RCT United States	Knee OA (n = 232) 25-42 kg/m^2 4 arms	Weight loss focused (n = 59; reduced-calorie diet and exercise) 24 wk. 16 weekly sessions of the LEARN program for weight management and appetite-awareness training. Goal was to lose 0.45-0.92 kg/wk using a 1200-kcal/d or 1500-kcal/d diet. Participants also attended group exercise sessions for 90 min, 3 times a week Multifocused with weight loss (n = 62; PCST reduced-calorie diet, and exercise) 24 wk. Behavior, weight-loss diet, and exercise program and PCST content combined	Minimal care (n = 51; control) No attention provided	PTA, 24 wk plus 6 mo plus 12 mo 29.75% BWM, 65%; PCST plus BWM, 73% of sessions completed	Pain (WOMAC pain subscale) and disability (WOMAC function subscale) Weight (pounds), mental health (AIMS psychological scale)

Table continues on B6.

APPENDIX B

Study/Type/ Country/Trial	Condition/BMI/ Arms	Intervention Group (Label Provided)/Duration, Content	Comparison Group (Label Provided)/Content	Length of Follow-up/Lost to Follow-up/Intervention Adherence	Primary/Secondary Outcomes
Strebkova and Alekseeva[54] RCT Russia	Knee OA (n = 50) >30 kg/m^2 2 arms	Weight loss focused (n = 25; pharmaceuticals, reduced-calorie diet, and exercise) 6 mo. Dose of orlistat: 120 mg, 3 times per day during meals, and hypocaloric diet with deficit of 500-600 kcal for weight loss. Explanations provided for exercises	Weight loss focused (n = 25; reduced-calorie diet and exercise) Hypocaloric diet with deficit of 500-600 kcal and explanations for exercises	6 mo 0% 100% drug compliance	Pain (WOMAC pain VAS, 0-100) and disability (WOMAC function VAS, 0-100) Weight (kilograms)
Toda et al[56] RCT Japan	Knee OA (n = 40) >26.4 kg/m^2 2 arms	Weight loss focused (n = 22; pharmaceuticals and exercise) 6 wk. Participants took mazindol (Sanorex; Sandoz-Wander) once per day to restrict appetite; meal replacements and basic exercise instructions (30 min/d)	Minimal care (n = 18; brief exercise instruction) Exercise instruction and NSAIDs twice per day	6 wk 7.5% NR	Disability (Lequesne index of severity) Weight (kilograms), physical activity (steps per day)
Williams et al[59] RCT Australia	CLBP (n = 160) 27-40 kg/m^2 2 arms	Multifocused with weight loss (n = 79; CLBP education and telephone coaching for weight loss) 6 mo. Brief advice over the phone and 1 physical therapy clinical consultation providing back pain education. All patients referred to telephone-based weight-loss coaching service	Minimal care (n = 80; usual care) Description not provided	26 wk 21.8% 41% completed ≥6 calls	Pain (NRS, 0-10) and disability (RMDQ) Weight (kilograms), mental health (SF-12 Version 2 MCS), physical activity (MVPA), dietary intake (FFQ)
Wolf et al[60] RCT United States	Knee OA (n = 110) NR 4 arms	Weight loss focused (n = 27; reduced-calorie diet) 24 wk. Food diary completion and attending 16 × 60-min weekly dietitian-run sessions of the LEARN program for weight management, and then biweekly 60-min sessions for 8 wk Weight loss focused (n = 28; reduced-calorie diet and exercise) 24 wk. Diet and exercise intervention combined	Minimal care (n = 25; usual care) 16 weekly sessions and 8 biweekly sessions with trial staff, discussing health-related issues, medications, etc. No nutrition or exercise advice Exercise (n = 30; exercise program) Weekly home-based exercise program of 60-min sessions for 16 wk and biweekly for 8 wk	24 wk 22% NR	Disability (WOMAC function subscale) Weight (pounds), physical performance (6MW), mental health (SF-36 MCS)
Yázigi[61] RCT Portugal	Knee OA (n = 52) NR 2 arms	Weight loss focused (n = 26; aquatic exercise program) 12 wk. Aquatic exercise program for 60 min, 2 times per week	Weight management program (n = 26) PESO educational program to prevent obesity and manage weight and health	12 wk 7.7% NR	Pain (BPI) and disability (KOOS) Weight (kilograms), KOOS knee-related QoL subscale

Abbreviations: 6MW, 6-minute walk; ADAPT, Arthritis, Diet, and Activity Promotion Trial; AIMS, Arthritis Impact Measurement Scales; ARTIST, osteoarthritis intervention standardized; BMI, body mass index; BPI, Brief Pain Inventory; BWM, behavioral weight management; CHAMPS, Community Healthy Activities Model Program for Seniors; CLBP, chronic low back pain; C-RCT, cluster randomized controlled trial; FFQ, Food Frequency Questionnaire; IDEA, Intensive Diet and Exercise for Arthritis; KOOS, Knee injury and Osteoarthritis Outcome Score; LBP, low back pain; LEARN, Lifestyle, Exercise, Attitudes, Relationships, Nutrition; LIGHT, Long-term Intervention With Weight Loss in Patients With Concomitant Obesity and Knee Osteoarthritis; MCS, mental component summary; MPQ, McGill Pain Questionnaire; MVPA, moderate to vigorous physical activity; NR, not reported; NRS, numeric rating scale; NSAID, nonsteroidal anti-inflammatory drug; OA, osteoarthritis; OARSI, Osteoarthritis Research Society International; ODQ, Oswestry Low Back Pain Disability Questionnaire; OMERACT, Outcome Measures in Rheumatology; PCST, pain coping skills training; PHQ, Patient Health Questionnaire; PRI, Pain Rating Index; PTA, posttreatment average; QoL, quality of life; RCT, randomized controlled trial; RMDQ, Roland-Morris Disability Questionnaire; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; TUG, timed up and go; VAS, visual analog scale; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

APPENDIX B

RESULTS OF TRIALS NOT INCLUDED IN META-ANALYSES[a]

Study/ Comparators	Reason Not in MA	Pain	Disability	Weight	Performance/ Activity	Mental Health	QoL	Dietary Outcomes
Bliddal et al[10] n = 96 LED versus conventional diet	Active weight-loss control group could not be synthesized into comparison groups	WOMAC pain subscale: MD, 7.2 (95% CI: 1, 13.4); *P* = .02	WOMAC function subscale: MD, 3.7 (95% CI: −1.9, 9.2); *P* = .20	MD, 7.3 kg (95% CI: 5, 10); *P*≤.01	NR	NR	NR	NR
Christensen et al[11] n = 153 Intermittent diet versus regular diet	Active weight-loss control group unable to be synthesized into comparison groups	KOOS pain subscale: MD, 0.3 (95% CI: −4.4, 5.0); *P* = .91	KOOS function subscale: MD, 0.1 (95% CI: −5.5, 5.2); *P* = .97	MD, 1.06 kg (95% CI: 0.63, 2.75); *P* = .22	NR	NR	KOOS QoL subscale: MD, 0.8 (95% CI: −4.3, 5.8); *P* = .77	NR
Irandoust et al[28] n = 36 Aquatic exercise plus diet versus control	Primary outcome data not sufficient to be included in MA	Pain VAS: *P* = .001	NR	Follow-up: aquatic exercise plus diet, 80.9 to 79.2 kg; control, 83.5 to 79.5 kg; *P*<.001	TUG: mean change for aquatic exercise plus diet, 1.85 ± 0.004; *P* = .001; control, 1.92 ± 0.03; *P* = .958	NR	NR	NR
Miller et al[38] n = 87 Weight loss versus weight stable	Lack of dietary data to synthesize	In MA	In MA	In MA	In MA	NR	NR	Energy intake: weight loss, 1396 ± 64 cal; weight stable, 1817 ± 71 cal
O'Brien et al[41] n = 120 Telephone weight loss versus usual care	Lack of dietary data to synthesize	In MA	In MA	In MA	In MA	In MA	NR	Fruit intake OR = 0.85 (95% CI: 0.38, 1.89); vegetable intake OR = 0.35 (95% CI: 0.16, 0.77); consumption of DC more than once per week OR = 0.36 (95% CI: 0.08, 1.55)
Ravaud et al[43] n = 336 Standard consultation versus usual care	Postintervention results in MA; long-term results presented here	Standard consultations, −1.35 ± 2.48; usual care, −0.86 ± 2.59	Standard consultations, −8.67 ± 12.05; usual care, −5.44 ± 12.97	Standard consultations, −2.85 ± 4.76; usual care, −2.07 ± 4.37; *P* = .005	Standard consultations, 0.23 ± 0.72; usual care, 0.08 ± 0.85	NR	NR	NR

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APPENDIX B

Study/ Comparators	Reason Not in MA	Pain	Disability	Weight	Performance/ Activity	Mental Health	QoL	Dietary Outcomes
Riecke et al[46] n = 192 Phase 1: VLED versus LED Christensen et al[14] n = 192 Phase 2: diet versus exercise versus control	A 2-phase RCT; the active weight-loss control group was unable to be synthesized into comparison groups	Phase 1: OMERACT-OARSI pain MD, 1.1 (95% CI: −4.11, 6.32) Phase 2: pain VAS mean change for diet, −6.1 (95% CI: −11.1, −1.1); exercise, −5.6 (95% CI: −10.5, −0.6); control, −5.5 (95% CI: −10.5, −0.5); *P* = .98	Phase 1: OMERACT-OARSI disability MD, 1.69 (95% CI: −4.16, 7.54) Phase 2: disability VAS mean change for diet, −7.5 (95% CI: −12.8, −2.1); exercise, −7.6 (95% CI: −13, −2.2); control, −9 (95% CI: −14.4, −3.6); *P* = .91	Phase 1: MD, 1.08 kg (95% CI: −0.67, 2.81) Phase 2: mean change for diet, −10.96 kg (95% CI: −12.83, −9.09); exercise, −6.24 kg (95% CI: −8.11, −4.38); control, −8.23 kg (95% CI: −10.09, −6.36); *P* = .002	Phase 2: 6MW mean change for diet, 37.5 (95% CI: 22.8, 52.3); exercise, 38.5 (95% CI: 23.7, 53.2); control, 22.9 (95% CI: 7.9, 37.9); *P* = .3	Phase 1: SF-36 MCS MD, −3.11 (95% CI: −5.49, −0.73) Phase 2: SF-36 MCS mean change for diet, −0.3 (95% CI: −2.1, 1.6); exercise, 0.1 (95% CI: −1.7, 2); control, 1.3 (95% CI: −0.5, 3.2); *P* = .5	Phase 2: KOOS QoL subscale mean change for diet, 8.2 (95% CI: 4.5, 11.9); exercise, 5.8 (95% CI: 2.1, 9.5); control, 5.4 (95% CI: 1.7, 9.2); *P* = .5	NR
Saraboon et al[50] n = 80 MUFIP versus control	Postintervention results in MA; long-term results presented here	VAS: MUFIP, 1.1 ± 1; control, 4.2 ± 2.7; ES, 0.24	NR	MUFIP, 61.1 ± 9.6 kg; control, 64.3 ± 9.5 kg	TUG: MUFIP, 9 ± 1.7; control, 13.3 ± 2.9; ES, 0.21	NR	NR	NR
Strebkova and Alekseeva[54] n = 50 Orlistat versus diet plus PA	Active weight-loss control group unable to be synthesized into comparison groups	WOMAC pain subscale: orlistat change, −118 ± 96.4; diet plus PA, −48 ± 74.1	WOMAC function subscale: orlistat change, −415.9 ± 322.14; diet plus PA, −160.7 ± 354.4	Orlistat change, −10.5 ± 11.37 kg; diet plus PA, −0.9 ± 17.4 kg	NR	NR	NR	NR
Toda et al[56] n = 6 Weight loss versus control	Unable to use follow-up data in MA, as change data were required	NR	NR	NR	Steps per day (103): weight loss, 7.5 ± 1.7; control, 7.3 ± 2.1	NR	NR	NR
Williams et al[59] n = 160 Telephone weight-loss coaching versus usual care	Lack of PA and dietary data to synthesize	NR	NR	NR	Minutes of MVPA per week: MD, 99.3 (95% CI: −260.2, 61.5)	NR	NR	Fruit intake OR = 0.79 (95% CI: 0.38, 1.63), vegetable intake OR = 1.3 (95% CI: 0.62, 2.72), consumption of DC more than once per week OR = 1.11 (95% CI: 0.36, 2.72)
Yázigi[61] n = 52 AQE versus PESO	Active weight-loss control group unable to be synthesized into comparison groups	KOOS pain subscale: AQE, 69.6 ± 19; PESO, 53.7 ± 19; *P*≤.001	KOOS function subscale: AQE, 52.2 ± 25; PESO, 36.5 ± 27; *P*≤.001	Body mass: AQE, 87.3 ± 11; PESO, 92.8 ± 16.8; *P* = .006	6MW: AQE, 18 ± 42; PESO, 55 ± 38; *P*≤.001	BDI: AQE, 6.2 ± 7; PESO, 11.1 ± 8; *P*≤.05	KOOS QoL subscale: AQE, 48.3 ± 25; PESO, 39.9 ± 21; *P*≤.05	NR

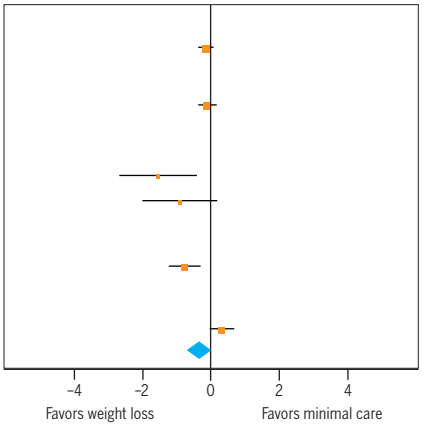
Abbreviations: 6MW, 6-minute walk; AQE, aquatic exercise; BDI, Beck Depression Inventory; CI, confidence interval; DC, discretionary choices; ES, effect size; KOOS, Knee injury and Osteoarthritis Outcome Score; LED, low-energy diet; MA, meta-analysis; MCS, mental component summary; MD, mean difference; MUFIP, multifactorial intervention program; MVPA, moderate to vigorous physical activity; NR, not reported; OARSI, Osteoarthritis Research Society International; OMERACT, Outcome Measures in Rheumatology; OR, odds ratio; PA, physical activity; QoL, quality of life; RCT, randomized controlled trial; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; TUG, timed up and go; VAS, visual analog scale; VLED, very low–energy diet; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

