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American Physical Therapy Association Clinical Practice Guideline Implementation for Neck and Low Back Pain in Outpatient Physical Therapy: A Nonrandomized, Cross-sectional Stepped-Wedge Pilot Study

Neck pain and low back pain (LBP) are leading causes of disability.[23] Nonpharmacological interventions are recommended as first-line treatments for musculoskeletal pain conditions.[17,31,44] Physical therapists are well positioned to help individuals experiencing neck pain and LBP; however, unwarranted variation in clinical practice is a barrier to demonstrating the value of physical therapy when communicating with important stakeholders (eg, patients, payers, policy makers).[34] Extensive variability in clinical decision making makes it difficult to identify patient characteristics associated with a positive or negative treatment response; therefore, a certain degree of clinical practice standardization is needed.

OBJECTIVE: To determine whether a multifaceted implementation strategy for American Physical Therapy Association neck and low back pain clinical practice guidelines (CPGs) was associated with changes in clinician and patient outcomes.

DESIGN: Cross-sectional stepped-wedge pilot study.

METHODS: Physical therapy clinics (n = 9) were allocated to 1 of 4 clusters that varied by CPG implementation timing. Clinics crossed over from usual care (control) to CPG implementation (intervention) every 8 weeks and ended with a 24-week follow-up period. Implementation outcomes were measured at the clinician (perspectives and behaviors) and patient (pain and disability outcomes) levels. Descriptive statistics were used to summarize clinician perspectives and behaviors. Generalized linear mixed models were used to analyze patient-level outcomes data (pain and disability) and total number of physical therapy visits.

RESULTS: Improvements in several clinician perspectives about CPGs were observed 8 weeks after training and sustained at 16 weeks ($P<.05$), although it is unclear whether these changes were meaningful. Training on CPGs was relevant to physical therapists and more acceptable at 16 weeks ($P<.05$). In a random sample (n = 764/1994, 38.3%), the overall rate of CPG classification was 65.0% (n = 497/764), and CPG intervention concordance was 71.2% (n = 354/497). Implementation of a CPG was not associated with final pain and disability scores ($P>.05$) but was associated with an approximate increase of 8% in total visits.

CONCLUSION: Our multifaceted implementation strategy was associated with statistical changes in clinician perspectives and behaviors, but not in patient outcomes. *J Orthop Sports Phys Ther 2022;52(2):113-123. doi:10.2519/jospt.2022.10545*

KEY WORDS: *attitudes, beliefs, clinical practice guidelines, implementation, physical therapy, professional behaviors*

American Physical Therapy Association (APTA) clinical practice guidelines (CPGs) for neck pain (revised in 2017)[9] and LBP (published in 2012 and revised in 2021)[16,25] were developed to describe evidence-based practice, classify common conditions, and identify appropriate interventions and outcome measures. The APTA CPGs are a resource to limit unwarranted variation in clinical practice. However, many physical therapists do not follow guidelines for managing musculoskeletal pain.[57]

Clinical practice is complex and challenging.[39,51] Lack of time,[15,36,52] interpretation,[52] confidence,[51] disagreement,[52] inadequate facilitation,[15,36] and organizational constraints[36] are barriers to suc-

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cessfully implementing CPGs. Therefore, implementation study reporting standards include both primary (associated with implementation strategy, eg, clinician process or quality measures) and secondary (associated with the treatment provided, eg, patient health measures) outcomes.[42,43]

Implementation strategy selection is one important component to addressing many factors associated with CPG implementation. However, recommendations are often specific to outcomes of interest (eg, professional behaviors, patient outcomes). Multifaceted implementation strategies are required to improve CPG adherence,[58] as well as increased implementation intervention frequency and duration.[35] Others suggest that multifaceted implementation strategies are not effective for improving patient outcomes and inconsistent for professional behavior outcomes.[1,50] Collectively, identifying an optimal implementation strategy is a dilemma requiring assessment of clinician- and patient-level outcomes prior to larger-scale, system-level initiatives.

The purpose of this pilot study was to determine whether a multifaceted implementation intervention strategy for neck pain and LBP CPGs was associated with (1) physical therapist perspectives, (2) physical therapist behaviors, and (3) patient outcomes.

METHODS

The methods are described according to the Standards for Reporting Implementation Studies (StaRI) statement.[42,43]

Design

This pilot study incorporated a nonrandomized, cross-sectional stepped-wedge design.[2,28] Nine physical therapy clinics were allocated to 1 of 4 clusters that varied by CPG implementation timing (**FIGURE 1**). Sequential participation was identified by outpatient leadership, based on feasibility. This study included 6 observation periods over 68 weeks, with the initial 12 weeks (T0) serving as a baseline washout phase. Clinics crossed over from usual care (control) to CPG implementation (intervention) every 8 weeks (T1-T4) and ended with a 24-week follow-up period (T5).

Context

During project planning, we consulted 2 patient partners for their general perspective about the planned study.[5] Both agreed that incorporating CPGs into physical therapy clinical practice was a good strategy to limit unwarranted variability in care and potentially even improve communication between patients and clinicians. We also identified barriers to CPG implementation using the Consolidated Framework for Implementation Research model.[14] We focused on 4 Consolidated Framework for Implementation Research constructs (inner setting, characteristics of individuals, characteristics of intervention, and implementation process). During workshops, clinicians also identified perceived barriers to and facilitators of CPG implementation during clinical practice.

Participants and Settings

Participants and Settings Targeted by Implementation Strategy Ten outpatient physical therapy clinics, part of a single health system in Jacksonville, FL, were invited to participate. Clinics were eligible if (1) over 50% of the caseload consisted of orthopaedic diagnoses, and (2) clinicians were able to attend a 2-hour training workshop.

Participants and Settings Targeted by CPGs Target patient populations were those receiving outpatient physical therapy for neck pain or LBP. Inclusion criteria were (1) aged 18 years or older, and (2) able to read and comprehend the English language (necessary for completion of self-report e-forms). Exclusion criteria were (1) any diagnosis indicating systemic involvement, (2) widespread chronic pain, and (3) neurological disorders.

Ethics Approval

This study was approved for a waiver of documentation of informed consent (for clinician data) and for a full waiver of informed consent (for patient retrospective outcome data) by the University of Florida Gainesville Health Science Center Institutional Review Board (IRB-01), and was registered at www.ClinicalTrials.gov (NCT03523793) on May 14, 2018.

Protocol Deviations

After trial registration, we made the following changes. (1) The primary and secondary outcomes were reversed to be consistent with StaRI statement recommendations,[42,43] such that we report physical therapist–level (primary) and patient-level (secondary) outcomes. (2) We only included Evidence-Based Practice Questionnaire (EBPQ)[29] items relevant to clinician behaviors pertaining to CPGs (eg, use in practice, ability to incorporate patient preferences); nonincluded items assessed other general aspects of evidence-based practice. (3) We included 8 additional questions developed for this study to further inform findings relevant to physical therapist perspectives, as the EBPQ items did not assess other potentially relevant domains (eg, personal viewpoint, confidence in applying recommendations). (4) We did not report patient satisfaction outcomes due to bar-

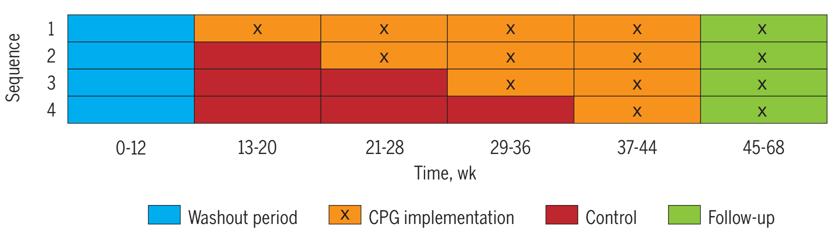

FIGURE 1. Cross-sectional stepped-wedge design, with 9 physical therapy clinics being allocated to 1 of 4 sequences that differ in CPG implementation timing. Abbreviation: CPG, clinical practice guideline.

riers linking these data to our internal outcomes-collection system.

Multifaceted Implementation Strategy

The implementation strategy consisted of several components guided by the Cochrane Effective Practice and Organisation of Care classification system,[18,19] summarized in **TABLE 1** and described in detail below.

Clinicians were required to attend a 2-hour training workshop. Four separate workshops were provided (1 for each cluster) before transitioning to implementation phases. Clinicians were asked to review neck pain and LBP CPGs[9,16] and several questions about perceived barriers to and facilitators of CPG implementation. To be consistent with statements of intent, we emphasized that CPGs were not intended to serve as standards of care and that available clinical data needed to be considered for individual patients to inform clinical decision making.[9,16]

Implementation tools promote CPG uptake and are associated with increased adherence[20]; therefore, single-page decision trees consisting of CPG core components were provided. The LBP decision tree was developed for this study and replicated neck pain decision tree formatting.[38] "Perspectives for Patients"[32,37] were disseminated to educate patients and family members about physical therapy. Next, we used fishbone diagrams to identify clinician-perceived implementation barriers that may be targets for implementation interventions (**FIGURE 2**). Finally, electronic medical record (EMR) documentation to assess CPG classification and intervention concordance was discussed, with acceptability and feasibility perspectives provided by clinicians. Following workshops, "communities of practice" calls were scheduled (30 minutes, every 2 weeks, shifting to every 4 weeks), with at least 1 clinician from each clinic present. Participants were asked to complete a questionnaire that was readministered 8 and 16 weeks after training. Participants received a $50 gift card for attending the workshop and completing the survey.

TABLE 1 MULTIFACETED IMPLEMENTATION INTERVENTIONS TARGETING PHYSICAL THERAPISTS[a]

Subcategory	Implementation Intervention Description
Audit and feedback	EMR audits • CPG classification rates (initial and interim) • CPG intervention concordance (postimplementation analysis)
Monitoring treatment delivery	Communities of practice (indirectly) Clinical outcomes compared to outpatient division (directly)
Communities of practice	Routine conferences (30 minutes, every 2-4 weeks)
Continuous quality improvement	Modification of the classification documentation process Modification of treatment decision making associated with patients meeting multiple classification criteria
Education materials	CPG decision trees Perspectives for Patients, Perspectives for Practice
Education meetings	Training workshop (2 hours): provided for each cluster (n = 4)
CPGs	APTA CPG for neck pain APTA CPG for LBP
Local consensus process	Study protocol (outpatient leadership support) CPG implementation (participating clinicians)
Local opinion leaders	Guest speaker promotion of CPGs and PROMs (external) Clinician champion promotion of CPGs (internal)
Managerial supervision	Clinic manager support provided
Patient-mediated interventions	Patient partner perspectives (CPGs and PROMs)
Public release of performance data	Professional conferences, peer-reviewed journals (external) PROM data (internal)
Reminders	Routine e-mail reminders Communities of practice
Routine PROMs	NDI (for neck pain), ODI (for LBP), NPRS (for neck pain and LBP)
Tailored interventions	Not specifically implemented

Abbreviations: APTA, American Physical Therapy Association; CPG, clinical practice guideline; EMR, electronic medical record; LBP, low back pain; NDI, Neck Disability Index; NPRS, numeric pain-rating scale; ODI, Oswestry Disability Index; PROM, patient-reported outcome measure.
[a]Cochrane Effective Practice and Organisation of Care Review Group domain: implementation strategies; category: interventions targeted at health care workers.

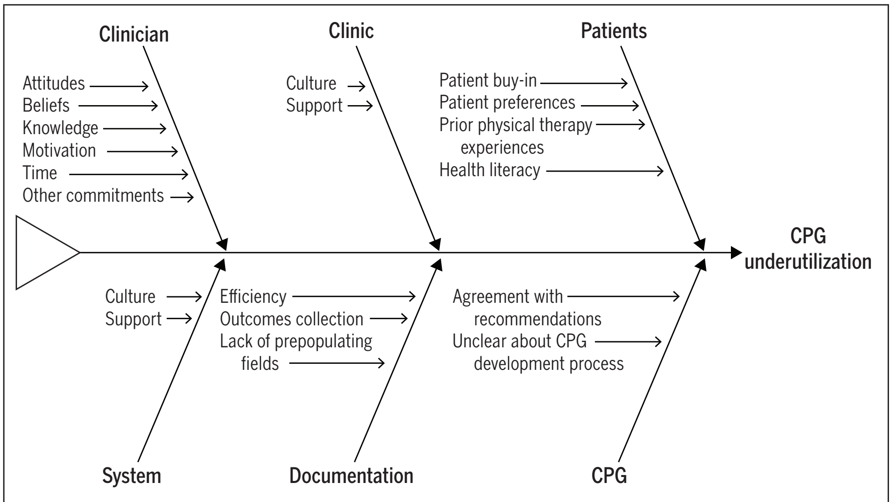

FIGURE 2. Summary of barriers that can lead to CPG underutilization, identified during 4 training sessions. Abbreviation: CPG, clinical practice guideline.

Outcomes

Implementation Strategy Outcomes (Physical Therapist Level) Clinicians' use of and access to CPGs were assessed using 4 items from the EBPQ.[29] Acceptable test-retest reliability and good content validity have been reported for a modified version of the EBPQ,[6] similar to that used in this study. Clinician perspectives about CPGs were assessed using an 8-item questionnaire, developed for this study, that has not yet been psychometrically tested (supplemental file, available at www.jospt.org). Items associated with CPG awareness; clinician viewpoint, confidence, and knowledge; and clinical outcome impact were measured using a 0-to-10 scale (with higher ratings indicating greater levels in the domain assessed) that was administered before training and 8 and 16 weeks later. Previous studies have used similar methods to assess training program impact on physical therapist–reported confidence.[4] Items associated with CPG training relevance, training acceptability, and frequency of CPG application during clinical practice were measured using a similar 0-to-10 scale that was administered 8 and 16 weeks after training.

Clinician behaviors were assessed through EMR audits. Documentation was reviewed and compared to CPG decision trees to assess how patients were initially classified and whether they received a matched intervention. We used a computer-generated random sample of neck pain and LBP cases across the T1 to T5 observation periods to assess initial CPG classification. All initially classified cases were then assessed for neck pain and LBP CPG intervention concordance, categorized as "nonconcordant" (not providing any recommended interventions), "partially concordant" (providing 1 recommended intervention), or "concordant" (providing 2 or more recommended interventions). Previous studies have used similar methodology to assess guideline concordance.[49]

CPG Intervention Outcomes (Patient Level) Secondary outcomes consisted of patient-reported outcome measures, assessed at intake and every 2 weeks until discharge using portable, touchscreen tablets. Pain intensity was assessed for all patients using the numeric pain-rating scale (NPRS), which has sound psychometric properties and a minimal clinically important difference (MCID) of approximately 2 points for patients with neck pain and LBP.[12,56] Neck disability was assessed using the Neck Disability Index (NDI), which has sound psychometric properties[10,33] and an MCID of between 10 and 17 percentage points.[55,56] Low back pain disability was assessed using the Oswestry Disability Index (ODI), which has sound psychometric properties[11,22] and an MCID of 10 percentage points.[40] The total number of physical therapy visits over the episode of care was also assessed. Patients with fewer than 3 visits were excluded from analyses, as there was inadequate time to initiate and progress plans of care.[21]

Analysis

Implementation Strategy Outcomes (Physical Therapist Level) Distributions of EBPQ and clinician questionnaire responses were examined by inspecting histograms and computing skewness, kurtosis, and Shapiro-Wilk test statistics. Nonparametric alternatives (the Wilcoxon signed-rank test) were used to compare pretraining, 8-week, and 16-week results if a significant deviation from normal distribution was detected. Cronbach's alpha was used to evaluate internal consistency for the 8-item questionnaire (5 items before training: awareness, viewpoint, confidence, knowledge, and outcome impact, with the addition of 3 items at 8 and 16 weeks after training: relevance, acceptability, and applicability). Values were interpreted as fair (.70-.79), good (.80-.89), or excellent (.90 or greater) internal consistency.[13]

Descriptive statistics were used to summarize behaviors (CPG classification and intervention documentation). The kappa statistic was used to test intervention concordance, auditing for interrater reliability using previous recommended guidelines (ie, values less than 0.00 were labeled as no agreement, 0.00-0.20 as slight agreement, 0.21-0.40 as fair agreement, 0.41-0.60 as moderate agreement, 0.61-0.80 as substantial agreement, and 0.81-1.00 as almost perfect agreement).[30] Prevalence- and bias-adjusted kappa (PABAK) was also calculated for interrater reliability when data were categorized using an ordinal scale.[53]

CPG Intervention Outcomes (Patient Level) Descriptive statistics were used to characterize baseline and final outcome measure scores across clusters and with respect to implementation phases of study. For each final outcome measure score (NPRS, NDI, ODI), individual patient-level data were analyzed using a generalized linear mixed model, controlling for baseline outcome measure scores and CPG implementation timing as fixed effects and using a random intercept for clinic site to account for variation. For the NPRS model, we included 2 comparisons (combined neck pain and LBP cases versus LBP cases alone and neck pain versus LBP cases) as additional fixed effects to account for variation between body regions.

We included a combined disability model, using final NDI and ODI z scores as the dependent variable, because standardizing and combining these scores would provide increased power to the model with increased sample size. For visit models, we used similar modeling approaches as those for the NPRS, NDI, and ODI, but included total number of physical therapy visits as the dependent variable. Corresponding 95% confidence intervals (CIs) were calculated for each regression coefficient.

RESULTS

Implementation Strategy Outcomes (Physical Therapist Level)

Nine of the 10 identified clinics (28 physical therapists) participated in this study. Four separate training workshops (1 for each cluster) were provided at the beginning of each observation period, with 27 physical therapists (63% female; 6.5 ± 3.5 years in practice) responding to questionnaires.

Clinician perspectives about CPGs, training, and application frequency are described in **TABLE 2**. Improvements in actively seeking CPGs, using CPGs in practice, and the ability to incorporate patient preferences were observed at 8 weeks and sustained at 16 weeks (**TABLE 2**). Improvements in items pertaining to awareness, viewpoint, confidence, and knowledge about CPGs were also observed at 8 weeks and at 16 weeks (**TABLE 2**). Self-perceived impact on patient outcomes remained stable at 8 and 16 weeks (**TABLE 2**). Training on CPGs was relevant and more acceptable at 16 weeks (**TABLE 2**). Items pertaining to awareness, viewpoint, confidence, knowledge, and outcome impact had fair to good internal consistency when assessed before training (α = .72) and when combined with items pertaining to relevance, acceptability, and applicability 8 and 16 weeks after training (α = .79-.80).

Based on a random sample (n = 764/1994, 38.3%) across the T1 to T5 observation periods, CPG classification by physical therapists was 65.0% (n = 497/764), with between-cluster rates ranging from 56.4% to 68.2%. Of those cases initially classified (n = 497), CPG intervention concordance was 71.2% (n = 354/497) (partially concordant: n = 72/497, 14.5%; nonconcordant: n = 71/497, 14.3%), with between-cluster concordance rates ranging from 57.4% to 80.8%. Reliability testing of intervention concordance auditing in a random sample of classified cases (n = 45) indicated substantial (κ = 0.78; 95% CI: 0.60, 0.96; P<.001) to almost perfect (PABAK = 0.83; 95% CI: 0.69, 0.97; P<.001) agreement between 2 raters.

CPG Intervention Outcomes (Patient Level)

The final sample consisted of data from 1441 patients, resulting in 1480 cases based on body region (neck pain, n = 457; LBP, n = 944; combined neck pain and LBP, n = 79). Complete cases were those with baseline and follow-up outcome data for the NPRS (n = 1116), NDI (n = 503), and ODI (n = 987). There were no differences in baseline NDI (P = .281) or ODI (P = .919) scores between those with and without follow-up outcome data. Those with follow-up data had slightly lower baseline NPRS scores compared to those without follow-up data (4.08 ± 2.07 versus 4.43 ± 2.28, P<.001).

Patient outcome measure scores across clusters and with respect to implementation are provided in **TABLE 3**. We observed a greater number of clusters achieving the MCID for the NPRS, NDI, and ODI outcomes during implementation (n = 6) when compared to preimplementation (n = 2); however, none of the 95% CI lower bounds included MCID values. Generalized linear mixed model analyses indicated that baseline scores were the only predictors associated with final outcome scores for the NPRS, NDI, and ODI models (**TABLE 4**). The timing of CPG implementation was not associated with final outcome scores in any model. Clinic effects were observed in the NPRS and combined NDI and ODI z score models (with a trend observed in the ODI model), indicating significant variation in final outcome scores across clinics.

Physical therapy visits across clusters and with respect to implementation are provided in **TABLE 5**. Outcome measure scores at baseline, CPG implementation timing, and random clinic effects were associated with number of visits for neck pain and LBP, neck pain, and LBP models (**TABLE 6**). After adjusting for other variables, the number of visits increased between 7% and 8% after CPG implementation (visits based on NPRS: β = 0.08, NDI: β = 0.08, and ODI: β = 0.07 scores).