[a]*Values are mean ± SD unless otherwise indicated.*

SENSITIVITY ANALYSIS: META-ANALYSIS RESULTS FOR ALL PRIMARY OUTCOMES AND WEIGHT FOR 2 COMPARISONS, EXCLUDING HIGH-RISK-OF-BIAS STUDIES

Pain

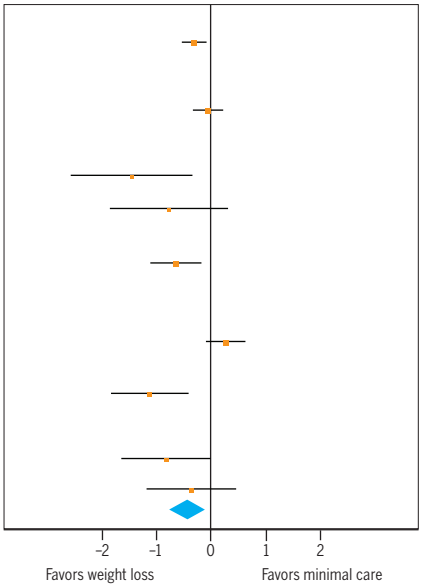
Study/Subgroup	SMD ± SE	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]			
Telephone coaching plus referral	−0.1613 ± 0.1157	23.8%	−0.16 (−0.39, 0.07)
Allen et al[2]			
Telephone coaching plus referral	−0.1101 ± 0.142	22.7%	−0.11 (−0.39, 0.17)
Ghroubi et al[23]			
Reduced-calorie diet plus exercise	−1.5539 ± 0.5795	7.2%	−1.55 (−2.69, −0.42)
Reduced-calorie diet	−0.9165 ± 0.5617	7.5%	−0.92 (−2.02, 0.18)
Miller et al[37]			
MR, reduced-calorie diet plus exercise	−0.7797 ± 0.242	18.0%	−0.78 (−1.25, −0.31)
O'Brien et al[41]			
Telephone coaching	0.3132 ± 0.1845	20.7%	0.31 (−0.05, 0.67)
Total[a]		100.0%	−0.32 (−0.68, 0.04)



[a]*Heterogeneity: τ^2 = 0.13, χ^2 = 20.85, df = 5 (P = .0009), I^2 = 76%. Test for overall effect: z = 1.75 (P = .08).*
Abbreviations: IV, inverse variance; MR, meal replacement; SE, standard error; SMD, standardized mean difference.

Disability

Study/Subgroup	SMD ± SE	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]			
Telephone coaching plus referral	−0.3104 ± 0.1162	17.8%	−0.31 (−0.54, −0.08)
Allen et al[2]			
Telephone coaching plus referral	−0.0578 ± 0.1419	17.0%	−0.06 (−0.34, 0.22)
Ghroubi et al[23]			
Reduced-calorie diet plus exercise	−1.4544 ± 0.5703	5.3%	−1.45 (−2.57, −0.34)
Reduced-calorie diet	−0.7708 ± 0.5532	5.6%	−0.77 (−1.86, 0.31)
Miller et al[37]			
MR, reduced-calorie diet plus exercise	−0.6445 ± 0.2391	13.4%	−0.64 (−1.11, −0.18)
O'Brien et al[41]			
Telephone coaching	0.2644 ± 0.1842	15.4%	0.26 (−0.10, 0.63)
Toda et al[56]			
Pharmacology plus MR	−1.122 ± 0.3622	9.4%	−1.12 (−1.83,−0.41)
Wolf et al[60]			
Reduced-calorie diet plus exercise	−0.8239 ± 0.4179	8.0%	−0.82 (−1.64, 0.00)
Reduced-calorie diet	−0.3599 ± 0.4186	8.0%	−0.36 (−1.18, 0.46)
Total[a]		100.0%	−0.43 (−0.73, −0.13)



[a]*Heterogeneity: τ^2 = 0.12, χ^2 = 25.69, df = 8 (P = .001), I^2 = 69%. Test for overall effect: z = 2.81 (P = .005).*
Abbreviations: IV, inverse variance; MR, meal replacement; SE, standard error; SMD, standardized mean difference.

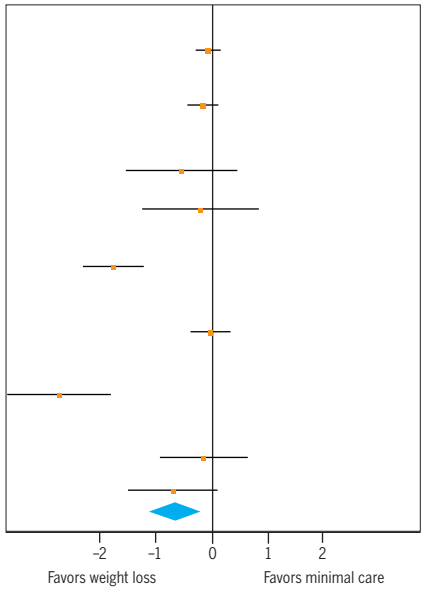
Figure continues on page B10.

FIGURE 1. Weight-loss interventions versus minimal care for knee and hip osteoarthritis, excluding high-risk-of-bias studies.

APPENDIX C

Weight

Study/Subgroup	SMD ± SE	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]			
Telephone coaching plus referral	−0.0564 ± 0.1155	14.1%	−0.06 (−0.28, 0.17)
Allen et al[2]			
Telephone coaching plus referral	−0.1526 ± 0.1421	13.8%	−0.15 (−0.43, 0.13)
Ghroubi et al[23]			
Reduced-calorie diet plus exercise	−0.5325 ± 0.51	8.7%	−0.53 (−1.53, 0.47)
Reduced-calorie diet	−0.1941 ± 0.5336	8.4%	−0.19 (−1.24, 0.85)
Miller et al[37]			
MR, reduced-calorie diet plus exercise	−1.7559 ± 0.2786	12.1%	−1.76 (−2.30, −1.21)
O'Brien et al[41]			
Telephone coaching	−0.015 ± 0.1833	13.4%	−0.01 (−0.37, 0.34)
Toda et al[56]			
Pharmacology plus MR	−2.7287 ± 0.4741	9.2%	−2.73 (−3.66, −1.80)
Wolf et al[60]			
Reduced-calorie diet plus exercise	−0.1344 ± 0.4018	10.3%	−0.13 (−0.92, 0.65)
Reduced-calorie diet	−0.6852 ± 0.4184	10.0%	−0.69 (−1.51, 0.13)
Total[a]		100.0%	−0.64 (−1.10, −0.18)

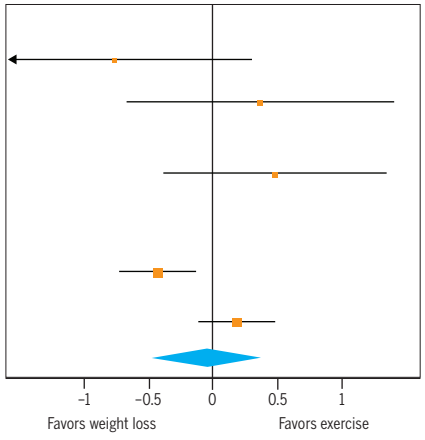


[a]*Heterogeneity: $T^2 = 0.38$, $\chi^2 = 62.72$, $df = 8$ ($P<.0001$), $I^2 = 87\%$. Test for overall effect: $z = 2.70$ ($P = .007$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SE, standard error; SMD, standardized mean difference.

FIGURE 1 (CONTINUED). Weight-loss interventions versus minimal care for knee and hip osteoarthritis, excluding high-risk-of-bias studies.

Pain

	Experimental		Control			
Study/Subgroup	Mean ± SD	Total, n	Mean ± SD	Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	3.62 ± 1.9	12	5.28 ± 2.4	5	11.4%	−0.77 (−1.85, 0.31)
Reduced-calorie diet	6.08 ± 1.83	12	5.28 ± 2.4	5	11.9%	0.38 (−0.67, 1.43)
Messier et al[35]						
Reduced-calorie diet plus exercise	2.21 ± 1.247	12	1.57 ± 1.23	9	14.9%	0.50 (−0.38, 1.38)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	3.3 ± 2.436	129	4.35 ± 2.436	64	31.0%	−0.43 (−0.73, −0.13)
MR, reduced-calorie diet	4.8 ± 2.813	124	4.3 ± 1.985	63	30.9%	0.19 (−0.11, 0.50)
Total[a]		289		146	100.0%	−0.04 (−0.48, 0.40)



[a]*Heterogeneity: $T^2 = 0.14$, $\chi^2 = 12.16$, $df = 4$ ($P = .02$), $I^2 = 67\%$. Test for overall effect: $z = 0.19$ ($P = .85$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

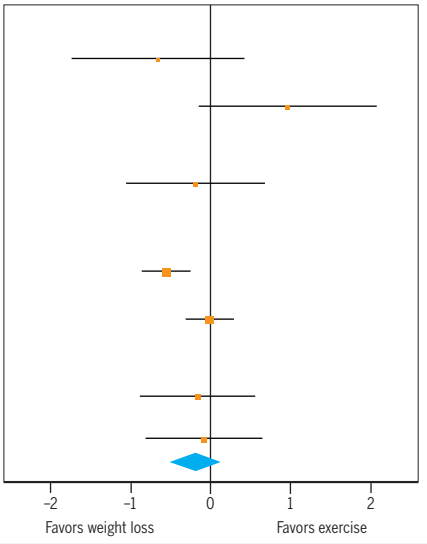
Figure continues on page B11.

FIGURE 2. Weight-loss interventions versus exercise-only interventions for knee osteoarthritis, excluding high-risk-of-bias studies.

APPENDIX C

Disability

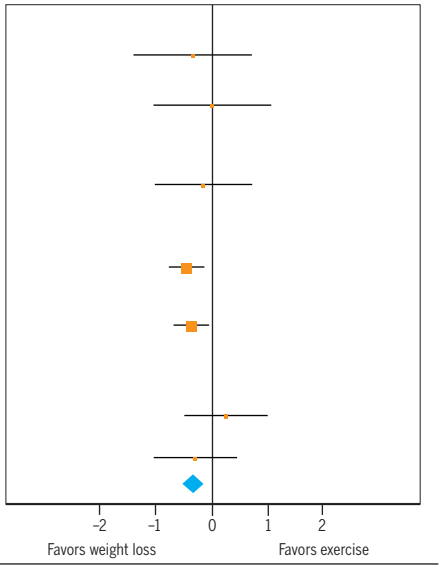
Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	6.08 ± 1.5	12	7.0 ± 0.72	5	6.9%	−0.65 (−1.73, 0.42)
Reduced-calorie diet	7.75 ± 0.75	12	7.0 ± 0.72	5	6.5%	0.96 (−0.15, 2.07)
Messier et al[35]						
Reduced-calorie diet plus exercise	1.42 ± 0.312	12	1.48 ± 0.3	9	9.5%	−0.19 (−1.05, 0.68)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	13.0 ± 7.608	129	17.21 ± 7.608	64	26.3%	−0.55 (−0.86, −0.25)
MR, reduced-calorie diet	17.3 ± 7.255	124	17.34 ± 7.255	63	26.3%	−0.01 (−0.31, 0.30)
Wolf et al[60]						
Reduced-calorie diet plus exercise	33.6 ± 11.4	20	35.4 ± 10.6	12	12.4%	−0.16 (−0.87, 0.56)
Reduced-calorie diet	34.4 ± 12	21	35.4 ± 10.6	11	12.1%	−0.08 (−0.81, 0.65)
Total[a]		330		169	100.0%	−0.18 (−0.49, 0.14)



[a]*Heterogeneity: $\tau^2 = 0.07$, $\chi^2 = 11.61$, $df = 6$ ($P = .07$), $I^2 = 48\%$. Test for overall effect: $z = 1.10$ ($P = .27$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

Weight

Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	−6.21 ± 11.3	12	−2.38 ± 10.2	5	3.4%	−0.33 (−1.38, 0.72)
Reduced-calorie diet	−2.15 ± 11.7	12	−2.38 ± 10.2	5	3.4%	0.02 (−1.02, 1.06)
Messier et al[35]						
Reduced-calorie diet plus exercise	−18.8 ± 96.995	12	−4.0 ± 111.0	9	5.0%	−0.14 (−1.00, 0.73)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	−10.6 ± 19.445	121	−1.8 ± 21.112	58	37.4%	−0.44 (−0.75, −0.12)
MR, reduced-calorie diet	−8.9 ± 19.363	120	−1.8 ± 21.112	57	37.1%	−0.35 (−0.67, −0.04)
Wolf et al[60]						
Reduced-calorie diet plus exercise	−2.1 ± 5.6	20	−4.8 ± 15.3	11	6.9%	0.26 (−0.48, 1.00)
Reduced-calorie diet	−8.2 ± 10.1	24	−4.8 ± 15.3	10	6.8%	−0.28 (−1.02, 0.46)
Total[a]		321		155	100.0%	−0.31 (−0.51, −0.12)



[a]*Heterogeneity: $\tau^2 = 0.00$, $\chi^2 = 3.54$, $df = 6$ ($P = .74$), $I^2 = 0\%$. Test for overall effect: $z = 3.18$ ($P = .001$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

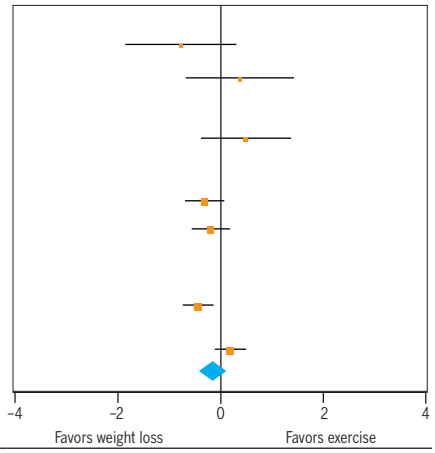
FIGURE 2 (CONTINUED). Weight-loss interventions versus exercise-only interventions for knee osteoarthritis, excluding high-risk-of-bias studies.

APPENDIX D

META-ANALYSIS RESULTS FOR PRIMARY OUTCOMES AND WEIGHT FOR 3 COMPARISONS

Pain

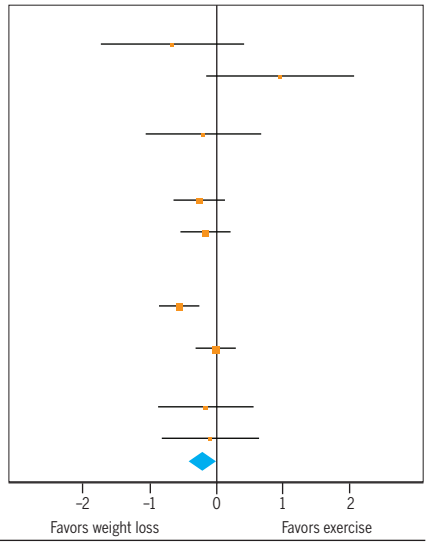
Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	3.62 ± 1.9	12	5.28 ± 2.4	5	5.2%	−0.77 (−1.85, 0.31)
Reduced-calorie diet	6.08 ± 1.83	12	5.28 ± 2.4	5	5.4%	0.38 (−0.67, 1.43)
Messier et al[35]						
Reduced-calorie diet plus exercise	2.21 ± 1.247	12	1.57 ± 1.23	9	7.2%	0.50 (−0.38, 1.38)
Messier et al[34]						
Reduced-calorie diet plus exercise	5.07 ± 4.097	76	6.24 ± 2.972	40	18.9%	−0.31 (−0.69, 0.08)
Reduced-calorie diet	5.51 ± 4.075	82	6.24 ± 2.972	40	19.1%	−0.19 (−0.57, 0.19)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	3.3 ± 2.436	129	4.35 ± 2.436	64	22.1%	−0.43 (−0.73, −0.13)
MR, reduced-calorie diet	4.8 ± 2.813	124	4.3 ± 1.985	63	22.0%	0.19 (−0.11, 0.50)
Total[a]		447		226	100.0%	−0.13 (−0.40, 0.14)



[a]*Heterogeneity: $\tau^2 = 0.06$, $\chi^2 = 13.20$, $df = 6$ ($P = .04$), $I^2 = 55\%$. Test for overall effect: $z = 0.95$ ($P = .34$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

Disability

Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	6.08 ± 1.5	12	7.0 ± 0.72	5	3.4%	−0.65 (−1.73, 0.42)
Reduced-calorie diet	7.75 ± 0.75	12	7.0 ± 0.72	5	3.2%	0.96 (−0.15, 2.07)
Messier et al[35]						
Reduced-calorie diet plus exercise	1.42 ± 0.312	12	1.48 ± 0.3	9	4.9%	−0.19 (−1.05, 0.68)
Messier et al[34]						
Reduced-calorie diet plus exercise	17.87 ± 12.205	76	20.93 ± 11.628	40	16.5%	−0.25 (−0.64, 0.13)
Reduced-calorie diet	19.07 ± 11.772	82	20.93 ± 11.628	40	16.8%	−0.16 (−0.54, 0.22)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	13.0 ± 7.608	129	17.21 ± 7.608	64	20.9%	−0.55 (−0.86, −0.25)
MR, reduced-calorie diet	17.3 ± 7.255	124	17.34 ± 7.255	63	21.0%	−0.01 (−0.31, 0.30)
Wolf et al[60]						
Reduced-calorie diet plus exercise	33.6 ± 11.4	20	35.4 ± 10.6	12	6.8%	−0.16 (−0.87, 0.56)
Reduced-calorie diet	34.4 ± 12	21	35.4 ± 10.6	11	6.6%	−0.08 (−0.81, 0.65)
Total[a]		488		249	100.0%	−0.20 (−0.41, 0.00)



[a]*Heterogeneity: $\tau^2 = 0.03$, $\chi^2 = 11.75$, $df = 8$ ($P = .16$), $I^2 = 32\%$. Test for overall effect: $z = 1.92$ ($P = .05$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

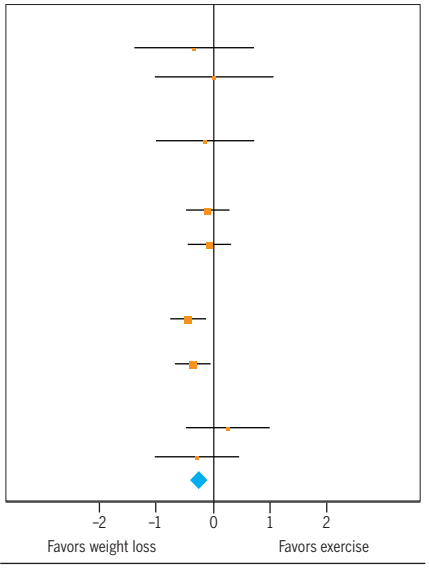
Figure continues on page B13.

FIGURE 1. Weight-loss interventions versus exercise-only interventions for knee osteoarthritis.

APPENDIX D

Weight

Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	−6.21 ± 11.3	12	−2.38 ± 10.2	5	2.2%	−0.33 (−1.38, 0.72)
Reduced-calorie diet	−2.15 ± 11.7	12	−2.38 ± 10.2	5	2.3%	0.02 (−1.02, 1.06)
Messier et al[35]						
Reduced-calorie diet plus exercise	−18.8 ± 96.995	12	−4.0 ± 111.0	9	3.3%	−0.14 (−1.00, 0.73)
Messier et al[34]						
Reduced-calorie diet plus exercise	−5.2 ± 19.036	76	−3.46 ± 19.008	40	16.8%	−0.09 (−0.47, 0.29)
Reduced-calorie diet	−4.61 ± 19.251	82	−3.46 ± 19.008	40	17.3%	−0.06 (−0.44, 0.32)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	−10.6 ± 19.445	121	−1.8 ± 21.112	58	24.6%	−0.44 (−0.75, −0.12)
MR, reduced-calorie diet	−8.9 ± 19.363	120	−1.8 ± 21.112	57	24.5%	−0.35 (−0.67, −0.04)
Wolf et al[60]						
Reduced-calorie diet plus exercise	−2.1 ± 5.6	20	−4.8 ± 15.3	11	4.5%	0.26 (−0.48, 1.00)
Reduced-calorie diet	−8.2 ± 10.1	24	−4.8 ± 15.3	10	4.5%	−0.28 (−1.02, 0.46)
Total[a]		479		235	100.0%	−0.23 (−0.39, −0.08)

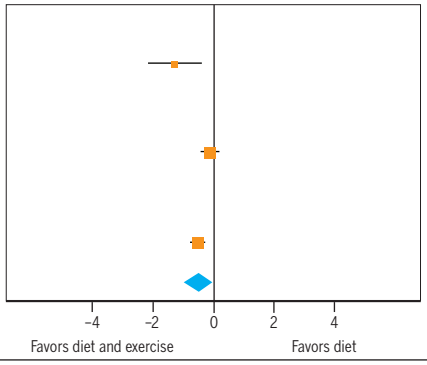


[a]*Heterogeneity: $\tau^2 = 0.00$, $\chi^2 = 5.55$, $df = 8$ ($P = .70$), $I^2 = 0\%$. Test for overall effect: $z = 2.90$ ($P = .004$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

FIGURE 1 (CONTINUED). Weight-loss interventions versus exercise-only interventions for knee osteoarthritis.

Pain

Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Diet Only Mean ± SD	Diet Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	3.62 ± 1.9	12	6.08 ± 1.83	12	17.0%	−1.27 (−2.17, −0.38)
Messier et al[34]						
Reduced-calorie diet plus exercise	5.07 ± 4.097	76	5.51 ± 4.075	82	40.1%	−0.11 (−0.42, 0.21)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	3.3 ± 2.840	129	4.78 ± 2.834	124	43.0%	−0.52 (−0.77, −0.27)
Total[a]		217		218	100.0%	−0.48 (−0.94, −0.03)



[a]*Heterogeneity: $\tau^2 = 0.11$, $\chi^2 = 7.93$, $df = 2$ ($P = .02$), $I^2 = 75\%$. Test for overall effect: $z = 2.09$ ($P = .04$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

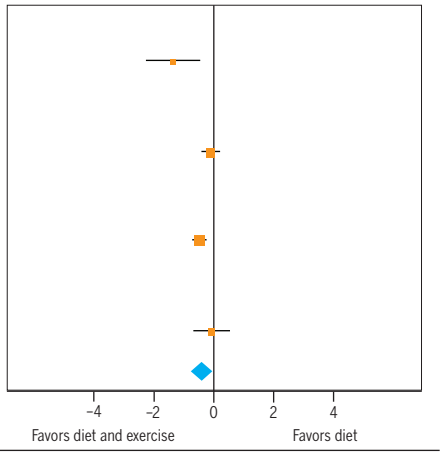
Figure continues on page B14.

FIGURE 2. Dietary weight-loss and exercise interventions versus dietary weight loss–only interventions for knee osteoarthritis.

APPENDIX D

Disability

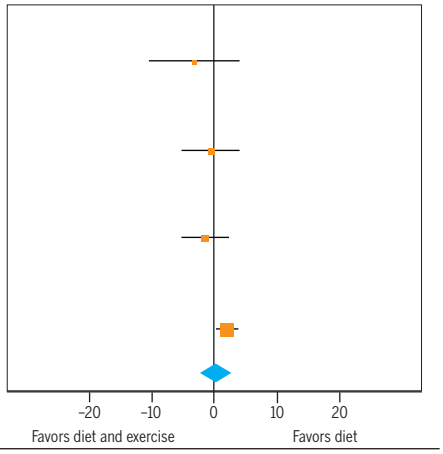
Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Diet Only Mean ± SD	Diet Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	6.08 ± 1.5	12	7.75 ± 0.75	12	12.3%	−1.36 (−2.26, −0.46)
Messier et al[34]						
Reduced-calorie diet plus exercise	17.87 ± 12.205	76	19.07 ± 11.772	82	32.5%	−0.10 (−0.41, 0.21)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	13.0 ± 8.925	129	17.25 ± 8.925	124	35.4%	−0.47 (−0.72, −0.22)
Wolf et al[60]						
Reduced-calorie diet plus exercise	33.6 ± 11.4	20	34.4 ± 12	21	19.9%	−0.07 (−0.68, 0.55)
Total[a]		237		239	100.0%	−0.38 (−0.76, 0.00)



[a]*Heterogeneity: $\tau^2 = 0.09$, $\chi^2 = 9.04$, $df = 3$ ($P = .03$), $I^2 = 67\%$. Test for overall effect: $z = 1.98$ ($P = .05$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

Weight

Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Diet Only Mean ± SD	Diet Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	−6.21 ± 11.3	12	−2.15 ± 11.7	12	9.2%	−4.06 (−13.26, 5.14)
Messier et al[34]						
Reduced-calorie diet plus exercise	−5.2 ± 19.036	76	−4.61 ± 19.251	82	18.3%	−0.59 (−6.56, 5.38)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	−10.6 ± 19.445	121	−8.9 ± 19.363	120	23.9%	−1.70 (−6.60, 3.20)
Wolf et al[60]						
Reduced-calorie diet plus exercise	−0.95 ± 2.5	20	−3.72 ± 4.6	24	48.7%	2.77 (0.63, 4.91)
Total[a]		229		238	100.0%	0.46 (−2.55, 3.48)



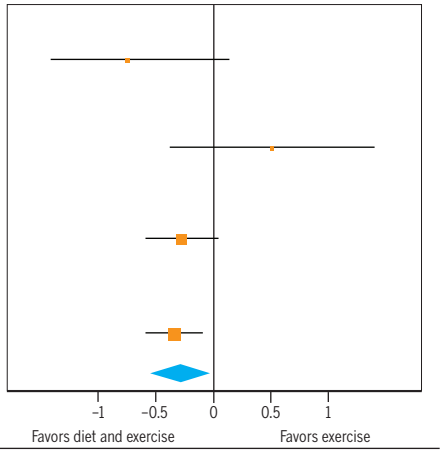
[a]*Heterogeneity: $\tau^2 = 3.66$, $\chi^2 = 4.86$, $df = 3$ ($P = .18$), $I^2 = 38\%$. Test for overall effect: $z = 0.30$ ($P = .76$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

FIGURE 2 (CONTINUED). Dietary weight-loss and exercise interventions versus dietary weight loss–only interventions for knee osteoarthritis.