DISCUSSION

We aimed to determine whether a multifaceted implementation strategy for neck pain and

TABLE 2 Physical Therapist Survey Responses (n = 27)

	Pretraining	8 wk	16 wk
EBPQ items[a]			
CPG availability for topics related to practice (yes), n (%)	26 (96.3)	27 (100)	27 (100)
Actively seek CPGs pertaining to practice (agree), n (%)	17 (63.0)	22 (81.5)[b]	24 (88.9)
Use CPGs in practice (agree), n (%)	20 (74.1)	26 (96.3)[b]	27 (100)
Able to incorporate patient preferences with CPGs (agree), n (%)	21 (77.8)	26 (96.3)[b]	26 (96.3)
Additional items[c]			
Awareness	8.0 (7.0-9.2)	10.0 (9.2-10.0)[b]	10.0 (9.2-10.0)
Viewpoint	8.0 (7.0-9.0)	9.0 (8.0-10.0)[b]	8.0 (8.0-10.0)
Confidence	8.0 (6.0-9.2)	9.0 (8.0-10.0)[b]	9.0 (8.2-10.0)[b]
Knowledge	6.5 (5.0-8.0)	8.0 (7.0-10.0)[b]	9.0 (8.0-10.0)
Outcome impact	8.0 (7.0-8.2)	8.0 (7.0-10.0)	8.0 (7.0-9.0)
Relevance (training)	NA	10.0 (9.0-10.0)	10.0 (9.2-10.0)[b]
Acceptability (training)	NA	8.0 (7.0-10.0)	10.0 (9.0-10.0)[b]
Application (frequency)	NA	9.0 (8.0-10.0)	9.5 (8.0-10.0)

Abbreviations: CPG, clinical practice guideline; EBPQ, Evidence-Based Practice Questionnaire; NA, not available.
[a]Items 15, 16, 17, and 20.
[b]Wilcoxon signed-rank test (P<.05).
[c]Additional questions were rated using a 0-to-10 scale, with higher ratings indicating greater levels of the construct assessed. Values are median (interquartile range).

LBP CPGs was associated with changes in (1) physical therapist perspectives, (2) physical therapist behaviors, and (3) patient outcomes. We observed positive changes in several clinician perspectives about CPGs at 8 weeks and 16 weeks following training. However, because the measurement properties of several items used to assess clinician perspectives are unknown, we are uncertain that these changes were meaningful. The implementation strategy was associated with positive behaviors, including CPG classification documentation and recommended intervention concordance.

Unfortunately, implementing CPGs was not associated with improved patient outcomes, but it was associated with an

TABLE 3 CLINICAL OUTCOME SCORES WITH RESPECT TO CLINICAL PRACTICE GUIDELINE IMPLEMENTATION[a]

	Preimplementation[b]				Implementation[c]			
	n	Initial	Final	Mean Difference	n	Initial	Final	Mean Difference
NPRS								
Cluster 1	44	3.9 (3.2, 4.7)	2.5 (1.9, 3.2)	1.4 (0.8, 2.0)	385	4.2 (4.0, 4.4)	2.9 (2.6, 3.1)	1.4 (1.2, 1.6)
Cluster 2	49	4.0 (3.5, 4.6)	2.7 (2.2, 3.2)	1.3 (0.9, 1.7)	148	4.3 (4.0, 4.7)	2.2 (1.9, 2.5)	2.1 (1.8, 2.4)[d]
Cluster 3	110	3.6 (3.3, 4.0)	2.3 (1.9, 2.6)	1.3 (1.0, 1.7)	250	3.9 (3.7, 4.2)	2.4 (2.2, 2.7)	1.5 (1.2, 1.8)
Cluster 4	78	4.0 (3.6, 4.5)	3.3 (2.8, 3.9)	0.7 (0.3, 1.1)	52	4.1 (3.5, 4.7)	3.2 (2.6, 3.9)	0.8 (0.4, 1.3)
NDI								
Cluster 1	21	26.0 (19.9, 32.0)	16.3 (11.1, 21.4)	9.7 (3.4, 16.0)	141	34.9 (32.1, 37.8)	24.7 (21.7, 27.7)	10.2 (7.9, 12.5)[d]
Cluster 2	31	34.9 (30.1, 39.7)	23.8 (18.3, 29.3)	11.1 (7.4, 14.8)[d]	77	33.1 (29.4, 36.9)	20.3 (16.4, 24.1)	12.8 (9.6, 16.1)[d]
Cluster 3	49	29.3 (25.3, 33.4)	20.3 (16.2, 24.3)	9.0 (5.5, 12.6)	108	30.9 (28.0, 33.9)	20.0 (17.2, 22.8)	10.9 (8.1, 13.8)[d]
Cluster 4	36	36.8 (32.0, 41.6)	28.0 (22.2, 33.8)	8.8 (4.1, 13.5)	40	32.9 (28.4, 37.5)	24.0 (20.0, 28.0)	8.9 (5.1, 12.7)
ODI								
Cluster 1	32	33.1 (27.6, 38.7)	22.5 (16.2, 28.7)	10.6 (6.5, 14.7)[d]	302	33.7 (31.9, 35.6)	23.8 (21.7, 25.8)	10.0 (8.2, 11.7)[d]
Cluster 2	45	33.0 (27.5, 38.5)	23.7 (18.7, 28.8)	9.3 (5.7, 12.9)	158	36.0 (33.3, 38.7)	25.6 (22.8, 28.4)	10.4 (8.2, 12.6)[d]
Cluster 3	88	26.2 (22.9, 29.5)	16.8 (13.8, 19.7)	9.4 (6.9, 12.0)	231	29.5 (27.6, 31.4)	20.2 (18.1, 22.2)	9.4 (7.8, 10.9)
Cluster 4	61	34.4 (29.9, 39.0)	27.4 (23.1, 31.6)	7.1 (4.1, 10.1)	70	36.1 (32.5, 39.7)	26.4 (22.3, 30.6)	9.7 (6.4, 12.9)

Abbreviations: NDI, Neck Disability Index; NPRS, numeric pain-rating scale; ODI, Oswestry Disability Index.
[a]*Values are mean (95% confidence interval) unless otherwise indicated.*
[b]*Time points in relation to the stepped-wedge study design: cluster 1, weeks 0 to 12 (washout period); cluster 2, weeks 0 to 20; cluster 3, weeks 0 to 28; cluster 4, weeks 0 to 36.*
[c]*Time points in relation to the stepped-wedge study design: cluster 1, weeks 13 to 68; cluster 2, weeks 21 to 68; cluster 3, weeks 29 to 68; cluster 4, weeks 37 to 68.*
[d]*Exceeded the minimal clinically important difference: NPRS, 2 points; NDI, 10-17 points; ODI, 10 points.*

TABLE 4 MODEL PERFORMANCE FOR PREDICTING FINAL CLINICAL OUTCOME SCORES

	NPRS (n = 1116)		NDI (n = 503)		ODI (n = 987)		NDI and ODI (n = 1490)	
	Coefficient[a]	*P* Value	Coefficient[a]	*P* Value	Coefficient[a]	*P* Value	Coefficient[a]	*P* Value
Intercept	0.75 (0.31, 1.15)	<.001	1.74 (–1.24, 5.11)	.286	0.56 (–2.06, 2.90)	.645	–0.48 (–0.59, –0.37)	<.001
Neck pain and LBP[b]	0.31 (–0.16, 0.79)	.200	...	...	...	...	...	...
Neck pain versus LBP[c]	–0.13 (–0.34, 0.10)	.237	...	...	...	...	...	...
Baseline score	0.51 (0.46, 0.56)	<.001	0.65 (0.57, 0.71)	<.001	0.69 (0.65, 0.75)	<.001	0.66 (0.62, 0.70)	<.001
CPG implementation	–0.18 (–0.42, 0.06)	.153	–0.92 (–3.28, 1.53)	.469	–0.17 (–2.22, 1.92)	.859	–0.03 (–0.12, 0.07)	.625
Random effect								
Clinic	0.35 (0.03, 0.57)	<.001	1.19 (0.00, 2.68)	.129	1.15 (0.00, 2.15)	.061	0.09 (0.02, 0.16)	.005
Residual	1.73 (1.66, 1.80)	...	12.47 (11.61, 13.26)	...	12.59 (12.01, 13.16)	...	0.87 (0.85, 0.91)	...

Abbreviations: CPG, clinical practice guideline; LBP, low back pain; NDI, Neck Disability Index; NPRS, numeric pain-rating scale; ODI, Oswestry Disability Index.
[a]*Values in parentheses are 95% confidence interval.*
[b]*Neck pain and LBP cases versus LBP-only cases.*
[c]*Neck pain cases versus LBP cases.*

increased number of total visits over an episode of care. Objective assessment of preimplementation behaviors was not feasible, as EMR documentation was not standardized prior to the study. Therefore, it was difficult to determine whether lack of patient outcome improvement was associated with lack of implementation strategy effectiveness or lack of CPG effectiveness, or resulted because clinicians did not change earlier treatment patterns. These are important findings because this was the first study to implement APTA CPGs for neck pain and LBP, while also separately assessing relationships with physical therapist– and patient-level outcomes.