APPENDIX D

Pain

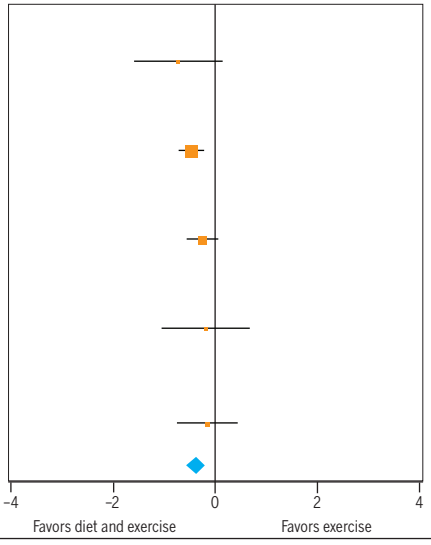
Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Exercise Only Mean ± SD	Exercise Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	3.62 ± 1.9	12	5.28 ± 2.4	10	7.9%	−0.75 (−1.62, 0.13)
Messier et al[35]						
Reduced-calorie diet plus exercise	2.21 ± 1.247	12	1.57 ± 1.23	9	7.8%	0.50 (−0.38, 1.38)
Messier et al[34]						
Reduced-calorie diet plus exercise	5.07 ± 4.097	76	6.24 ± 4.204	80	37.1%	−0.28 (−0.60, 0.04)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	3.3 ± 2.870	129	4.3 ± 2.847	127	47.2%	−0.35 (−0.60, −0.10)
Total[a]		229		226	100.0%	−0.29 (−0.55, −0.03)



[a]*Heterogeneity: $T^2 = 0.02$, $\chi^2 = 4.30$, $df = 3$ ($P = .23$), $I^2 = 30\%$. Test for overall effect: $z = 2.19$ ($P = .03$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

Disability

Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Exercise Only Mean ± SD	Exercise Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	6.08 ± 1.5	12	7.0 ± 0.72	10	4.1%	−0.73 (−1.60, 0.14)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	13.0 ± 8.61	129	17.2 ± 9.111	127	51.1%	−0.47 (−0.72, −0.22)
Messier et al[34]						
Reduced-calorie diet plus exercise	17.87 ± 12.205	76	20.93 ± 11.628	80	31.8%	−0.26 (−0.57, 0.06)
Messier et al[35]						
Reduced-calorie diet plus exercise	1.42 ± 0.312	12	1.48 ± 0.3	9	4.2%	−0.19 (−1.05, 0.68)
Wolf et al[60]						
Reduced-calorie diet plus exercise	33.6 ± 11.4	20	35.4 ± 10.6	23	8.8%	−0.16 (−0.76, 0.44)
Total[a]		249		249	100.0%	−0.38 (−0.55, −0.20)



[a]*Heterogeneity: $T^2 = 0.00$, $\chi^2 = 2.45$, $df = 4$ ($P = .65$), $I^2 = 0\%$. Test for overall effect: $z = 4.14$ ($P < .0001$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

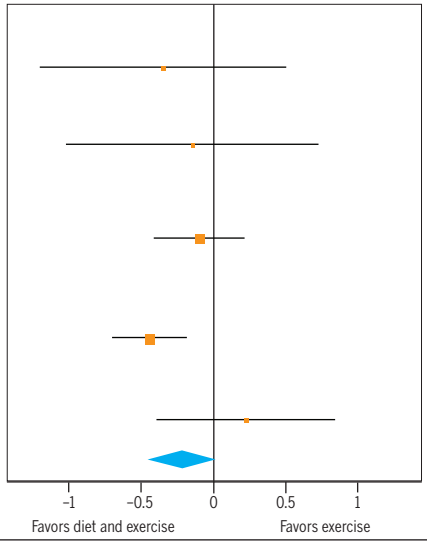
Figure continues on page B16.

FIGURE 3. Dietary weight-loss and exercise interventions versus exercise-only interventions for knee osteoarthritis.

APPENDIX D

Weight

Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Exercise Only Mean ± SD	Exercise Only Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	−6.21 ± 11.3	12	−2.38 ± 10.2	10	7.0%	−0.34 (−1.19, 0.51)
Messier et al[35]						
Reduced-calorie diet plus exercise	−18.8 ± 96.995	12	−4.0 ± 11.1	9	6.8%	−0.14 (−1.00, 0.73)
Messier et al[34]						
Reduced-calorie diet plus exercise	−5.2 ± 19.036	76	−3.46 ± 19.008	80	33.0%	−0.09 (−0.41, 0.22)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	−10.6 ± 19.445	121	−1.8 ± 21.112	115	40.8%	−0.43 (−0.69, −0.17)
Wolf et al[60]						
Reduced-calorie diet plus exercise	−2.1 ± 5.6	20	−4.8 ± 15.3	21	12.4%	0.23 (−0.39, 0.84)
Total[a]		241		235	100.0%	−0.21 (−0.45, 0.02)



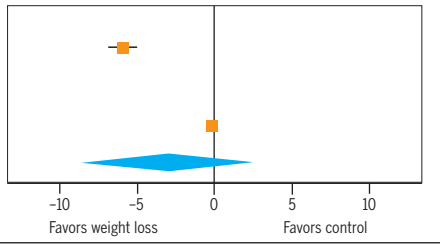
[a]*Heterogeneity: $\tau^2 = 0.02$, $\chi^2 = 5.33$, $df = 4$ ($P = .26$), $I^2 = 25\%$. Test for overall effect: $z = 1.77$ ($P = .08$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SMD, standardized mean difference.

FIGURE 3 (CONTINUED). Dietary weight-loss and exercise interventions versus exercise-only interventions for knee osteoarthritis.

APPENDIX D

Pain

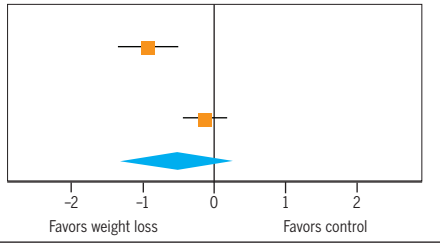
Study/Subgroup	Weight Loss Mean ± SD	Weight Loss Total, n	Usual Care Mean ± SD	Usual Care Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Muehlbacher et al[39]						
Pharmaceuticals	22.9 ± 1.4	48	34.3 ± 2.3	48	49.7%	−5.94 (−6.89, −4.99)
Williams et al[59]						
Telephone coaching and education	5.8 ± 2.7	79	6.3 ± 2.4	80	50.3%	−0.19 (−0.51, 0.12)
Total[a]		127		128	100.0%	−3.05 (−8.68, 2.58)



[a]*Heterogeneity: τ^2 = 16.37, χ^2 = 127.64, df = 1 (P<.0001), I^2 = 99%. Test for overall effect: z = 1.06 (P = .29).*
Abbreviations: IV, inverse variance; SMD, standardized mean difference.

Disability

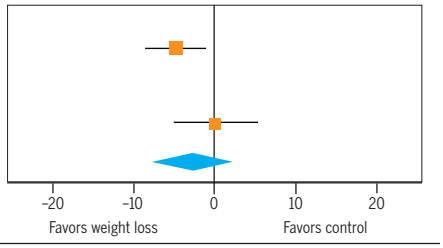
Study/Subgroup	Weight Loss Mean ± SD	Weight Loss Total, n	Usual Care Mean ± SD	Usual Care Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Muehlbacher et al[39]						
Pharmaceuticals	34.0 ± 5.2	48	38.9 ± 5.3	48	48.3%	−0.93 (−1.35, −0.50)
Williams et al[59]						
Telephone coaching and education	13.9 ± 6.5	79	14.7 ± 5.9	80	51.7%	−0.13 (−0.44, 0.18)
Total[a]		127		128	100.0%	−0.51 (−1.29, 0.27)



[a]*Heterogeneity: τ^2 = 0.28, χ^2 = 8.89, df = 1 (P = .003), I^2 = 89%. Test for overall effect: z = 1.29 (P = .20).*
Abbreviations: IV, inverse variance; SMD, standardized mean difference.

Weight

Study/Subgroup	Weight Loss Mean ± SD	Weight Loss Total, n	Usual Care Mean ± SD	Usual Care Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Muehlbacher et al[39]						
Pharmaceuticals	86.2 ± 9.5	48	91.0 ± 9.8	48	57.0%	−4.80 (−8.66, −0.94)
Williams et al[59]						
Telephone coaching and education	93.5 ± 17.4	79	93.3 ± 16.8	80	43.0%	0.20 (−5.12, 5.52)
Total[a]		127		128	100.0%	−2.65 (−7.50, 2.20)



[a]*Heterogeneity: τ^2 = 6.88, χ^2 = 2.22, df = 1 (P = .14), I^2 = 55%. Test for overall effect: z = 1.07 (P = .28).*
Abbreviations: IV, inverse variance; SMD, standardized mean difference.

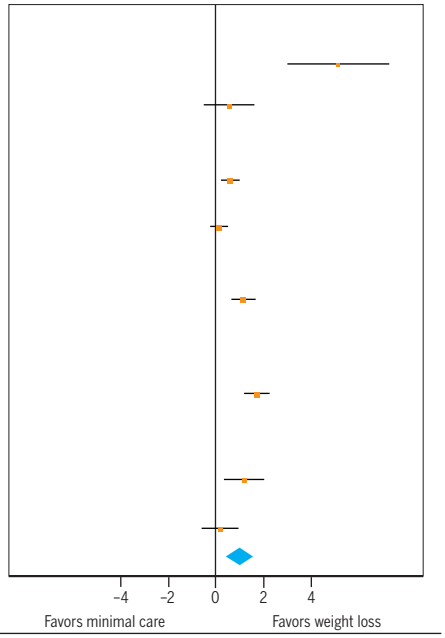
FIGURE 4. Weight-loss interventions versus controls for chronic low back pain.

APPENDIX E

META-ANALYSIS RESULTS FOR SECONDARY OUTCOMES (PHYSICAL PERFORM WEIGHT LOSS HEALTH, AND PHYSICAL ACTIVITY) FOR 4 COMPARISONS

Physical Performance

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Ghroubi et al[23]					
Reduced-calorie diet plus exercise	5.1301 ± 1.089	12	6	4.9%	5.13 (3.00, 7.26)
Reduced-calorie diet	0.5498 ± 0.5431	12	5	10.4%	0.55 (−0.51, 1.61)
Messier et al[34]					
Reduced-calorie diet plus exercise	0.5882 ± 0.2009	76	39	15.4%	0.59 (0.19, 0.98)
Reduced-calorie diet	0.1249 ± 0.1947	82	39	15.4%	0.12 (−0.26, 0.51)
Miller et al[37]					
MR, reduced-calorie diet plus exercise	1.1544 ± 0.2585	39	32	14.7%	1.15 (0.65, 1.66)
Saraboon et al[50]					
Reduced-calorie diet plus exercise plus education	1.7097 ± 0.2737	40	40	14.4%	1.71 (1.17, 2.25)
Wolf et al[60]					
Reduced-calorie diet plus exercise	1.1769 ± 0.4305	21	9	12.1%	1.18 (0.33, 2.02)
Reduced-calorie diet	0.1697 ± 0.3964	22	9	12.6%	0.17 (−0.61, 0.95)
Total[a]		304	179	100.0%	1.00 (0.44, 1.56)



[a]*Heterogeneity: $\tau^2 = 0.50$, $\chi^2 = 45.14$, $df = 7$ ($P<.0001$), $I^2 = 84\%$. Test for overall effect: $z = 3.47$ ($P = .0005$).*

Abbreviations: IV, inverse variance; MR, meal replacement; SE, standard error; SMD, standardized mean difference.

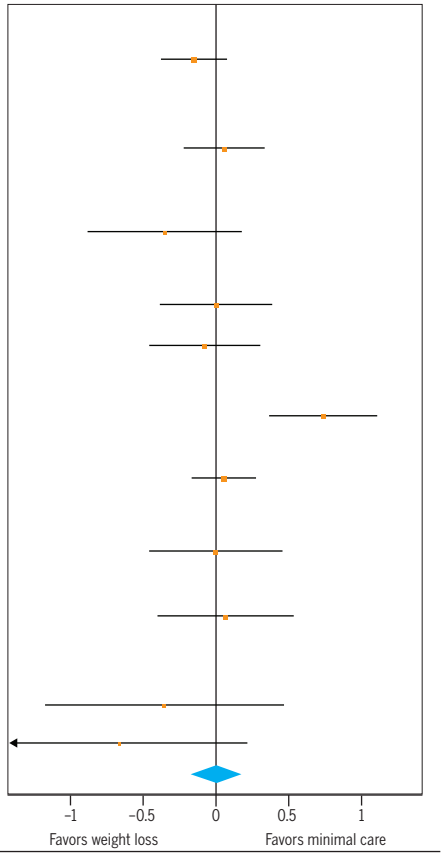
Figure continues on page B19.

FIGURE 1. Weight-loss interventions versus minimal care for knee and hip osteoarthritis.

APPENDIX E

Mental Health

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]					
Telephone coaching plus referral	−0.1505 ± 0.1156	151	149	14.2%	−0.15 (−0.38, 0.08)
Allen et al[2]					
Telephone coaching plus referral	0.0566 ± 0.1419	151	74	12.6%	0.06 (−0.22, 0.33)
Lim et al[33]					
Exercise only	−0.351 ± 0.2697	46	20	6.8%	−0.35 (−0.88, 0.18)
Messier et al[34]					
Reduced-calorie diet plus exercise	0.0009 ± 0.197	76	39	9.6%	0.00 (−0.39, 0.39)
Reduced-calorie diet	−0.0766 ± 0.1946	82	39	9.8%	−0.08 (−0.46, 0.30)
O'Brien et al[41]					
Telephone coaching	0.7357 ± 0.1897	59	60	10.0%	0.74 (0.36, 1.11)
Ravaud et al[43]					
Counseling plus education	0.054 ± 0.1127	146	171	14.4%	0.05 (−0.17, 0.27)
Somers et al[53]					
Reduced-calorie diet plus exercise plus PCS	0.0 ± 0.2336	62	26	8.0%	0.00 (−0.46, 0.46)
Reduced-calorie diet plus exercise	0.0661 ± 0.2387	59	25	7.8%	0.07 (−0.40, 0.53)
Wolf et al[60]					
Reduced-calorie diet plus exercise	−0.3532 ± 0.4185	21	8	3.5%	−0.35 (−1.17, 0.47)
Reduced-calorie diet	−0.66 ± 0.4467	21	7	3.2%	−0.66 (−1.54, 0.22)
Total[a]		874	618	100.0%	0.01 (−0.16, 0.18)



[a]*Heterogeneity: $\tau^2 = 0.04$, $\chi^2 = 21.86$, $df = 10$ ($P = .02$), $I^2 = 54\%$. Test for overall effect: $z = 0.09$ ($P = .93$).*

Abbreviations: IV, inverse variance; PCS, pain coping skills; SE, standard error; SMD, standardized mean difference.

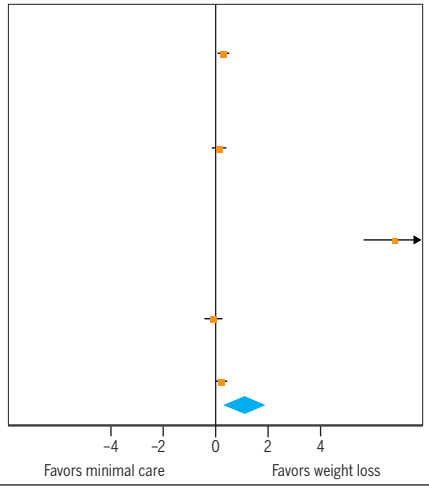
Figure continues on page B20.