Physical Therapist Perspectives and Behaviors

We observed improvements in the proportion of clinicians actively seeking CPGs, using CPGs in practice, and incorporating patient preferences with CPGs at 8 weeks and at 16 weeks. We observed similar improvements in awareness, viewpoint, confidence, and knowledge about CPGs. These findings suggest that education initiatives focusing on CPG implementation are needed and should be tailored to clinicians practicing in busy outpatient settings. Clinicians did not believe that CPG implementation would have greater positive impact on clinical outcomes, and we speculate that clinicians may have already been using evidence-based interventions, even if they were not specifically following published CPGs. Our findings are consistent with prior research that found multifaceted implementation interventions to be

TABLE 5 TOTAL NUMBER OF PHYSICAL THERAPY VISITS WITH RESPECT TO CLINICAL PRACTICE GUIDELINE IMPLEMENTATION

	Preimplementation[a]		Implementation[b]	
	n	Visits, n[c]	n	Visits, n[c]
Neck pain/LBP[d]				
Cluster 1	44	10.3 ± 5.2	385	13.1 ± 7.9
Cluster 2	49	10.5 ± 4.1	148	12.1 ± 4.9
Cluster 3	110	9.6 ± 4.6	250	10.5 ± 5.8
Cluster 4	78	13.3 ± 6.6	52	12.2 ± 7.5
Neck pain				
Cluster 1	21	9.3 ± 4.4	141	11.6 ± 6.5
Cluster 2	31	11.3 ± 5.9	77	12.0 ± 5.5
Cluster 3	49	9.6 ± 4.6	108	11.4 ± 5.9
Cluster 4	36	12.9 ± 5.6	40	12.2 ± 6.7
LBP				
Cluster 1	32	11.0 ± 4.9	302	13.3 ± 8.4
Cluster 2	45	10.6 ± 4.3	158	13.4 ± 6.6
Cluster 3	88	9.9 ± 5.5	231	10.8 ± 5.5
Cluster 4	61	13.3 ± 7.2	70	12.3 ± 7.0

Abbreviation: LBP, low back pain.
[a]*Time points in relation to the stepped-wedge study design: cluster 1, weeks 0 to 12 (washout period); cluster 2, weeks 0 to 20; cluster 3, weeks 0 to 28; cluster 4, weeks 0 to 36.*
[b]*Time points in relation to the stepped-wedge study design: cluster 1, weeks 13 to 68; cluster 2, weeks 21 to 68; cluster 3, weeks 29 to 68; cluster 4, weeks 37 to 68.*
[c]*Values are mean ± SD.*
[d]*Values were generated from cases providing numeric pain-rating scale data.*

TABLE 6 MODEL PERFORMANCE FOR PREDICTING TOTAL PHYSICAL THERAPY VISITS

	Neck Pain/LBP (n = 1116)[a]		Neck Pain (n = 503)		LBP (n = 987)	
	Coefficient[b]	*P* Value	Coefficient[b]	*P* Value	Coefficient[b]	*P* Value
Intercept	2.33 (2.24, 2.42)	<.001	2.09 (2.00, 2.17)	<.001	2.29 (2.20, 2.38)	<.001
Neck pain and LBP[c]	0.13 (0.05, 0.20)	<.001	...	...	...	...
Neck pain versus LBP[d]	−0.07 (−0.11, −0.02)	<.001	...	...	...	...
Baseline outcome score[e]	0.02 (0.01, 0.03)	<.001	0.008 (0.007, 0.010)	<.001	0.004 (0.003, 0.006)	<.001
CPG implementation	0.08 (0.03, 0.12)	<.001	0.08 (0.02, 0.14)	.008	0.07 (0.02, 0.12)	.002
Random effect						
Clinic	0.11 (0.04, 0.15)	<.001	0.07 (0.02, 0.10)	<.001	0.12 (0.05, 0.17)	<.001

Abbreviations: CPG, clinical practice guideline; LBP, low back pain.
[a]*Values were generated from cases providing numeric pain-rating scale data.*
[b]*Values in parentheses are 95% confidence interval.*
[c]*Neck pain and LBP cases versus LBP-only cases.*
[d]*Neck pain cases versus LBP cases.*
[e]*For neck pain/LBP (numeric pain-rating scale), neck pain (Neck Disability Index), and LBP (Oswestry Disability Index).*

associated with positive effects on CPG awareness, knowledge, access, and utilization, but not with clinician attitudes about CPGs.[7] Future studies should incorporate validated implementation outcome measures[54] and qualitative assessments to distinguish between clinician attitudes, beliefs, and behaviors.

The CPG classification rate was 65.0%. Clinicians provided concordant care for 71.2% of patients, which supports our multifaceted implementation strategy. Clinical practice guideline classification documentation has not been reported as a behavioral outcome for neck pain or LBP samples, which was a novel method used in this study and should be considered in future studies. Adherence to CPGs is not commonly assessed through clinical note auditing, and other common methods (eg, claims data and clinician questionnaires) have limitations.[27,58] Interventions based on strength of recommendation may be more relevant to assessing concordant care than was the number of recommended interventions provided, as we reported. Therefore, we suggest incorporating grades of evidence when operationally defining adherence in future CPG implementation studies.

Patient Outcomes

Our multifaceted strategy was not associated with improvements in patient outcomes. Clinical practice guideline implementation did not contribute to variability in final NPRS, NDI, or ODI scores in predictive models. Baseline outcome scores were the only consistent predictor in all models, which is consistent with previous findings.[3,24,41] Our results are also consistent with recent findings indicating that knowledge translation strategies to increase CPG uptake are generally not effective for improving patient outcomes.[1] Therefore, it is important that future studies aim to understand whether and how implementing CPGs in physical therapy leads to better patient outcomes.

We did not assess statistical interaction effects between intervention concordance and clinical outcomes, based on our sampling methods. This area is worthy of further study. Clinical practice guideline intervention concordance was 71.2% (with between-cluster rates ranging from 57.4% to 80.8%); this variability may have influenced patient outcomes. Greater LBP CPG adherence is associated with functional improvement, but relationships between care processes and patient outcomes require more comprehensive indicators.[45] Collectively, our findings reinforce the need for tailoring implementation interventions to match not only barriers identified within the health system, but also those within individual clinics.[26,47]

Implementation Strategy

We used a multifaceted implementation strategy based on previous literature[35] and incorporated interventions recommended by the Cochrane Effective Practice and Organisation of Care Review Group,[18,19] while also realizing that effectiveness for changing behaviors is contested.[46] Recent physical therapy systematic reviews support a multifaceted implementation strategy to improve CPG uptake and adherence.[47,58] However, recommendations for improving patient outcomes are unclear.[1,8,50] We incorporated decision trees as reference tools; however, they were not intended to promote a linear clinical decision-making process, and this was emphasized during training. Clinicians indicated decision trees to be valuable resources to help understand CPGs and inform decision making, but specific clinical decision making was not assessed and is worthy of future investigation. Future studies incorporating more sophisticated statistical analyses to assess direct and indirect pathways between changes in physical therapist beliefs, physical therapist behaviors, and patient outcomes would illuminate potential mechanisms for implementing CPGs.

Key Strengths

We studied data from a large sample generated from a single health system, and used EMR note auditing to assess CPG classification and matched interventions. Our random sampling methods may limit external validity, although intervention assessment by EMR documentation auditing is uncommon in studies evaluating CPG implementation, and common survey methods have increased risk of recall and performance bias.[58] We incorporated routine "communities of practice" for continued engagement and as a component of an iterative implementation process. Clinicians shared testimonials, sought feedback about ongoing barriers, and described clinic strategies. For example, regarding clinical decision making for patients fitting more than 1 classification, the consensus was to incorporate clinical experience when prioritizing treatment, as CPGs are intended to guide (not dictate) clinical practice.

Key Limitations

Lack of randomization introduces bias,[48] including baseline confounding (prognostic factors were not assessed), selection of clinics (combined with lack of detailed prestudy behaviors and practice patterns), and classification of interventions, which may have influenced our results. Clinical practice guideline classification documentation was not standardized prior to training. Therefore, pretraining CPG treatment concordance could not be assessed. Clinician perspectives were assessed using a questionnaire we developed specifically for this study. The measurement properties (reliability or validity) of the questionnaire are unknown; therefore, we could not assess meaningful change in beliefs over time. We do not recommend incorporating this measure in future studies until further psychometric testing is completed.

We incorporated decision trees as a single component of our multifaceted implementation strategy. However, we did not specifically assess how decision trees were implemented by each clinician. The LBP CPG was published in 2012,[16] and recommended practice patterns may have changed. We did not incorporate more sophisticated analyses to assess relationships between physical therapist perspectives, physical therapist behaviors, and patient outcomes (including cost-effectiveness) that may have further informed our findings.

We provided clinicians with gift cards to attend training sessions after clinic hours, which may have influenced motivation to participate. Finally, we only included cases with at least 3 visits, and final patient outcomes may not have reflected discharge status.

CONCLUSION

A multifaceted implementation strategy for neck pain and LBP CPGs was associated with positive physical therapist perspectives and behaviors, but not with improved patient outcomes. ◉

KEY POINTS

FINDINGS: A multifaceted implementation strategy for neck and low back pain clinical practice guidelines (CPGs) was associated with positive physical therapist perspectives and behaviors, but not with improved patient pain and disability outcomes.

IMPLICATIONS: Although the multifaceted implementation strategy was associated with beneficial physical therapist–level outcomes, future research must determine whether and how implementing CPGs in physical therapy improves outcomes for people with neck and low back pain.

CAUTION: Physical therapists were not routinely documenting CPG classification prior to training. Therefore, we could not assess pretraining CPG treatment concordance. Several questions used to assess physical therapist perspectives were developed for this study and have not been tested for reliability or validity.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Dr Beneciuk contributed to the acquisition of project funding, conception of the project, interpretation of data; drafted and revised the manuscript for important intellectual content; and is accountable for all aspects of the work. Dr Osborne and Michael B. Hagist contributed to the conception of the project and interpretation of data, revised the manuscript for important intellectual content, and gave final approval of the manuscript. Jane Crittenden contributed to the acquisition and interpretation of data and gave final approval of the manuscript. Katherine E. Buzzanca contributed to the analysis and interpretation of data and gave final approval of the manuscript. Hanzhi Gao contributed to the analysis and interpretation of data, drafted and revised the manuscript for important intellectual content, and gave final approval of the manuscript. Dr Wu contributed to the study design and the analysis and interpretation of data, and gave final approval of the manuscript.

DATA SHARING: All data relevant to the study are included in the article or are available in the supplemental file.

PATIENT AND PUBLIC INVOLVEMENT: During project planning, we consulted 2 patient partners for their general perspective about the planned study.

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EDITORIAL

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Mastering the Topic, the Message, and the Delivery: Leveraging the Social Marketing Mix to Better Implement Sports Injury Prevention Programs

The Implementation Problem

The real-world effectiveness of exercise-based injury prevention programs (IPPs) is hamstrung by inadequate implementation (adoption, adherence, maintenance).[2] To improve implementation, we propose leveraging social marketing principles to promote behavior change.[9] Social marketing is successful at tackling global health threats and social change, but its success in the sports injury risk-reduction context is largely unexplored.[6,9]

Social Marketing as a Possible Solution

Unlike commercial marketing efforts, which are traditionally motivated by organizational goals like financial gain, social marketing seeks to influence voluntary behaviors toward societal and individual change and well-being.[6] Voluntary behaviors include adopting, adhering to, and maintaining IPPs. Public health campaigns to reduce road accidents, promote physical activity, and increase vaccination rates[6,7] illustrate the success of social marketing in health contexts. Social marketing efforts were effective in increasing helmet use among cyclists in the United States.[8] To promote helmet use, attractive logos, slogans, and stickers were codesigned with the community and widely distributed. Cyclists and bicycle shop owners were recruited as peer ambassadors and incentivized to role play, endorse, and promote helmet usage. The social marketing effort doubled helmet use in 5 weeks.[8]

In 2013, Newton et al[9] challenged the sports injury prevention community to adopt social marketing principles to help disseminate and implement evidence-based practice. However, it was unclear how the community should take action. In this editorial, we share steps that researchers and sports administrators can take tomorrow to leverage social marketing—encouraging downstream consumers such as coaches, clinicians, parents, and athletes to implement IPPs.

SYNOPSIS: Social marketing is successful at tackling global health threats and social change but has not been fully explored in sports injury prevention contexts. The social marketing mix (product, price, place, and promotion) can help create exercise-based injury prevention programs with high-value propositions that will be relevant to their implementation (adoption, adherence, maintenance). To improve the real-world effectiveness of injury prevention programs, we share steps that researchers and sports administrators can take tomorrow to leverage the social marketing mix to encourage downstream consumers, such as coaches, clinicians, parents, and athletes, to implement injury prevention programs. *J Orthop Sports Phys Ther 2022;52(2):55-59. doi:10.2519/jospt.2022.10839*

KEY WORDS: *implementation science, injury risk reduction programs, interdisciplinary approach, neuromuscular warm-up*

Introducing the Social Marketing Mix (the "4 Ps")

The success of a social marketing campaign depends on creating, communicating, and delivering value through the 4 Ps: product, price, place, and promotion (**FIGURE 1**).[6]

It is essential to have a clear description of the product.[3,6] The core product describes the benefits that the target audience will experience in exchange for adopting the desired behavior (eg, performing an IPP reduces the risk of

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FIGURE 1. The "4 Ps" of the social marketing mix. Abbreviation: IPP, injury prevention program. Adapted with permission from Lee and Kotler.[6]

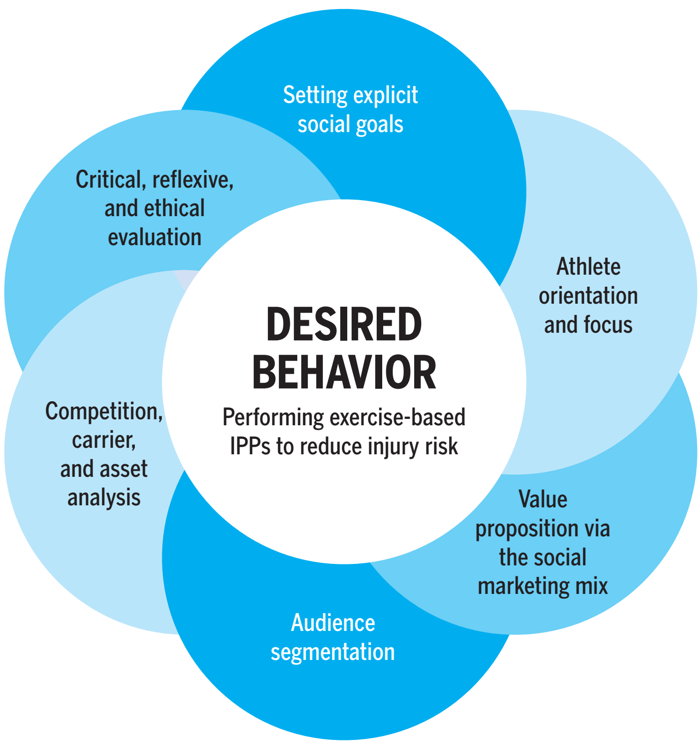

FIGURE 2. The social marketing mix, used to create a strong value proposition, is one of 6 core social marketing concepts. Abbreviation: IPP, injury prevention program. Adapted with permission from French and Gordon.[3]

injuries). The actual product describes its main tangible or intangible features (eg, tangible: exercises, sets, and repetitions; intangible: duration, ease of performance, risks). The augmented product describes any additional services that support the behavior change (eg, providing after-market services to integrate IPPs into specific requirements or providing free access to training resources).

Price refers to costs associated with adopting or not adopting the desired behavior that lead to its promised benefits.[6] A sensible pricing strategy should aim to minimize monetary and nonmonetary costs while maximizing benefits. Increasing costs of the competing behavior (eg, not performing IPPs or performing inadequate warm-ups) could also be considered.[4]

Place refers to where and when the target audience will be encouraged to perform the desired behavior and acquire the related products or services.[6] Because athletes do not usually acquire IPPs directly from researchers and developers but through intermediaries such as parents, coaches, and medical staff, these distribution channels can also alter the acquisition process of IPP-related products and services. An effective place strategy ensures the desired behavior is convenient and pleasant for the target audience to perform and acquire by enhancing accessibility and reducing barriers.

Promotion is the persuasive communication of product, price, and place information to inspire the target audience to engage in the desired behavior.[6] Effective promotion involves identifying key messages, selecting messengers and communication channels and media, constructing communication elements, and delivering the communications.

Applying the Social Marketing Mix

In the **TABLE**, we explain how to leverage product, price, place, and promotion strategies to improve exercise-based IPP implementation. To illustrate how these strategies can be applied to solve real-world problems, we link these strategies

TABLE	Potential Strategies Relating to the "4 Ps" of the Social Marketing Mix and How They Can Be Applied to Solve Real-World Problems

Component	Potential Strategies	How These Strategies Can Address FIFA 11+ Implementation Issues[a]
Product	Describe the core product • The primary benefits may include reduced injury rates, increased player availability, and greater individual performance[5] • The secondary benefits may include decreased health care costs, improved team performance, larger and stronger talent pools (especially for countries with smaller sporting populations), and greater sport participation	Improve • Player enjoyment and engagement • Link to sport-related goals
	Define the actual product • Identify similarities between exercise-based IPPs and traditional training components such as warm-up, cool-down, and fitness sessions instead of thinking of IPPs as an exclusive, additional, and time-consuming training component • Reassure coaches that skills required to deliver an IPP are similar to those employed when coaching on the field or in the weight room • Highlight that IPPs are not rigid and that IPP content and delivery can and should be tailored to each user's context. For example, rescheduling the most time-consuming component (part 2) of the FIFA 11+ program to the end of training or as a home exercise component of the program is effective and increases compliance[10]	Improve • Player enjoyment and engagement • IPP knowledge among stakeholders Reduce • Barriers due to lack of facilities/resources • Barriers due to lack of time at training
	Provide after-market support services for consumers • These support services could include personalized staff training sessions or assistance with individualizing IPPs to individual contexts. Services could be offered in a purchase (one-off) or subscription (monthly transactions) model, where consumers get access to a consultant from a local or state sporting organization	Improve • IPP knowledge among stakeholders • Player enjoyment and engagement • Link to sport-related goals Reduce • Barriers due to lack of facilities/resources • Barriers due to lack of leadership • Barriers due to lack of time at training
Price	Aim to offer IPPs with high returns on investment[4] • To lower costs, consider decreasing the time commitment of sessions/programs, offering IPP training or learning opportunities at minimal (or no) cost, the ability to perform IPPs with little (to no) specialized equipment or supervision, minimizing discomfort (eg, delayed-onset muscle soreness) following sessions or, if unavoidable, educating about side effects • To increase benefits, consider emphasizing the health, societal, and economic burdens of injuries; increasing the efficacy of IPPs on injury risk reduction and sport-specific performance; and offering incentives for teams to engage in IPPs (eg, sporting organizations could offer registration fee discounts for clubs that adopt and implement IPPs) • With reduced injury rates, sporting organizations may be able to explore possible savings from state or national insurance programs	Improve • IPP knowledge among stakeholders • Player enjoyment and engagement Reduce • Barriers due to lack of leadership
Place	Highlight that IPPs can be performed at a time or location suitable to the user's circumstances, with minimal equipment	Improve • IPP knowledge among stakeholders Reduce • Barriers due to lack of leadership • Barriers due to lack of facilities/resources • Barriers due to lack of time at training
	Make IPP information and equipment accessible and available at locations where IPPs are usually performed (eg, warm-up tracks, courts, gymnasiums)	Improve • IPP knowledge among stakeholders Reduce • Barriers due to lack of facilities/resources
	Consider the distribution channel (administrators, coaches, parents, performance staff, medical personnel, team managers) to improve the convenience and pleasantness of IPP acquisition by athletes	Improve • IPP knowledge among stakeholders Reduce • Barriers due to lack of leadership

Table continues on page 58.

to findings from a qualitative study that investigated coach- and administrator-related issues influencing the implementation of the FIFA 11+ IPP.[1]

Future Directions and Call to Action

Leveraging the social marketing mix to create a strong value proposition is one of 6 core social marketing concepts (**FIGURE 2**). To fully realize the potential of social marketing in the IPP implementation context, the sports injury prevention community should also consider[3,6]:

TABLE Potential Strategies Relating to the "4 Ps" of the Social Marketing Mix and How They Can Be Applied to Solve Real-World Problems (continued)