FIGURE 1 (CONTINUED). Weight-loss interventions versus minimal care for knee and hip osteoarthritis.

APPENDIX E

Physical Activity

Study/Subgroup	SMD ± SE	Experimental Total, n	Control Total, n	Weight	SMD IV, Random (95% Confidence Interval)
Allen et al[3]					
Telephone coaching plus referral	0.298 ± 0.1161	151	149	21.6%	0.30 (0.07, 0.53)
Allen et al[2]					
Telephone coaching plus referral	0.1329 ± 0.142	151	74	21.4%	0.13 (−0.15, 0.41)
Miller et al[37]					
MR, reduced-calorie diet plus exercise	6.8348 ± 0.6055	39	39	14.4%	6.83 (5.65, 8.02)
O'Brien et al[41]					
Telephone coaching	−0.0647 ± 0.1834	59	60	21.0%	−0.06 (−0.42, 0.29)
Ravaud et al[43]					
Counseling plus education	0.2218 ± 0.1159	146	181	21.6%	0.22 (−0.01, 0.45)
Total[a]		546	503	100.0%	1.11 (0.34, 1.88)



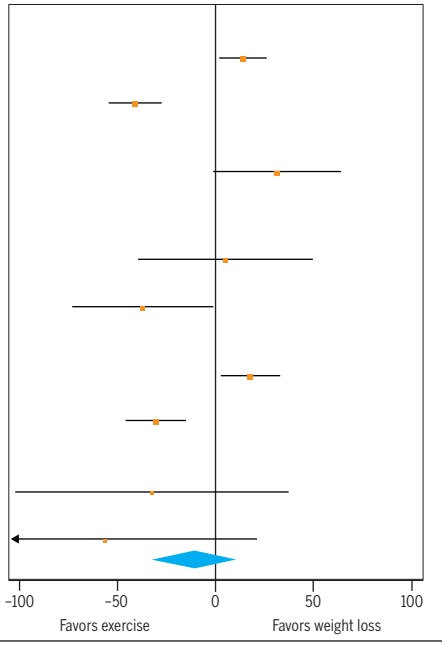
[a]*Heterogeneity: $\tau^2 = 0.70$, $\chi^2 = 122.04$, $df = 4$ ($P<.0001$), $I^2 = 97\%$. Test for overall effect: $z = 2.84$ ($P = .005$).*
Abbreviations: IV, inverse variance; MR, meal replacement; SE, standard error; SMD, standardized mean difference.

FIGURE 1 (CONTINUED). Weight-loss interventions versus minimal care for knee and hip osteoarthritis.

APPENDIX E

Physical Performance

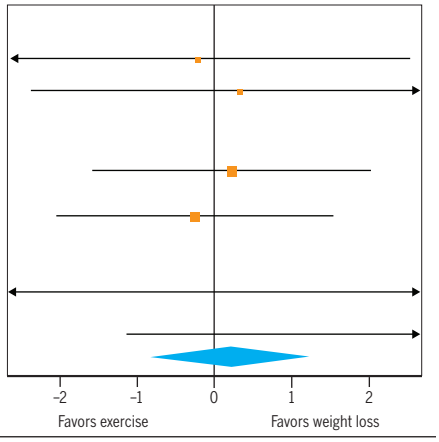
Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	MD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	480.0 ± 10.4	12	466.0 ± 12.13	5	14.6%	14.00 (1.85, 26.15)
Reduced-calorie diet	425.0 ± 14.8	12	466.0 ± 12.13	5	14.4%	−41.00 (−54.53, −27.47)
Messier et al[35]						
Reduced-calorie diet plus exercise	555.04 ± 38.001	12	523.64 ± 37.47	9	11.4%	31.40 (−1.18, 63.98)
Messier et al[34]						
Reduced-calorie diet plus exercise	477.76 ± 114.377	76	472.73 ± 117.349	40	9.3%	5.03 (−39.51, 49.57)
Reduced-calorie diet	435.63 ± 116.633	82	472.73 ± 117.349	80	10.8%	−37.10 (−73.14, −1.06)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	548.0 ± 46.776	116	530.2 ± 46.776	53	14.2%	17.80 (2.60, 33.00)
MR, reduced-calorie diet	499.0 ± 46.778	107	529.5 ± 46.778	53	14.2%	−30.50 (−45.90, −15.10)
Wolf et al[60]						
Reduced-calorie diet plus exercise	486.54 ± 92.6	21	518.98 ± 101.4	12	5.9%	−32.44 (−102.15, 37.27)
Reduced-calorie diet	462.52 ± 125.4	22	518.98 ± 101.4	12	5.2%	−56.46 (−134.16, 21.24)
Total[a]		460		269	100.0%	−10.47 (−32.20, 11.26)



[a]*Heterogeneity: T^2 = 804.24, χ^2 = 65.11, df = 8 (P<.0001), I^2 = 88%. Test for overall effect: z = 0.94 (P = .34).*
Abbreviations: IV, inverse variance; MD, mean difference; MR, meal replacement.

Mental Health

Study/Subgroup	Experimental Mean ± SD	Experimental Total, n	Control Mean ± SD	Control Total, n	Weight	MD IV, Random (95% Confidence Interval)
Messier et al[34]						
Reduced-calorie diet plus exercise	53.84 ± 7.149	76	54.06 ± 7.245	40	14.4%	−0.22 (−2.98, 2.54)
Reduced-calorie diet	54.39 ± 7.063	82	54.06 ± 7.245	40	14.8%	0.33 (−2.39, 3.05)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	56.0 ± 5.905	124	55.78 ± 5.905	61	33.4%	0.22 (−1.59, 2.03)
MR, reduced-calorie diet	55.5 ± 5.840	124	55.76 ± 5.840	60	33.8%	−0.26 (−2.06, 1.54)
Wolf et al[60]						
Reduced-calorie diet plus exercise	52.38 ± 10.6	21	47.97 ± 11.4	12	1.8%	4.41 (−3.47, 12.29)
Reduced-calorie diet	54.52 ± 9.8	21	47.97 ± 11.4	12	1.8%	6.55 (−1.14, 14.24)
Total[a]		448		225	100.0%	0.20 (−0.84, 1.25)



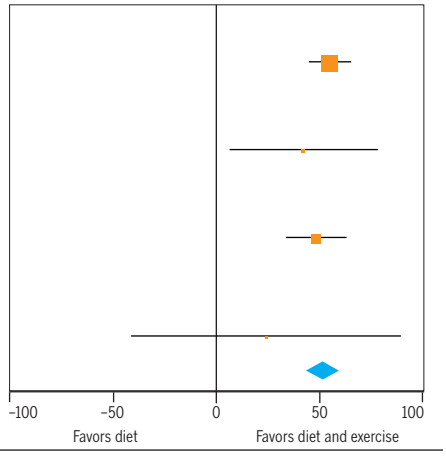
[a]*Heterogeneity: T^2 = 0.00, χ^2 = 4.06, df = 5 (P = .54), I^2 = 0%. Test for overall effect: z = 0.38 (P = .71).*
Abbreviations: IV, inverse variance; MD, mean difference; MR, meal replacement.

FIGURE 2. Weight-loss interventions versus exercise-only interventions for knee osteoarthritis.

APPENDIX E

Physical Performance

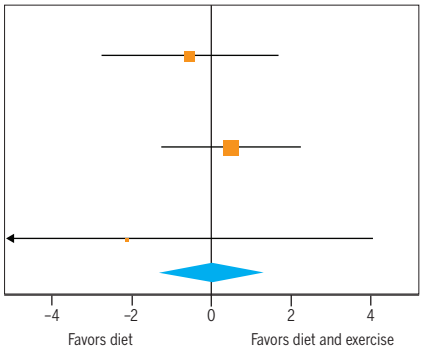
Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Diet Only Mean ± SD	Diet Only Total, n	Weight	MD IV, Random (95% Confidence Interval)
Ghroubi et al[23]						
Reduced-calorie diet plus exercise	480.0 ± 10.4	12	425.0 ± 14.8	12	62.9%	55.00 (44.77, 65.23)
Messier et al[34]						
Reduced-calorie diet plus exercise	477.76 ± 114.378	76	435.63 ± 116.633	82	5.1%	42.13 (6.09, 78.17)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	548.0 ± 55.955	116	499.7 ± 55.955	107	30.5%	48.30 (33.60, 63.00)
Wolf et al[60]						
Reduced-calorie diet plus exercise	486.54 ± 92.6	21	462.52 ± 125.4	22	1.5%	24.02 (−41.66, 89.70)
Total[a]		225		223	100.0%	51.83 (43.71, 59.95)



[a]*Heterogeneity: $\tau^2 = 0.00$, $\chi^2 = 1.56$, $df = 3$ ($P = .67$), $I^2 = 0\%$. Test for overall effect: $z = 12.51$ ($P<.0001$).*
Abbreviations: IV, inverse variance; MD, mean difference; MR, meal replacement.

Mental Health

Study/Subgroup	Diet and Exercise Mean ± SD	Diet and Exercise Total, n	Diet Only Mean ± SD	Diet Only Total, n	Weight	MD IV, Random (95% Confidence Interval)
Messier et al[34]						
Reduced-calorie diet plus exercise	53.84 ± 7.149	76	54.39 ± 7.063	82	36.6%	−0.55 (−2.77, 1.67)
Messier et al[36]						
MR, reduced-calorie diet plus exercise	56.0 ± 7.031	124	55.52 ± 7.031	124	58.7%	0.48 (−1.27, 2.23)
Wolf et al[60]						
Reduced-calorie diet plus exercise	52.38 ± 10.6	21	54.52 ± 9.8	21	4.7%	−2.14 (−8.31, 4.03)
Total[a]		221		227	100.0%	−0.02 (−1.36, 1.32)



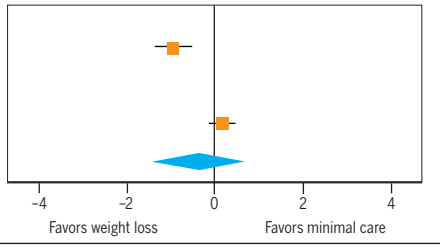
[a]*Heterogeneity: $\tau^2 = 0.00$, $\chi^2 = 0.99$, $df = 2$ ($P = .61$), $I^2 = 0\%$. Test for overall effect: $z = 0.03$ ($P = .98$).*
Abbreviations: IV, inverse variance; MD, mean difference; MR, meal replacement.

FIGURE 3. Dietary weight-loss interventions and exercise versus dietary weight loss only for knee osteoarthritis.

APPENDIX E

Mental Health

	Diet and Exercise		Usual Care			
Study/Subgroup	**Mean ± SD**	**Total, n**	**Mean ± SD**	**Total, n**	**Weight**	**SMD IV, Random (95% Confidence Interval)**
Muehlbacher et al[39]						
Pharmaceuticals	−72.9 ± 5.5	48	−67.5 ± 5.8	48	49.1%	−0.95 (−1.37, −0.52)
Williams et al[59]						
Telephone coaching and education	46.5 ± 13.8	79	44.3 ± 13.3	80	50.9%	0.16 (−0.15, 0.47)
Total[a]		127		128	100.0%	−0.38 (−1.47, 0.70)



[a]*Heterogeneity: $\tau^2 = 0.58$, $\chi^2 = 17.14$, $df = 1$ ($P<.0001$), $I^2 = 94\%$. Test for overall effect: $z = 0.69$ ($P = .49$).*
Abbreviations: IV, inverse variance; SMD, standardized mean difference.

FIGURE 4. Weight-loss interventions versus minimal care for chronic low back pain.

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Prevalence, Severity, and Correlates of Pain Flares in Response to a Repeated Sit-to-Stand Activity: A Cross-sectional Study of 14 902 Patients With Knee and Hip Osteoarthritis in Primary Care

OBJECTIVE: To determine prevalence, severity, and clinical correlates of pain flares in response to a repeated sit-to-stand activity.

DESIGN: Cross-sectional.

METHODS: The analyses included 11 013 patients with knee osteoarthritis (OA) and 3889 patients with hip OA who completed a 30-second chair-stand test before starting the Good Life with osteoArthritis in Denmark treatment program. Prevalence and severity of pain flares were evaluated by change in self-reported joint pain intensity on an 11-point numeric rating scale after the test. Correlates with pain flares (an increase on the numeric rating scale of 2 points or greater) were assessed using regression analyses.

RESULTS: One out of 3 patients with knee OA and 1 out of 5 patients with hip OA experienced pain flares (numeric rating scale of 2 or greater). Low knee/hip confidence, 3 or more painful body sites, fewer than 12 chair stands in 30 seconds, and body mass index of 30 kg/m^2 or greater were associated with pain flares in response to the 30-second chair-stand test in patients with knee and hip OA. Low self-efficacy and joint stiffness were associated with pain flares in patients with knee OA. Using pain medication was associated with pain flares in patients with hip OA.

CONCLUSION: Pain flares in response to a repeated sit-to-stand activity were common in patients with knee and hip OA. The clinical correlates associated with pain flares included joint confidence, functional performance, and body mass index, and are potentially modifiable with patient education, exercise therapy, and weight loss, respectively. *J Orthop Sports Phys Ther 2020;50(6):309-318. Epub 6 Sep 2019. doi:10.2519/jospt.2019.9125*

KEY WORDS: *hip, knee, osteoarthritis, pain, physical activity*

Osteoarthritis (OA) is one of the leading contributors to the global burden of disease and affects at least 250 million people worldwide.[11,19] Pain is the hallmark symptom of OA.[12] Short episodes of intense, unpredictable pain—pain flares[39]—may limit participation in social and recreational activities to avoid triggering the pain.[24] Although a more broadly acknowledged definition of pain flares does not exist,[10,39] a recent systematic review found that an increase of 2 or more points on a 0-to-10 pain-rating scale was one of the most widely used definitions of pain flares.[39]

Current clinical care of OA does not adhere to clinical guideline recommendations.[20] Fifty-three percent of people with knee OA and 42% of people with hip OA do not meet physical activity guidelines,[50] which substantially increases their risk of functional decline[15] and of at least 34 other chronic conditions, including type 2 diabetes, depression, and cardiovascular disease.[5] Pain is one of the main barriers that prevents patients with knee and hip OA from engaging in physical activity.[24,28,40] Activity-related pain is often misinterpreted as physical activity leading to exacerbation of OA,[28] although ac-

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tivity-related pain flares seem to decrease with more sessions of supervised physical activity.[43]

Although some studies have investigated pain flares in OA in general,[39] there is limited evidence on pain flares evoked by specific activities. To address misconceptions about physical activity and encourage patients with knee and hip OA to adhere to treatment and physical activity guidelines, clinicians require knowledge of the prevalence and severity of pain flares from specific daily activities and the clinical correlates that are modifiable by treatment.

The aim of this study was to determine the prevalence, severity, and clinical correlates of pain flares in response to repeated chair stands, a frequent daily activity in patients with knee and hip OA.

METHODS

Design and Setting

This was a cross-sectional, registry-based study using baseline data from 11 013 patients with knee OA and 3889 patients with hip OA, who were participating in Good Life with osteoArthritis in Denmark (GLA:D),[47] an OA treatment program of education and supervised exercise provided by certified clinicians in more than 400 primary care units across Denmark. While the vast majority of GLA:D units are private physical therapy clinics (treating approximately 85% of all patients in GLA:D), 35 of the 98 Danish municipalities offer GLA:D. A detailed description of GLA:D, including training of physical therapists, treatment, and outcomes, has previously been published.[47]

This report conforms to the Strengthening the Reporting of Observational Studies in Epidemiology statement for reporting observational studies.[49] According to the local ethics committee of the North Denmark Region, ethics approval of GLA:D was not required. The GLA:D program has previously been approved by the Danish Data Protection Agency (SDU; 10.084), and all patients consented to submitting their data to the GLA:D registry.

Participants

Patients seeking care at 1 of the more than 400 primary care units described above can enter the GLA:D program. A physical therapist, who had completed the 2-day GLA:D course, including training on how to diagnose OA, evaluated patients' eligibility to join GLA:D based on the following criteria: knee/hip joint pain or functional impairments associated with knee or hip OA and ability to understand Danish. Exclusion criteria were (1) joint symptoms not associated with OA (eg, inflammatory joint disease or patellar tendinopathy), as evaluated by the physical therapist; and (2) symptoms that are more pronounced than those of OA (eg, chronic, generalized pain or fibromyalgia). While the physical therapists were trained in using the European League Against Rheumatism clinical criteria for diagnosing OA,[55] they were also instructed to include all patients adhering to the eligibility criteria presented above to ensure that patients with early OA[34] would also receive treatment according to clinical guidelines.

We analyzed data from patients with knee and hip OA who were enrolled in GLA:D and had baseline data for self-reported pain intensity (**TABLE 1**).

Outcome Variable

Self-reported pain intensity in the most affected knee or hip was evaluated using the valid and reliable 11-point numeric rating scale (NRS), ranging from 0 ("no pain") to 10 ("worst pain imaginable").[23] The instructions given to the patients before evaluating their knee or hip joint pain explained the difference between joint pain and muscle soreness and fatigue. Pain flares were defined as an increase of at least 2 points on the NRS from immediately before to immediately after the 30-second chair-stand test performed prior to starting the GLA:D program.[14] A change of at least 2 points on the 11-point NRS has been considered a clinically relevant difference[17] and a definition of a pain flare.[39]

Independent Variables

We assessed a range of patient-reported and clinician-assessed characteristics prior to the treatment program for their association with the occurrence of a pain flare. The characteristics we chose from the outcomes available in GLA:D[47] had previously been associated with pain flares and/or were expected to be associated with pain flares following a repeated sit-to-stand activity due to their interrelatedness with pain and the specific activity.

Pain-Related Variables We recorded the use of pain medication within the last 3 months, including paracetamol, oral or topical nonsteroidal anti-inflammatory drug, morphine, or other opioid (categorized as yes/no). Use of pain medication may be more frequent in patients who experience pain flares.[35] Self-reported body sites with pain in the previous 24 hours were reported on an electronic, region-divided body chart (56 sites in total) (**FIGURE**). The total number of pain sites was used to quantify the spreading of pain,[7] a measure that has previously been suggested as an indicator of a more sensitized pain system in patients with OA.[3]

Functional and Physical Activity–Related Variables The 30-second chair-stand test measures the number of chair stands that the patient can complete in a 30-second period. The test is recommended as a core outcome of functional performance for people with OA.[14] Guided by the physical therapist, the patient sat in the middle of the chair (43 to 44 cm in height), with a straight back and feet placed on the floor. The patient crossed the arms at the wrist and held them over the chest, fully stood up, and then sat down. If the patient could not stand up once, a modified test was carried out from a chair (44- to 47-cm seat height) with an armrest, allowing the patient to use the hands to stand up. For analysis, patients who were unable to stand up once in the regular test were assigned a score of zero.

We measured physical activity using the 10-level University of California, Los Angeles (UCLA) activity scale ("inactive" to "regular participation" in impact sports).[54] People with higher activity levels were expected to experience less severe pain flares[43] from the 30-second chair-stand test, and functional limitations are related to pain flares.[35]

Psychological Variables We assessed fear of movement using the question, "Are you afraid that your joints will be damaged from physical activity and exercise?" (yes/no).

We assessed knee/hip confidence using item Q3 from the Knee injury and Osteoarthritis Outcome Score and the Hip disability and Osteoarthritis Outcome Score ("How much are you troubled with lack of confidence in your knee/hip?"), reclassified as yes (not at all) and no (mildly to extremely) regarding being confident in the knee/hip.[9,30,37,42] Although not validated, the measure has been applied in several previous studies as a single-item measure of joint confidence in patients with OA.[8,22,46,48] Mental health was assessed using the Medical Outcomes Study 12-Item Short-Form Health Survey (SF-12) mental component summary,[51] and self-efficacy was assessed using the pain subscale from the Arthritis Self-Efficacy Scale.[33] Psychological variables were included because the pain experience is a highly complex biopsychosocial phenomenon[4,29] and because psychological factors have previously been linked to pain flares.[16,53]

Joint-Related and Anthropometric Variables Physical therapists assessed passive flexion or internal rotation of the hip in patients with hip OA and passive knee flexion or extension of the knee in patients with knee OA, and compared them to values in the contralateral leg and normative values. The findings were classified as range-of-motion restriction (yes/no), a common symptom in patients with OA[55] that, in the affected joint, could be related to pain flares from sit-to-stand activity.[25,32] Joint stiffness after inactivity in patients with hip OA and short-lasting morning joint stiffness in patients with knee OA were assessed and classified as joint stiffness (yes/no). Joint stiffness has been associated with pain flares.[35,38] We calculated body mass index (BMI) from the patients' weight and height reported by the clinicians.[35,38]

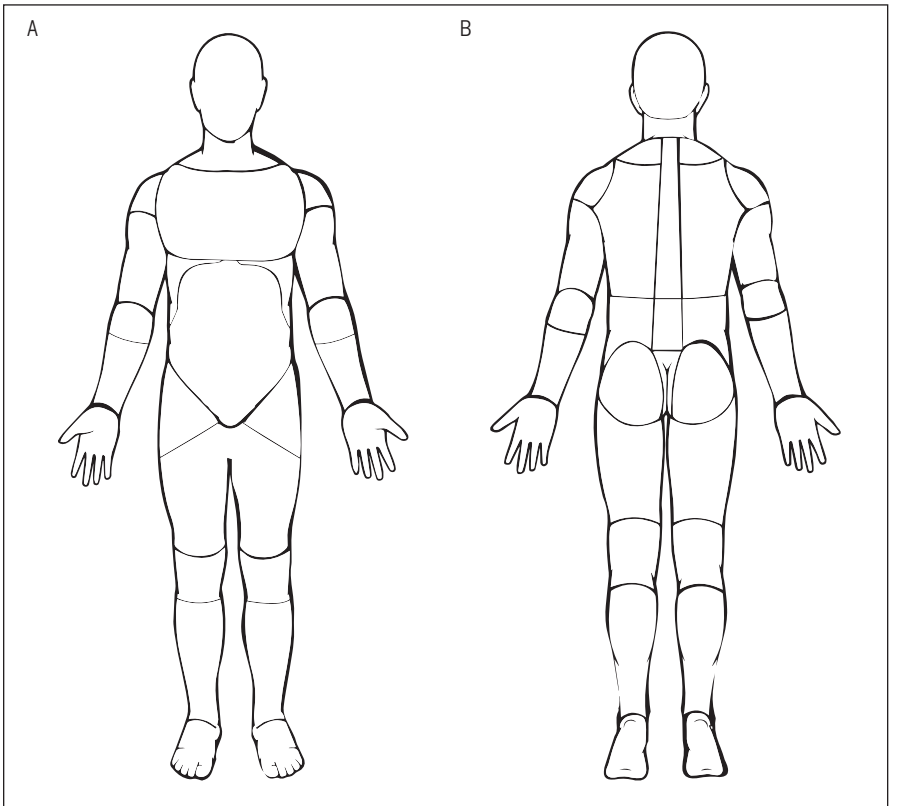

FIGURE. Self-reported body sites with pain in the previous 24 hours were reported on an electronic, region-divided body chart of the front (A) and back (B) sides of the body.

Statistical Analysis

Data were collected from May 8, 2017 to December 31, 2018 and included in the analyses according to the time when the outcome variable (pain intensity prior to and directly after the 30-second chair-stand test) was included in the GLA:D registry.

We used paired-samples *t* tests to assess change in pain intensity from before to after the 30-second chair-stand test for patients with knee and hip OA, respectively. We used univariable and multivariable logistic regressions to investigate associations between pain flares (an increase on the NRS of 2 points or greater) and the independent variables for patients with knee and hip OA. We constructed the regression model following the approach proposed by Hosmer and Lemeshow and described by Bursac et al.[6] Variables with a *P* value less than .25 in the univariable analysis were included in the multivariable analysis, as more traditional levels such as $P<.05$ can fail in identifying important variables.[6]

If a variable included in the initial multivariable model was not significant ($P\geq.10$) and changed the estimate of the other variables by 20% or less in the multivariable analysis, it was removed. Variables not selected for the initial model ($P\geq.25$) in the univariable analysis were re-entered into the model one at a time to identify those making an important contribution to the model in the presence of the other variables. If a re-entered variable was significant ($P<.10$), it was retained, and the process was repeated for the newly added variables until a final

crude model was reached. Subsequently, an analysis adjusted for age, sex, and the baseline value for the outcome of interest (pain intensity on the 11-point NRS before the 30-second chair-stand test) was conducted, repeating the process of removing variables that were not significant ($P \geq .10$). Sensitivity analyses, including an increase in pain of at least 3 points and 4 points instead of 2 points as the outcome variable in the final model, were conducted.

Odds ratios and 95% confidence intervals were applied to assess the association between each of the potential associated variables and the outcome variable, and Nagelkerke R^2 was used to describe the overall performance of the model (explained variation). The Hosmer-Lemeshow goodness-of-fit test was used to assess the agreement between observed and predicted outcomes in the model ($P \geq .05$).

Due to violations of the assumption of a linear relationship between the continuous independent variables and the logit transformation of the outcome variable (assessed using the Box-Tidwell approach), BMI (yes/no to 30 kg/m^2 or greater), number of painful body sites (yes/no to 3 or more), and number of chair stands in the 30-second chair-stand test (yes/no to 12 or more) were reclassified as binary variables. All other continuous variables were linearly related to the logit of the outcome variable. Multicollinearity among the candidate independent variables was not a problem, with correlation coefficients below 0.27. There was no standardized residual with a value of ±3 standard deviations.

The significance level of the final regression model was set at $P < .05$, and all analyses were performed in SPSS Statistics Version 24 (IBM Corporation, Armonk, NY).

RESULTS

We excluded data from 105 patients, as the outcome variable for the most affected knee/hip joint was missing. Patients with knee OA (n = 193, 1.8%) and hip OA (n = 59, 1.5%) completed the modified chair-stand test instead of the standard test. Data from 51 (0.3%) patients who had an NRS pain rating of 9 or 10 before the 30-second chair-stand test and therefore could not achieve a 2-point increase on the NRS were excluded.

Pain intensity increased following the 30-second chair-stand test ($P < .001$). One in 3 patients with knee OA and 1 in 5 patients with hip OA experienced an increase in pain intensity of at least 2 points (**TABLES 2** and **3**). Eighteen percent of patients with knee OA and 10% of patients with hip OA experienced an increase of at least 3 points. Ten percent of patients with knee OA and 5% of patients with hip OA experienced an increase of at least 4 points.

For patients with knee OA, the crude model was statistically significant ($\chi^2_6 = 237.001$, $P < .001$). The model explained 3.6% (Nagelkerke R^2) of the variance in pain flares and correctly classified 68.1% of cases. There was a statistically significant association between pain flares and the following variables: low knee confidence, 3 or more painful body sites, lower pain self-efficacy, fewer than 12 chair stands in 30 seconds, joint stiffness, and BMI of 30 kg/m^2 or greater (**TABLE 4**). The model adjusted for age and pain intensity before the 30-second chair-stand test was also statistically significant ($\chi^2_8 = 403.579$, $P < .001$). The model explained 6.1% (Nagelkerke R^2) of the variance in pain flares and cor-

TABLE 1 Participant Characteristics[a]

	Knee Osteoarthritis (n = 11013)	Hip Osteoarthritis (n = 3889)
Age, y	65.4 ± 9.8	66.8 ± 9.7
Sex, n (%)		
Men	3351 (30.4)	1175 (30.2)
Women	7662 (69.6)	2714 (69.8)
BMI, kg/m^2	29.1 ± 5.5	27.2 ± 4.7
Symptom duration, mo[b]	12 (6-36)	12 (6-36)
Baseline NRS (0-10)	1.7 ± 2.0	1.8 ± 2.1
Number of chair stands in 30 s	11.7 ± 3.9	12.0 ± 4.0
Pain medication, n (%)[c]		
Yes	7388 (67.1)	2799 (72.0)
No	3625 (32.9)	1090 (28.0)
Educational level, n (%)[d]		
Primary school	1668 (18.2)	632 (19.3)
Secondary school	1000 (10.9)	351 (10.7)
Short-term education	1876 (20.4)	639 (19.5)
Middle-term education	3592 (39.1)	1284 (39.1)
Long-term education	1049 (11.4)	375 (11.4)
Fear of movement, n (%)		
Yes	1436 (15.6)	392 (11.9)
No	7749 (84.4)	2890 (88.1)
Limited range of motion, n (%)		
Yes	6880 (62.6)	3197 (82.3)
No	4117 (37.4)	690 (17.8)
Joint stiffness, n (%)		
Yes	7105 (64.6)	3200 (82.3)
No	3892 (35.4)	687 (17.7)

Table continues on page 313.