Component	Potential Strategies	How These Strategies Can Address FIFA 11+ Implementation Issues[a]
Promotion	Use concise and nontechnical language to describe the key messages of IPPs 1. What does the target audience need to do? 2. What are some key facts and information you want the target audience to know? 3. What do you want the target audience to believe or feel as a result of your key messages?	Improve • IPP knowledge among stakeholders
	Develop a creative strategy to translate the key messages to specific communications to capture the attention of the target audience and persuade them to implement IPPs. The creative strategy would apply to slogans, logos, typeface, copy, headlines, visuals, and colors in online and printed media and to scripts, models, scenes, and audio in broadcast media. Some tips: 1. Keep the focus simple, clear, and easy to remember 2. When using fear to highlight undesirable consequences (eg, https://roadsafety.transport.nsw.gov.au/campaigns/towards-zero/index.html), provide credible sources and solutions 3. Messages should be vivid, concrete, and personal to ensure attention and retention 4. Consider telling real stories about real people to improve credibility and likability 5. Leverage cognitive dissonance and the self-fulfilling prophecy effect in messaging. For example, "Have you looked after your knee today?" may encourage athletes to perform the targeted behavior, because not doing so may seem like they are neglecting their bodies. In comparison, asking, "Have you performed your knee IPP today?" might seem more like nagging	Improve • IPP knowledge among stakeholders • Player enjoyment and engagement Reduce • Barriers due to lack of leadership
	Consider objectives, budget, and timeline to select the most appropriate communication channels. Communication channels can range from mass media in the form of paid traditional broadcast media advertising, such as television commercials and newspaper advertisements, to target and persuade mass audiences quickly to more personal media, such as social networking sites and workshops, for a more intimate interaction that is sometimes required to promote IPP implementation	Improve • Player enjoyment and engagement • IPP knowledge among stakeholders Reduce • Barriers due to lack of leadership
	Communication channels should target the entire spectrum of upstream (national sporting organizations, team presidents, coaches, medical personnel, strength and conditioning coaches, sports trainers, physical education teachers) to downstream stakeholders (athletes, parents). Targeting upstream stakeholders would facilitate "pushing" IPPs to downstream consumers, and targeting downstream stakeholders would enhance the demand or "pulling" of the product from upstream stakeholders	Improve • IPP knowledge among stakeholders • Player enjoyment and engagement Reduce • Barriers due to lack of leadership
	Explore creative solutions to manage costs • Sponsorships and grants can be sourced from public health organizations, government, advocacy groups, or sport governing bodies • Approach athletes and celebrities with personal sports injury experiences to endorse the product, be part of the creative strategy, and/or be a communication channel for IPP promotion • Approach companies (eg, sports apparel, equipment, technology) with product integration proposals in tangible communication channels like videos, posters, websites, and promotional items	Improve • IPP knowledge among stakeholders • Player enjoyment and engagement Reduce • Barriers due to lack of leadership
	Time promotional strategies to coincide with the greatest windows of opportunity for IPP implementation. The IPPs could be more aggressively promoted in the offseason or preseason training phases to allow sufficient time for consumers to integrate IPPs into in-season schedules	Improve • Player enjoyment and engagement • IPP knowledge among stakeholders Reduce • Barriers due to lack of leadership

Abbreviation: IPP, injury prevention program.
[a]Improving IPP knowledge among stakeholders is concerned with increasing knowledge of IPP benefits, facilitation, and instruction among coaches and administrators. Improving player enjoyment and engagement relates to increasing player attention, player motivation, and IPP variety, tailoring, fun, and progression. Improving links to sport-related goals relates to improving the prioritization of IPPs over sport-specific drills and increasing the sport specificity of IPPs. Reducing barriers due to lack of facilities/resources is concerned with a lack of personnel, environment, facility, and resource support to conduct IPPs. Reducing barriers due to lack of leadership is concerned with issues relating to lack of support and direction from representative sporting bodies, lack of visible leadership from recognized role models on the value of injury prevention, and lack of club leadership and a culture that promotes player welfare and safety. Reducing barriers due to lack of time at training is concerned with issues relating to insufficient training time to conduct IPPs, the duration needed to complete IPPs, and not believing that the perceived benefit of IPPs is worth the time taken.

- Setting explicit social goals by using SMART (specific, measurable, achievable, relevant, time bound) criteria
- Athlete orientation and focus: additional commitment (and not as an afterthought) to inform, consult, involve, collaborate with, and empower athletes, who are the core of injury prevention efforts, in developing IPP social marketing propositions and interventions
- Audience segmentation: theory-, insight-, data-, and evidence-informed audience segmentation to tailor IPPs to individuals and groups (eg, by age group, sport, or sex)

- Competition, barrier, and asset analysis: especially when social marketing cannot influence the adoption of IPPs, identify and resolve other competitive factors, actors, and circumstances
- Critical, reflexive, and ethical evaluation: evaluating and improving subsequent social marketing programs through critical (comprehensive research and analysis), reflexive (examining and consciously acknowledging our own assumptions and preconceptions), and ethical (respect for autonomy, nonmaleficence, beneficence, justice) lenses

To improve the implementation of IPPs, social marketing principles like the social marketing mix must be woven into its ideation, research, development, testing, and evaluation phases. Interdisciplinary collaboration between the sports community and our public health and marketing colleagues can accelerate this process toward making sport safer for everyone. Social marketing is one of several theories, models, and frameworks in the implementation science toolkit that can be applied to influence broader voluntary health behavior change. ◉

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AUTHOR CONTRIBUTIONS: Lionel Chia conceived the initial idea and wrote the first draft. All authors contributed to the design, content, editing, and approval of the final version of this editorial.

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[VIEWPOINT]

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Procedural Drift: An Underappreciated Element of Clinical Treatment Fidelity

Clinical practice guidelines (CPGs) help practitioners and patients make evidence-informed decisions about appropriate health care choices. Clinical practice guidelines recommend interventions based on a robust review of the best available evidence. When well implemented, they reduce unwarranted variability. Unfortunately, CPGs often fail to detail the most effective ways to implement the intervention, which hinders implementation.

Patient outcomes are influenced by many factors that are outside the intervention and treating practitioners. When a patient's outcomes do not improve as expected, they may be associated with (1) failure to implement recommended interventions, or (2) low practitioner adoption of, adherence to, or competence with the appropriate interventions (eg, poor procedural fidelity).

Procedural fidelity (also known as treatment fidelity) includes selecting and delivering the correct intervention approach. Procedural drift (also known as therapist drift) is a subcomponent of procedural fidelity, and occurs when a practitioner selects the appropriate intervention initially (appropriate fidelity), but fails to implement the intervention in the recommended way.[9] Procedural drift can also occur when a practitioner fails to modify the intervention over time in response to changes in prognostic factors that inform patient outcomes (treatment monitoring). Examples of drift are low levels of resistance during strength training, poor reinforcement of homework during cognitive behavioral therapy, or delivering patient education/information that is poorly matched to a patient's education level.

How a practitioner implements an intervention in a within-session encounter can influence clinical outcomes.[9] Whereas ensuring procedural fidelity for research purposes is well established, guaranteeing procedural fidelity (including drift) in clinical practice is far more challenging.[7] Drift is especially difficult to track if the correct intervention codes are used, but the interventions are performed in a suboptimal manner. In this Viewpoint, we describe the reasons behind procedural drift, discuss potential adaptations in clinical practice, and suggest strategies to help practitioners identify and reduce drift.

SYNOPSIS: Procedural fidelity involves delivering the correct guideline-supported treatment choice, in its designed manner, over the full care episode of the patient. Procedural drift is a subcomponent of procedural fidelity that involves performing the right treatment the right way initially, then drifting toward suboptimal treatment over time. Procedural drift occurs most often when providing intricate, patient-centered interventions that require attention to subtle nuances that potentially maximize their effectiveness. Drift comes from the belief that subtle nuances do not matter, or from a lack of motivation or incentive to maintain high fidelity. Strategies to reduce drift in practice include investment in early, high-quality training; using checklists and manuals when providing an intervention; using risk-adjusted patient data as a checks-and-balances system; and incorporating measures of drift in the practitioner's annual review. *J Orthop Sports Phys Ther 2022;52(2):63-66. doi:10.2519/jospt.2022.10961*

KEY WORDS: *evidence-based practice, patient-centered care, procedural drift, treatment fidelity*

Why Do Clinicians Drift During Patient Care?

Delivering an intervention with adequate procedural fidelity over the full care cycle is not easy. Barriers include lack of time, poor access to high-quality literature, the practitioner's inability to appraise and interpret meaningful evidence, poor institutional support of best processes, financial pressures, and disharmony with patient expectations regarding what constitutes a successful intervention.[4] Even when practitioners overcome these barriers, additional challenges remain. In clinical practice, procedural departure and drift likely occur due to (1) biased beliefs and (2) poor motivation or incentive to change practice patterns.[10]

Biased beliefs include an unwillingness to adopt a new intervention, therapeutic allegiance to a philosophical approach (despite its incongruence with the patient's needs), and favoring intuition over evidence.[2,10] Biased beliefs may mean that practitioners fail to consider the patient's preferences or myopically

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focus on what they feel is appropriate (ie, a paternalistic approach). Therapeutic allegiance results in attending to the same intervention philosophy no matter the patient presentation, and can be disguised as the proper intervention, even though it is not performed in an optimal way.[10] Practitioners who prioritize intuition over recommended care tend to use fewer patient-centered strategies and overemphasize pathophysiologic, biomedical-based reasoning when making decisions about interventions.[3]

Procedural drift is more common among experienced practitioners, who fail to adopt the distinctions of evidence-based interventions that make their application successful.[8] Practitioners who drift often do not agree with or do not have a deep understanding of the recommended interventions, have low self-efficacy about adopting the intervention, or lack formal training in an evidence-based framework; all 3 diminish the practitioner's motivation to adhere to principles of the intervention.[4]

Fee-for-service reimbursement systems provide little incentive for practitioners to change their practice patterns, especially once they have established which interventions are billable. Although CPGs help reinforce the selection of the "right treatment" (on the front end of care), there may be a disincentive for doing the "right length of treatment" or "right intensity of treatment" (on the back end of care), because it may not be sufficiently reimbursed.

Patient-Centered Care and Procedural Drift

Procedural fidelity does not require the practitioner to treat all patients the same way, using the same interventions and the same parameters. Because patients present with variations of needs and preferences, some degree of adaptability is required and expected with patient-centered care (scenario 1 in the **TABLE**). Patient-centered care is delivered when the practitioner provides care that is informed by CPG recommendations, but also responds to individual patient preferences, needs, and values, which guide (not dictate) all clinical decisions.[5] Patient-centered care demands strong collaboration and communication between the practitioner and patient.[5] However, changes to interventions (whether patient centered or not) should be predictable by relevant patient-level factors when practice patterns are evaluated. Otherwise, there is a risk for care to be delivered in either a rigid (scenario 2 in the **TABLE**) or an unresponsive (scenario 3 in the **TABLE**) fashion, which reduces procedural drift but is not adapted to the patient's needs.

Recommendations to Reduce Procedural Drift in Clinical Practice

Most practitioners work autonomously in fast-paced environments. Unlike research studies, the interventions provided are not preordained or routinely checked for fidelity. Practitioners have authority to select an intervention and perform the intervention in the context they see fit—a process with strengths and weaknesses. The flexibility to provide the right care to the right patient at the right time (ie, meeting the demands of patient-centered care) is a strength. A weakness is the increased likelihood of drifting from the root benefit of an intervention (eg, appropriate intensity and timing of the intervention) and modifying the approach in a way that may lead to ineffectiveness (ie, inadvertently creating procedural drift).