TABLE 1 Participant Characteristics[a] (continued)

	Knee Osteoarthritis (n = 11013)	Hip Osteoarthritis (n = 3889)
Lack of knee/hip confidence, n (%)[e]		
Not at all	706 (7.7)	451 (13.8)
Mildly	2229 (24.3)	919 (28.0)
Moderately	3081 (33.6)	1084 (33.1)
Severely	2798 (30.5)	730 (22.3)
Extremely	366 (4.0)	95 (2.9)
Number of painful body sites, n (%)[f]		
0	161 (3.1)	42 (2.3)
1	362 (7.0)	98 (5.4)
2	1950 (37.5)	559 (31.0)
3	494 (9.5)	222 (12.3)
4	862 (16.6)	309 (17.1)
5+	1376 (26.4)	576 (31.9)
UCLA activity scale, n (%)		
1-2 (physically inactive)	317 (3.5)	104 (3.2)
3-4 (low physical activity level)	2768 (30.1)	1000 (30.4)
5-6 (moderate physical activity level)	3817 (41.5)	1384 (42.1)
7-8 (high physical activity level)	1837 (20.0)	625 (19.0)
9-10 (very high physical activity level)	460 (5.0)	172 (5.2)
SF-12 mental component summary	52.6 ± 9.7	51.7 ± 9.9
ASES pain subscale	66.1 ± 20.1	62.6 ± 20.5

Abbreviations: ASES, Arthritis Self-Efficacy Scale; BMI, body mass index; NRS, numeric rating scale; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; UCLA, University of California, Los Angeles.

[a]*Values are mean ± SD unless otherwise indicated. Missing values: age, n = 7; BMI, n = 89; symptom duration, n = 12; number of chair stands in 30 seconds, n = 1; educational level, n = 2436; fear of movement, n = 2435; joint stiffness and limited range of motion, n = 18; lack of knee/hip confidence, n = 2443; number of painful body sites, n = 2419; UCLA activity scale, n = 2418; SF-12 mental component summary, n = 2434; ASES pain subscale, n = 2421.*

[b]*Values are median (interquartile range).*

[c]*Defined as at least 1 of the following medications: paracetamol, oral or topical nonsteroidal anti-inflammatory drug, morphine, or other opioid.*

[d]*Short-term education, under 3 years after secondary school; middle-term education, 3 to 4 years after secondary school; long-term education, at least 5 years after secondary school.*

[e]*Derived from item Q3 of the Hip disability and Osteoarthritis Outcome Score and the Knee injury and Osteoarthritis Outcome Score.*

[f]*Missing values, n = 7891 (knee osteoarthritis, 5808; hip osteoarthritis, 2083). Of the 5808 missing values for knee osteoarthritis, 932 represented nonresponders to the patient questionnaire and 4876 were due to technical problems in the data collection of the variable. Of the 2083 missing values or hip osteoarthritis, 312 represented nonresponders to the patient questionnaire and 1771 were due to technical problems in the data collection of the variable.*

rectly classified 68.1% of cases. The associated variables from the crude model were still significant (**TABLE 4**). Restricting the analysis to an increase in pain flares of at least 3 points and 4 points instead of 2 points as the outcome variable demonstrated similar results (data not shown).

For patients with hip OA, the crude model was statistically significant (χ^2_5 = 69.615, P<.001). The model explained 3.3% (Nagelkerke R^2) of the variance in pain flares and correctly classified 79.8% of cases. There was a statistically significant association between pain flares and the following variables: low hip confidence, 3 or more painful body sites, using pain medication, fewer than 12 chair stands in 30 seconds, and BMI of 30 kg/m^2 or greater (**TABLE 5**). The model adjusted for age and pain intensity before the 30-second chair-stand test was also statistically significant (χ^2_7 = 118.820, P<.001). The model explained 5.7% (Nagelkerke R^2) of the variance in pain flares and correctly classified 79.8% of cases. The associated variables from the crude model remained significant (**TABLE 5**). Including an increase in pain flares of at least 3 points and 4 points instead of 2 points as the outcome variable demonstrated similar results (data not shown).

The goodness-of-fit test for crude and adjusted models for patients with knee and hip OA showed that each model was adequate (P>.05).

DISCUSSION

One out of 3 patients with knee OA and 1 out of 5 patients with hip OA experienced a pain flare (increase on the NRS of 2 points or greater) in response to the repeated sit-to-stand activity. Eighteen percent of patients with knee OA and 10% of patients with hip OA experienced an increase of at least 3 points. Ten percent of patients with knee OA and 5% of patients with hip OA experienced an increase of at least 4 points. Low knee/hip confidence, 3 or more painful body sites, fewer than 12 chair stands in 30 seconds, and BMI of 30 kg/m^2 or more were associated with a pain flare following the repeated sit-to-stand activity for patients with knee and hip OA. Low self-efficacy and joint stiffness for patients with knee OA, and using pain medication for patients with hip OA, were also associated with pain flares.

Proportions and Severity of Pain Flares

We investigated the prevalence and severity of pain flares in response to a specific and common daily activity in patients with knee and hip OA who had not completed a structured exercise therapy program. In previous studies, patients with knee OA had a greater increase in pain intensity than healthy controls after climbing stairs.[21] The prevalence of knee OA flare-

ups in general is about 53% in a population from general practice,[35] and 23% to 32% in older adults with knee pain.[38] Our study builds on existing literature by estimating the proportion of patients with knee and hip OA as their primary complaint, seeking treatment in primary care, who experience a pain flare in response to a repeated sit-to-stand activity.

The larger proportion of patients with knee OA who experienced pain flares suggests that they may be more susceptible to increases in pain from repeated sit-to-stand activity than patients with hip OA. We also quantified the severity of pain flares: 18% of patients with knee OA and 10% of patients with hip OA experienced an increase of at least 3 points on the NRS; 10% of patients with knee OA and 5% of patients with hip OA experienced an increase of at least 4 points. Therefore, there was a relatively large proportion of patients who experienced a large pain flare after repeated sit-to-stand activity, which should be considered when physical therapists and other clinicians are discussing individual treatment plans with the patient. This includes informing patients that pain flares of varying intensity are common following activity, but that the pain flares are likely to be fewer and less severe following supervised exercise.[43]

TABLE 2 Pain Intensity Before and After the 30-Second Chair-Stand Test in Patients With Knee Osteoarthritis[a]

	NRS After Test					
	0	1-2	3-5	6-8	9-10	Total
NRS before test						
0	2628 (54.6)	1116 (23.2)	888 (18.4)	174 (3.6)	9 (0.2)	4815 (100)
1-2	111 (3.8)	1621 (55.6)	1023 (35.1)	159 (5.5)	4 (0.1)	2918 (100)
3-5	54 (2.0)	102 (3.9)	1719 (65.0)	740 (28.0)	28 (1.1)	2643 (100)
6-8	13 (2.2)	7 (1.2)	67 (11.1)	448 (74.4)	67 (11.1)	602 (100)
9-10	1 (2.9)	1 (2.9)	1 (2.9)	1 (2.9)	31 (88.6)	35 (100)

Abbreviation: NRS, numeric rating scale.
[a]n = 11 013. The NRS is an 11-point scale ranging from 0 (best) to 10 (worst). Change in pain intensity of at least 2 points: better, 264 (2.4%); same, 7245 (65.8%); worse, 3504 (31.8%). Mean pain flare: before test, 1.72 points (95% confidence interval: 1.68, 1.76); after test, 2.78 points (95% confidence interval: 2.74, 2.83); change (before to after test), 1.06 points (95% confidence interval: 1.03, 1.10).

TABLE 3 Pain Intensity Before and After the 30-Second Chair-Stand Test in Patients With Hip Osteoarthritis[a]

	NRS After Test					
	0	1-2	3-5	6-8	9-10	Total
NRS before test						
0	1112 (69.4)	280 (17.5)	181 (11.3)	27 (1.7)	3 (0.2)	1603 (100)
1-2	66 (6.2)	655 (61.3)	315 (29.5)	31 (2.9)	1 (0.1)	1068 (100)
3-5	35 (3.5)	63 (6.3)	724 (72.8)	173 (17.4)	0 (0.0)	995 (100)
6-8	4 (1.9)	3 (1.5)	25 (12.1)	159 (76.8)	16 (7.7)	207 (100)
9-10	1 (6.3)	0 (0.0)	3 (18.8)	4 (25.0)	8 (50.0)	16 (100)

Abbreviation: NRS, numeric rating scale.
[a]n = 3889. The NRS is an 11-point scale ranging from 0 (best) to 10 (worst). Change in pain intensity of at least 2 points: better, 148 (3.8%); same, 2960 (76.1%); worse, 781 (20.1%). Mean pain flare: before test, 1.81 points (95% confidence interval: 1.75, 1.88); after test, 2.40 points (95% confidence interval: 2.32, 2.47); change (before to after test), 0.58 points (95% confidence interval: 0.54, 0.63).

Clinical Correlates of Pain Flares

Having 3 or more painful body sites increased the odds of a pain flare by approximately one quarter. This supports previous reports of a more sensitized pain system and higher pain intensity in patients with more body sites with pain.[2,3] The pain system in patients with long-lasting pain may undergo a transition from localized pain to more widespread pain: local pain stimulates the central nervous system and sensitizes adjacent and distant areas (widespread sensitization).[1] Knee discomfort and pain from walking have been associated with temporal summation,[52] a well-known measure of widespread sensitization frequently assessed in studies of OA pain.[3] The sensitized response to walking remained elevated and increased further when the activity was repeated.[52] In contrast to previous research,[35] our study found that use of pain medication did not increase the odds of pain flares for patients with knee OA. However, in patients with hip OA, the use of pain medication increased the odds of pain flares by 78% compared to no use of pain medication.

For both knee and hip OA, poorer function (fewer than 12 repetitions during the 30-second chair-stand test) was associated with a pain flare from the same activity. This supports a range of previous reports,[35,41,52] one of which demonstrated that pain flares were associated with work time loss.[41] Higher BMI in patients with knee OA has been linked with poorer self-reported function in daily living 3 years later.[44] Extending findings from previous studies of pain flares in general,[35,38] we found that high BMI was also related to pain flares after a repeated sit-to-stand activity in patients with knee and hip OA (20% to 28% increased odds). Furthermore, we confirmed previous associations between joint stiffness and pain flares in patients with knee OA.[35,38]

Associations between pain flares/

discomfort and pain catastrophizing,[52] higher negative affect and passive coping strategies,[16] and worsened overall mental health[53] have been previously reported. In our study, only low knee/hip confidence was significantly associated with pain flares in patients with knee and hip OA. Low pain self-efficacy was associated with pain flares in patients with knee OA. An individually tailored approach to addressing psychological aspects may help overcome barriers to being physically active (including fear of pain)[28,40] and reduce the risk of future deteriorating function.[44]

Clinical Implications

Pain is an important barrier to being physically active.[24,28,40] Osteoarthritis pain is associated with pain-related avoidance of activities, which is related to functional limitations in the following years.[26] If patients further restrict physical activity participation, they risk worsening their OA symptoms[15] and other chronic conditions, including type 2 diabetes, depression, and cardiovascular disease.[5] Therefore, clinicians should consider identifying patients at risk of activity-related pain flares prior to initiating an exercise therapy program. Clinical correlates of pain flares in our current study are all potentially modifiable through treatment.

Ensuring that patients receive appropriate care as recommended in international clinical guidelines, including patient education, exercise therapy, and weight loss,[18,36] has the potential to reduce pain flares in people with knee and hip OA.[43] Unfortunately, community-based OA care is still suboptimal.[20] Initiatives such as GLA:D[47] aim at implementing clinical guidelines in clinical practice. The GLA:D program includes patient education and 12 sessions of supervised neuromuscular exercise.[47]

In the context of pain flares, education is important to teach patients about facilitators of, and barriers to, physical activity.[13,40,45] One common misconception is that physical activity drives OA progression.[28] Furthermore, as activity-related pain flares subside with more sessions of supervised exercise therapy,[43] it is important to support the patient in continuing his or her participation in a supervised exercise therapy program for at least 12 sessions.[27,43] Patients with 1 or

TABLE 4 Variables Associated With Pain Flares After the 30-Second Chair-Stand Test in Patients With Knee Osteoarthritis

	Univariable		Crude Multivariable[a]	Adjusted Multivariable[b]
Independent Variable[c]	Odds Ratio[d]	*P* Value	Odds Ratio[d]	Odds Ratio[d]
Fear of movement[e]	1.14 (1.01, 1.28)	.03	...	...
Knee confidence[f]	1.47 (1.23, 1.75)	<.001	1.24 (1.03, 1.48)	1.28 (1.07, 1.54)
SF-12 mental component summary	0.99 (0.99, 1.00)	<.001	...	...
UCLA activity scale	0.93 (0.91, 0.96)	<.001	...	...
≥3 painful body sites	1.34 (1.23, 1.46)	<.001	1.22 (1.11, 1.33)	1.25 (1.14, 1.37)
ASES pain subscale	0.99 (0.99, 1.00)	<.001	0.996 (0.99, 1.00)	0.99 (0.99, 1.00)
Pain medication[g]	1.25 (1.14, 1.36)	<.001	...	...
≥12 chair stands in 30 s	0.57 (0.53, 0.62)	<.001	0.63 (0.58, 0.69)	0.57 (0.51, 0.62)
Limited range of motion	1.16 (1.07, 1.27)	<.001	...	...
Joint stiffness	1.27 (1.17, 1.38)	<.001	1.16 (1.06, 1.28)	1.20 (1.09, 1.33)
BMI, ≥30 kg/m^2[h]	1.39 (1.28, 1.51)	<.001	1.25 (1.14, 1.37)	1.24 (1.13, 1.36)

Abbreviations: ASES, Arthritis Self-Efficacy Scale; BMI, body mass index; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; UCLA, University of California, Los Angeles.