TABLE Three Potential Conceptual Outcomes Related to Procedural Drift

Scenario	Clinical Synopsis
Scenario 1: treatment fidelity with appropriate procedural adaptation	The practitioner treats all patients of a given diagnosis/clinical syndrome with a range of approaches that are supported by evidence—in this situation, there is good initial fidelity. Procedural adaptation is present but driven by the opportunity to tailor within-session intervention nuances based on clinical presentations, for example, intervention modification based on the patient's preferences and values. Intervention variability is controlled with the guardrails of what the intervention parameters require and how the patient has adapted to these strategies through monitoring responses to care
Clinical hallmark	Practice patterns evidenced by appropriate intervention variability and length of care episodes. Procedural adaptation is predictable given patient-level factors
Scenario 2: treatment fidelity with therapeutic rigidity	The practitioner demonstrates unreasonable rigidity in care by treating all patients of a given diagnosis/clinical syndrome with the same within-session strategies of a dedicated evidence-based approach, despite the changing needs of the patient. While this strategy minimizes procedural drift initially, it is not adaptive due to lack of patient-centered approaches that would allow for tailoring of treatments. This leads to missed opportunities for modification that could lead to optimization of an intervention over time
Clinical hallmark	Practice patterns evidenced by decreased intervention variability and often characterized by increased length of care episodes. With this approach, drift may not occur, but rigidity leads to a one-size-fits-all approach
Scenario 3: no fidelity	The practitioner treats all patients of a given diagnosis/clinical syndrome with all available approaches, regardless of whether they are supported by evidence. The lack of initial fidelity is not linked to patient-level clinical indicators or recent clinical practice guidelines. Determining procedural drift is irrelevant because initial fidelity is lacking
Clinical hallmark	Practice patterns appear random when viewed in the aggregate. Intervention variability and length of care episodes are predicted by patient-level factors

We share 3 recommendations (2 at the systems level and 1 at the individual level) to reduce the risks of procedural drift.

Recommendation 1 (Systems Level) Invest early in high-quality training experiences. Tailoring training toward useful, meaningful guideline-oriented interventions should increase the likelihood of procedural fidelity. Effective trainers consistently implement the interventions they teach and discuss in a way that reflects the nuances that are associated with intervention success.

Incorporate "booster" training sessions to review and refresh clinicians' knowledge, skills, and attitudes around the key components of an intervention. Booster skills sessions help clinicians adopt complex interventions, such as those associated with behavioral-based approaches, that are responsible for the majority of drift in clinical practice.[10]

Recommendation 2 (Individual Level) Use checklists and manuals when applying complex interventions such as behavioral or exercise-based care. Checklists and manuals are not protocols or a one-size-fits-all approach to care, nor do they erode the patient-provider experience.[2] Checklists and manuals are safeguards to improve the quality of the procedure provided; they are designed to ensure that the small details of each intervention are not overlooked. Although each checklist and manual is unique to the targeted intervention, all provide "prompts" that stimulate the clinician to address the small characteristics of each intervention (eg, motivational support for resistance training, reflection for cognitive restructuring, or graded progressions during strengthening). Checklists and manuals are especially beneficial in addressing schematic errors (errors in patterns of thoughts or behaviors) that occur due to lapses in concentration, distractions, or fatigue.[2]

Recommendation 3 (Systems Level) Provide risk-adjusted (patient-based), ongoing and annual performance feedback that is led by both analytics and teams of clinicians. Comparing practitioner to practitioner, without appropriate risk-adjustment analytics, is more likely to represent the characteristics of the patients treated than the outcomes of the intervention provided by the practitioner.[6] Drift is best determined from multiple cases over an extended period of time—this is why we suggest routine assessments over an extended period (eg, quarterly).

Using case-based reviews and having teams of practitioners work together to discuss and comment on interventions and subsequent outcomes is another safeguard toward appropriate procedural fidelity and avoidance of drift. There are scales for measuring procedural drift adherence and competence[1] in cognitive behavioral therapy. Similar lists could be developed for use in physical therapy settings and might be particularly useful for complex interventions. Emphasizing the importance of procedural drift in the annual review should improve the likelihood of adopting early training, checklists and manuals, and risk-adjusted, ongoing feedback.

Summary

Procedural drift is an important element of procedural fidelity; its negative impact is well known in research but less appreciated in clinical settings. Procedural drift reflects the appropriate selection of guideline-oriented and patient-preferred interventions but a failure to implement the intervention in the recommended way, and/or a failure to tailor the intervention to clinically relevant changes in patient status (failed adaptation to the patient's needs). Changes at the system and practitioner levels should improve the practitioner's capacity to provide high-fidelity interventions in practice during the entire episode of care.

Key Points

- Procedural drift is a component of fidelity that occurs when practitioners select the right intervention but fail to implement it in the recommended way and/or fail to tailor the intervention to the patient's needs.
- Some procedural drift is reasonable and even expected in clinical practice. Modifications of the interventions are to be expected for different patients and expectations.
- With proper attention, procedural drift can be monitored and managed in practice.

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Demystifying Qualitative Research for Musculoskeletal Practitioners Part 5: Rigor in Qualitative Research

In the final installment of our 5-part series aiming to assist musculoskeletal practitioners to understand qualitative research, we discuss rigor in qualitative research. In parts 2, 3, and 4, we used the metaphor of building a house to describe qualitative research, including the foundations (ontology and epistemology), the plan and concept for the house (methodological approach), the design intent (theoretical or conceptual frameworks), and the tools and materials (methods).

Rigor, sometimes referred to as "trustworthiness," in qualitative research is like the safety inspection once the house is built. Did the building team adhere to a safe building process? Were the materials of high quality? Depending on the type of structure and the location of the building, the safety criteria will change. The same is true for qualitative research. Given the many methodological approaches and underlying epistemologies and ontologies, there is no one-size-fits-all approach to establish rigor in qualitative research. This can make identifying high-quality qualitative research difficult for those new to this form of inquiry.

A recent systematic review identified 102 qualitative critical appraisal tools and reporting guidelines, with over half developed in the last 10 years and nearly 60% developed from the field of health care.[4] There is growing interest in qualitative research in health fields and a desire to standardize evaluations of quality in health-related qualitative research, but this is in opposition to the assumptions in some paradigms.

Although the use of qualitative reporting checklists is appealing and required by many journals, checklists are not appropriate for all contexts, research questions, methodological approaches, and underpinning epistemological assumptions.[1] The prescriptive nature of checklists risks a situation where the building safety checklist (the critical appraisal checklist) guides the design of the house (the qualitative research).[1] When checklists are used, they must be engaged critically and contextualized to the broader design of the qualitative study.[1]

The consolidated criteria for reporting qualitative research (COREQ) checklist[6] is commonly used in musculoskeletal qualitative research. The COREQ checklist has 3 key domains: (1) research team and reflexivity, (2) study design, and (3) analysis and findings. However, not all COREQ criteria are relevant for all qualitative studies, and some relevant reporting items are missing. For example, the COREQ checklist does not require researchers to report how rigor was achieved.

The COREQ checklist also has a criterion for "transcripts returned." This is also known as "member checking," which is where participants read their transcript to make changes to the content. In some studies, this is highly appropriate for clarifying meaning and interpretation, particularly in response to themes and subthemes. However, in health research, member checking may result in participants "checking" to see whether they an-

SYNOPSIS: In part 5 of this series, we turn our attention to concepts of rigor in qualitative research. In doing so, the use of quality appraisal tools and reporting checklists for qualitative studies is explored. Issues regarding a one-size-fits-all approach to these tools and checklists are discussed. Trustworthiness criteria are also described and applied to different qualitative paradigms and methodological approaches. *J Orthop Sports Phys Ther 2022;52(2):60-62. doi:10.2519/jospt.2022.10487*

KEY WORDS: *qualitative research, qualitative rigor, trustworthiness*

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swered questions correctly and changing answers. For example, in a study exploring how participants understand osteoarthritis, participants engaging in member checking may search for information online and change their responses according to what they find. Member checking also implies a form of "verification" of the qualitative study.[5] Qualitative research works in a world where knowledge is constructed by the researcher and the participants. Therefore, attempting to make the work more "objective" is incongruent with some qualitative philosophies.

Further, distinctions between quality reporting checklists and critical appraisal tools are blurring. While quality reporting checklists relate to reporting the research and critical appraisal tools are for assessing methodological strengths and limitations, there is substantial overlap between the current tools and checklists for qualitative research,[4] a situation in which it can be difficult to distinguish

TABLE Trustworthiness Criteria

Criterion	Explanation
Credibility	When looking for credibility, the reader should look for whether the research design and methods used were aligned with standard qualitative approaches. For example, if a researcher claims to have used a grounded theory research design, then the methods should be consistent with what grounded theory involves. This will include citing, and being faithful to, key publications that support the use of methods. The author must report all the steps in the qualitative study to facilitate the reader understanding all the steps Other techniques used to achieve credibility include: • Prolonged engagement: lengthy contact with the participants and phenomenon • Triangulation: use of different sources, methods, or researchers • Peer debriefing: seeking feedback from someone "removed" from the research • Negative cases: finding participants who do not fit the "norm" of the other participants to better explicate the phenomenon • Member checking: returning transcripts of findings to participants for their evaluation and changes Each of these techniques will not be evident in all musculoskeletal qualitative publications. For example, phenomenology usually has few participants; therefore, achieving a negative case may not be possible. Peer debriefing may not be appropriate for interpretive description, where clinical knowledge of the research is necessary to build on the research findings. Prolonged engagement may not be feasible with clinical qualitative studies nested within a randomized controlled trial
Dependability	In qualitative research, it is accepted that the experience of a particular phenomenon for one participant will be different for another participant in a different context or setting. Due to this, the researchers need to keep a detailed log of all the activities undertaken and decisions made during data collection and analysis, also known as an "audit trail." This ensures that the processes completed by the researcher are repeatable to some degree, despite many different perspectives and experiences of the study population. In a journal article, evidence of an audit trail may appear as providing the interview schedule, a coding tree, a data-reduction table, and a detailed description of the analytic steps taken in the study. An audit trail should be presented in all qualitative research so that readers are clear on the steps taken and decisions made by the researchers to arrive at their findings
Confirmability	Confirmability is concerned with ensuring that the researcher's interpretations are derived from the participants' voices. A reader should be able to look at the data, understanding that researcher's lens, and the findings should make sense. To achieve confirmability, the researcher needs to maintain a well-documented and logical audit trail. This demonstrates to the reader how analytical decisions were made, and how the researcher's existing knowledge and background were managed in ensuring that the participants' voices were prioritized. This is usually achieved through reflexive memos Other techniques used to achieve confirmability include: • Cross-coding/peer debriefing: using a second coder to analyze some of the raw data to gain an understanding of alternative interpretations • Member checking: participants can provide feedback on whether the researcher is interpreting their experiences correctly, or edit the original transcript As previously discussed, cross-coding and member checking are not always necessary or appropriate for high-quality musculoskeletal research. For many studies, a thorough audit trail and evidence of quotations can be sufficient for confirmability
Transferability	The extent to which the findings are useful in other similar settings. To achieve this, the researchers need to provide a rich, detailed description of the context, location, and people studied. Although often confused with generalizability, transferability is concerned with findings that will apply to patients with similar characteristics from a similar setting to that of the current study, rather than to an entire clinical population. Qualitative researchers need to provide readers with a comprehensive picture of the study sample and setting, which will inform readers of whether the findings will be useful in their clinical practice. For example, a study of knee osteoarthritis including patients of private hospitals in Australia may have limited transferability to patients of a public hospital in Bangladesh. While transferability is not a goal in all qualitative research (such as autoethnography, where n = 1), it is commonly desired in more clinical qualitative research
Authenticity	Relates to whether the researchers sought a range of different perspectives in their findings (diverse, appropriate people to answer their research question). Seeking this diversity shows that the phenomenon of interest has been investigated from a range of angles and perspectives. Researchers should describe sampling techniques that sought breadth and were conducted iteratively with the analysis. This allows the researchers to pursue different avenues and themes in their data to gain a complex understanding of the phenomenon under study. Where they exist, researchers should also describe "negative" (also known as "divergent") cases, where some participants may have experiences and perspectives that differ widely from those of the other participants in the study. Negative cases can be important for initiating different interpretations and providing direction for future research. However, as previously discussed, seeking negative cases may not be feasible for methodological approaches such as phenomenology, where the sample size is typically very small. Likewise, diversity in samples may not be appropriate for methodologies where the goal is to seek rich information from a narrow set of participants