[a] *Fear of movement, the SF-12 mental component summary, the UCLA activity scale, pain medication, and limited range of motion were not included in the crude model due to nonsignificance (P≥.10) and their impact on the estimate of the other variables of 20% or less. In this analysis, 9074 patients were included (1939 with missing data). Nagelkerke R^2 = 0.036.*

[b] *Fear of movement, the SF-12 mental component summary, the UCLA activity scale, pain medication, and limited range of motion were not included in the adjusted model due to nonsignificance (P≥.10) and their impact on the estimate of the other variables of 20% or less. In this model, 9069 patients were included (1944 with missing data). The model was adjusted for age (odds ratio = 0.99; 95% confidence interval: 0.98, 0.99) and pain intensity on the 11-point numeric rating scale before the 30-second chair-stand test (odds ratio = 0.86; 95% confidence interval: 0.84, 0.88), but not for sex, as it was not significant (P = .27) and its impact on the estimate of the other variables was less than 20%. Nagelkerke R^2 = 0.061.*

[c] *In the chair-stand test, doing fewer than 12 chair stands was the reference category. In all other dichotomous independent variables, not having the problem was the reference category (eg, not having problems with knee confidence).*

[d] *Values in parentheses are 95% confidence interval.*

[e] *The answer (yes/no) to, Are you afraid that your joints will be damaged from physical activity and exercise?*

[f] *Derived from item Q3 of the Knee injury and Osteoarthritis Outcome Score, regrouped as yes (0) and no (1-4) to the question of being confident in your knee.*

[g] *Defined as at least 1 of the following medications: paracetamol, oral or topical nonsteroidal anti-inflammatory drug, morphine, or other opioid.*

[h] *Regrouped to yes or no to being equal to or above 30 kg/m^2.*

more of the clinical characteristics associated with pain flares might require additional guidance during the early phases of an exercise therapy program to avoid discontinuing the program due to pain flares.

A previous study demonstrated excellent reliability and an acceptable smallest detectable change of pain intensity (1.95 points on a 0-to-10 NRS) during a 30-second standing knee-bend test in patients with knee OA.[31] A substantial proportion of patients with knee and hip OA had pain flares of 2 points or larger following the 30-second chair-stand test. Therefore, the test might serve as a clinically relevant test of pain flares to guide clinicians in identifying patients who may need additional support during an exercise therapy program. We believe that the external validity of our findings is high, as the data in the current study were collected nationwide in clinical practice.

Limitations

Pain flares after the 30-second chair-stand test may not reflect pain response to other activities. Two out of every 3 participants were at least moderately physically active at baseline and might have required a more challenging activity to experience a pain flare. Future analyses should compare pain flares after activities of different levels of difficulty. A broadly acknowledged definition of pain flares has not been reached,[10,39] and we did not investigate whether the increase in pain intensity persisted after the 30-second chair-stand test.

CONCLUSION

In a primary care setting, 1 in 3 patients with knee OA and 1 in 5 patients with hip OA experienced pain flares in response to a repeated sit-to-stand activity. A range of clinical correlates, including joint confidence, functional performance, and BMI, potentially modifiable with patient education, exercise therapy, and weight loss, were associated with pain flares. ◉

KEY POINTS

FINDINGS: Pain flares in response to a repeated sit-to-stand activity were common in patients with knee and hip osteoarthritis. Pain flares were associated with low knee/hip confidence, 3 or more painful body sites, fewer than 12 chair

TABLE 5 Variables Associated With Pain Flares After the 30-Second Chair-Stand Test in Patients With Hip Osteoarthritis

	Univariable		Crude Multivariable[a]	Adjusted Multivariable[b]
Independent Variable[c]	Odds Ratio[d]	*P* Value	Odds Ratio[d]	Odds Ratio[d]
Fear of movement[e]	1.02 (0.78, 1.32)	.91	...	...
Hip confidence[f]	1.81 (1.35, 2.41)	<.001	1.62 (1.21, 2.18)	1.71 (1.27, 2.30)
SF-12 mental component summary	0.99 (098, 1.00)	.007	...	...
UCLA activity scale	0.93 (0.89, 0.98)	.004	...	...
≥3 painful body sites	1.35 (1.14, 1.61)	.001	1.27 (1.06, 1.51)	1.28 (1.08, 1.53)
ASES pain subscale	0.99 (0.99, 1.00)	.001	...	...
Pain medication[g]	1.85 (1.53, 2.25)	<.001	1.61 (1.30, 2.00)	1.78 (1.43, 2.21)
≥12 chair stands in 30 s	0.63 (0.53, 0.73)	<.001	0.76 (0.64, 0.90)	0.65 (0.54, 0.78)
Limited range of motion	1.32 (1.06, 1.65)	.01	...	...
Joint stiffness	1.37 (1.10, 1.71)	.005	...	...
BMI, ≥30 kg/m^2[h]	1.39 (1.17, 1.66)	<.001	1.21 (1.00, 1.47)	1.20 (0.98, 1.46)

Abbreviations: ASES, Arthritis Self-Efficacy Scale; BMI, body mass index; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; UCLA, University of California, Los Angeles.

[a] *Fear of movement, the SF-12 mental component summary, the UCLA activity scale, self-efficacy (the ASES pain subscale), limited range of motion, and joint stiffness were not included in the crude model due to nonsignificance (P≥.10) and their impact on the estimate of the other variables of 20% or less. In this analysis, 3246 patients were included (643 with missing data). Nagelkerke R^2 = 0.033.*

[b] *Fear of movement, the SF-12 mental component summary, the UCLA activity scale, self-efficacy (the ASES pain subscale), limited range of motion, and joint stiffness were not included in the adjusted model due to nonsignificance (P≥.10) and their impact on the estimate of the other variables of 20% or less. In this analysis, 3244 patients were included (645 with missing data). The model was adjusted for age (odds ratio = 0.99; 95% confidence interval: 0.98, 0.99) and pain intensity on the 11-point numeric rating scale before the 30-second chair-stand test (odds ratio = 0.86; 95% confidence interval: 0.82, 0.90), but not for sex, as it was not significant (P = .25) and its impact on the estimate of the other variables was less than 20%. Nagelkerke R^2 = 0.057.*

[c] *In the chair-stand test, doing fewer than 12 chair stands was the reference category. In all other dichotomous independent variables, not having the problem was the reference category (eg, not having problems with hip confidence).*

[d] *Values in parentheses are 95% confidence interval.*

[e] *The answer (yes/no) to, Are you afraid that your joints will be damaged from physical activity and exercise?*

[f] *Derived from item Q3 of the Hip disability and Osteoarthritis Outcome Score, regrouped as yes (0) and no (1-4) to the question of being confident in your hip.*

[g] *Defined as at least 1 of the following medications: paracetamol, oral or topical nonsteroidal anti-inflammatory drug, morphine, or other opioid.*

[h] *Regrouped to yes or no to being equal to or above 30 kg/m^2.*

stands in 30 seconds, and a body mass index of 30 kg/m^2 or greater.

IMPLICATIONS: The clinical correlates of pain flares are potentially modifiable through patient education, exercise therapy, and weight loss, highlighting the importance of evaluating pain flares and increasing adherence to clinical guidelines.

CAUTION: The odds ratios of the associated variables in our study were relatively small, and the overall predictive capacities of the models were low, suggesting that other variables might be more important for pain flares in response to a repeated sit-to-stand activity.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: All authors were responsible for study conception and design, acquisition of data, analysis and interpretation of data, drafting the article or revising it critically for important intellectual content, and final approval of the article. Drs Skou and Roos were responsible for recruitment of patients. All authors had full access to all the data (including statistical reports and tables) in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

DATA SHARING: Deidentified data used in this study are available from Dr Roos (eroos@health.sdu.dk) and Dr Skou (stskou@health.sdu.dk) upon reasonable request. Data cannot be reused unless a collaboration agreement has been signed by both parties.

PATIENT AND PUBLIC INVOLVEMENT: The study did not include patient and public involvement.

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CORRIGENDUM

After the publication of the article "Prevalence, Severity, and Correlates of Pain Flares in Response to a Repeated Sit-to-Stand Activity: A Cross-sectional Study of 14 902 Patients With Knee and Hip Osteoarthritis in Primary Care," in the June 2020 issue of the *JOSPT*, the authors discovered a technical problem in the Good Life with osteoArthritis in Denmark registry. The problem relates to the registration of the variable "number of painful body sites," reported in **TABLE 1** of this article. Some marked areas were not recorded and, instead of a maximum number of 56 painful body sites, only a maximum of 4 painful body sites were recorded from April 9, 2018 onward. Hence, we recalculated the prevalence of painful body sites in patients with knee and hip osteoarthritis that was presented in **TABLE 1** on page 313 of the article, excluding data collected from April 9, 2018 onward. Given that the variable was recoded as binary (yes/no to 3 or more body sites) in the analyses of association with pain flares, the incorrect registration would only have a minor effect and, if anything, provide a larger odds ratio for the association. The corrected numbers of painful body sites have been updated in the online version of the article (available at www.jospt.org). The authors apologize for any inconvenience caused by this error. ◉

TABLE 1 Participant Characteristics[a]

	Knee Osteoarthritis (n = 11013)	Hip Osteoarthritis (n = 3889)
Age, y	65.4 ± 9.8	66.8 ± 9.7
Sex, n (%)		
Men	3351 (30.4)	1175 (30.2)
Women	7662 (69.6)	2714 (69.8)
BMI, kg/m^2	29.1 ± 5.5	27.2 ± 4.7
Symptom duration, mo[b]	12 (6-36)	12 (6-36)
Baseline NRS (0-10)	1.7 ± 2.0	1.8 ± 2.1
Number of chair stands in 30 s	11.7 ± 3.9	12.0 ± 4.0
Pain medication, n (%)[c]		
Yes	7388 (67.1)	2799 (72.0)
No	3625 (32.9)	1090 (28.0)
Educational level, n (%)[d]		
Primary school	1668 (18.2)	632 (19.3)
Secondary school	1000 (10.9)	351 (10.7)
Short-term education	1876 (20.4)	639 (19.5)
Middle-term education	3592 (39.1)	1284 (39.1)
Long-term education	1049 (11.4)	375 (11.4)
Fear of movement, n (%)		
Yes	1436 (15.6)	392 (11.9)
No	7749 (84.4)	2890 (88.1)
Limited range of motion, n (%)		
Yes	6880 (62.6)	3197 (82.3)
No	4117 (37.4)	690 (17.8)
Joint stiffness, n (%)		
Yes	7105 (64.6)	3200 (82.3)
No	3892 (35.4)	687 (17.7)
Lack of knee/hip confidence, n (%)[e]		
Not at all	706 (7.7)	451 (13.8)
Mildly	2229 (24.3)	919 (28.0)
Moderately	3081 (33.6)	1084 (33.1)
Severely	2798 (30.5)	730 (22.3)
Extremely	366 (4.0)	95 (2.9)

Table continues on page 89.

CORRIGENDUM

TABLE 1 Participant Characteristics[a] (continued)

	Knee Osteoarthritis (n = 11013)	Hip Osteoarthritis (n = 3889)
Number of painful body sites, n (%)[f]		
0	161 (3.1)	42 (2.3)
1	362 (7.0)	98 (5.4)
2	1950 (37.5)	559 (31.0)
3	494 (9.5)	222 (12.3)
4	862 (16.6)	309 (17.1)
5+	1376 (26.4)	576 (31.9)
UCLA activity scale, n (%)		
1-2 (physically inactive)	317 (3.5)	104 (3.2)
3-4 (low physical activity level)	2768 (30.1)	1000 (30.4)
5-6 (moderate physical activity level)	3817 (41.5)	1384 (42.1)
7-8 (high physical activity level)	1837 (20.0)	625 (19.0)
9-10 (very high physical activity level)	460 (5.0)	172 (5.2)
SF-12 mental component summary	52.6 ± 9.7	51.7 ± 9.9
ASES pain subscale	66.1 ± 20.1	62.6 ± 20.5

Abbreviations: ASES, Arthritis Self-Efficacy Scale; BMI, body mass index; NRS, numeric rating scale; SF-12, Medical Outcomes Study 12-Item Short-Form Health Survey; UCLA, University of California, Los Angeles.

[a]*Values are mean ± SD unless otherwise indicated. Missing values: age, n = 7; BMI, n = 89; symptom duration, n = 12; number of chair stands in 30 seconds, n = 1; educational level, n = 2436; fear of movement, n = 2435; joint stiffness and limited range of motion, n = 18; lack of knee/hip confidence, n = 2443; UCLA activity scale, n = 2418; SF-12 mental component summary, n = 2434; ASES pain subscale, n = 2421.*

[b]*Values are median (interquartile range).*

[c]*Defined as at least 1 of the following medications: paracetamol, oral or topical nonsteroidal anti-inflammatory drug, morphine, or other opioid.*

[d]*Short-term education, under 3 years after secondary school; middle-term education, 3 to 4 years after secondary school; long-term education, at least 5 years after secondary school.*

[e]*Derived from item Q3 of the Hip disability and Osteoarthritis Outcome Score and the Knee injury and Osteoarthritis Outcome Score.*

[f]*Missing values, n = 7891 (knee osteoarthritis, 5808; hip osteoarthritis, 2083). Of the 5808 missing values for knee osteoarthritis, 932 represented nonresponders to the patient questionnaire and 4876 were due to technical problems in the data collection of the variable. Of the 2083 missing values or hip osteoarthritis, 312 represented nonresponders to the patient questionnaire and 1771 were due to technical problems in the data collection of the variable.*