poor reporting from poor study design and procedures.[4]

We describe 5 key trustworthiness criteria, originally created by Lincoln and Guba[2,3] in 1985, on which many of the critical appraisal tools and quality reporting checklists are based (**TABLE**). These criteria were originally developed to assess the methodological quality of a qualitative study. However, as mentioned previously, nuances exist in assessing trustworthiness in a qualitative study, and not all criteria are appropriate for every qualitative study. To help readers identify where these nuances exist, we have indicated examples of the applicability of these criteria for musculoskeletal qualitative research based on the methodological approaches in part 3.

Conclusion

Well done on making it to the end of this qualitative series. Qualitative research is increasingly important to musculoskeletal practice for understanding patient and practitioner beliefs and experiences. We aimed to assist musculoskeletal practitioners in understanding qualitative research and recognizing its value to their practice. Hopefully, you now feel confident to unlock the benefits of qualitative research for improving patient care.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: All authors contributed to the conception and design of the work, drafted the work or revised it critically for important intellectual content, approved the final version to be published, and 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: There are no data in this editorial.
PATIENT AND PUBLIC INVOLVEMENT: Patients and the public were not involved in the development of this editorial.

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[LITERATURE REVIEW]

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Walking, Cycling, and Swimming for Nonspecific Low Back Pain: A Systematic Review With Meta-analysis

Low back pain (LBP) was responsible for 60.1 million disability-adjusted life-years in 2015.[12] Global estimates suggest that up to 540 million people have LBP at any time.[15] The clinical course of LBP is often favorable, with greater than 80% of people recovering from an episode within 3 months.[45] Despite this favorable recovery pattern, approximately 70% of individuals will experience a recurrence within 12 months following recovery.[6] This indicates the value of identifying strategies to both treat and prevent LBP.

Current guidelines[40] and reviews endorse the use of exercise interventions for treating chronic LBP[30,34] and preventing LBP recurrences.[18,38] Although exercise strategies have benefits across various LBP-related outcomes, limited focus has been given to exercise modes that are easily accessible to individuals. Walking, running, cycling, and swimming are among the most common forms of exercise.[1] They have high participation,[2] are accessible, do not require attendance of scheduled classes, and are relatively inexpensive.

OBJECTIVE: To investigate the effectiveness of walking/running, cycling, or swimming for treating or preventing nonspecific low back pain (LBP).

DESIGN: Intervention systematic review.

LITERATURE SEARCH: Five databases were searched to April 2021.

STUDY SELECTION CRITERIA: Randomized controlled trials evaluating walking/running, cycling, or swimming to treat or prevent LBP were included.

DATA SYNTHESIS: We calculated standardized mean differences (SMDs) and 95% confidence intervals (CIs). Certainty of evidence was evaluated with the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.

RESULTS: No trials assessed LBP prevention or addressed acute LBP. Nineteen trials (2362 participants) assessed treatment of chronic/recurrent LBP. Low-certainty evidence suggests that walking/running was less effective than alternate interventions in reducing pain in the short term (8 trials; SMD, 0.81; 95% CI: 0.28, 1.34) and medium term (5 trials; SMD, 0.80; 95% CI: 0.10, 1.49). High-certainty evidence suggests that walking/running was less effective than alternate interventions at reducing disability in the short term (8 trials; SMD, 0.22; 95% CI: 0.06, 0.38) and medium term (4 trials; SMD, 0.28; 95% CI: 0.05, 0.51). There was high-certainty evidence of a small effect in favor of walking/running compared to minimal/no intervention for reducing pain in the short term (10 trials; SMD, −0.23; 95% CI: −0.35, −0.10) and medium term (6 trials; SMD, −0.26; 95% CI: −0.40, −0.13) and disability in the short term (7 trials; SMD, −0.19; 95% CI: −0.33, −0.06). Scarcity of trials meant few conclusions could be drawn regarding cycling and swimming.

CONCLUSION: Although less effective than alternate interventions, walking/running was slightly more effective than minimal/no intervention for treating chronic/recurrent LBP. *J Orthop Sports Phys Ther 2022;52(2):85-99. Epub 16 Nov 2021. doi:10.2519/jospt.2022.10612*

KEY WORDS: *exercise, low back pain, physical activity*

Previous reviews investigated walking as a treatment for chronic LBP, and largely explored walking versus other interventions or walking as a supplement to other interventions.[23,37,43] Walking compared to minimal or no intervention has received little attention; there is no review of the effects of cycling or swimming on LBP. Two previous reviews investigated a wide range of interventions for preventing LBP (eg, exercise, back belts, shoe insoles, etc).[18,38] In these reviews, all forms of exercise were combined, and there is no high-quality review specifically investigating the effectiveness of walking/running, cycling, or swimming for LBP prevention.

Therefore, the primary aim of this systematic review with meta-analysis was to investigate the effectiveness of walking/running, cycling, and swimming for treating or preventing nonspecific LBP and associated disability, compared to alternate interventions (ie, any pharmacological,

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nonpharmacological, active, or passive therapies) or minimal/no intervention.

METHODS

This review was prospectively registered with PROSPERO (registration number CRD42020178896) and adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.[31]

Literature Search

A comprehensive search was conducted of MEDLINE, Embase, CINAHL, PEDro, and the Cochrane Central Register of Controlled Trials databases. The search strategy was based on the recommendations of the Cochrane Back and Neck Group for "randomised controlled trials" and "low back pain,"[10] combined with search terms for the exercise interventions of interest (walking/running, cycling, and swimming). The full search strategy is included in supplemental file 1 (available at www.jospt.org). Development of the search strategy was overseen by a medical librarian and included each database from inception to April 2021. The reference lists of included studies and relevant systematic reviews[18,23,30,35,37,43] were manually searched for potential studies, and forward citation searching of included trials was performed.

Study Selection

We included randomized controlled trials that met the following eligibility criteria:

1. Population: studies including participants with or without current or previous episodes of nonspecific LBP (ie, studies could look at prevention of a first episode, prevention of recurrences, or treatment of a current episode). Nonspecific LBP was defined as pain or discomfort localized in the area of the posterior aspect of the body, from the lower margin of the 12th rib to the lower gluteal folds, with or without pain referred into one or both lower limbs. Low back pain was also sometimes defined as nonspecific by the study authors. We excluded studies that involved participants with a specific cause of LBP (eg, cancer, infection, inflammatory arthritis) and those that included populations with radicular pain or radiculopathy. Participants who had spinal surgery in the last 6 months were also excluded.
2. Intervention: studies that investigated the effectiveness of walking/running, cycling, or swimming were included. No minimum dosage thresholds were set, and if an intervention of interest was delivered with a cointervention, then these were included, provided that the effects of the intervention of interest could be isolated. For example, trials examining walking and education versus education alone were included, as the effects of walking could be determined. Trials examining walking and education versus manipulation were excluded, as the effects of walking could not be isolated due to education being a cointervention.
3. Comparison: studies were included when the intervention was compared to an alternate intervention, minimal intervention, placebo, or no intervention. Alternate interventions could include any pharmacological, nonpharmacological, active, or passive therapies (eg, manual therapies, massage/heat/ultrasound therapies, traction devices, exercises other than walking/running, cycling, or swimming, etc). Minimal or no intervention included situations where the intervention of interest was compared to minimal (eg, advice or hot-pack therapy) or no treatment.
4. Outcomes: studies needed to report on at least 1 outcome of interest. Primary outcomes for this review were pain intensity (eg, a visual analog scale or numeric pain-rating scale) and disability (eg, the Oswestry Disability Index or the Roland-Morris Disability Questionnaire). Secondary outcome measures included other patient-centered outcomes relevant to LBP, such as quality of life, fear-avoidance beliefs, and adverse events.

Data Extraction

Following the search, all records were imported to the reference management software EndNote X9 (Clarivate Analytics, Philadelphia, PA) for removal of duplicates. Two reviewers (N.C.P. and T.F.C.) independently screened the title and abstract of each record and excluded clearly irrelevant studies. For each potentially eligible study, 2 reviewers (N.C.P., T.F.C., or M.J.H.) examined the full-text article and assessed whether the study fulfilled the inclusion criteria. In cases of disagreement, a third reviewer was consulted (either T.F.C. or M.J.H).

Data for each included trial were extracted independently by 2 reviewers (N.C.P., T.F.C., or M.J.H.), using a standardized data-extraction form in Excel (Microsoft Corporation, Redmond, WA), and discrepancies were resolved through discussion. We extracted study characteristics, covering study design (eg, population, sample size, setting, etc), description of interventions (eg, type of intervention and dosage), and the outcomes of interest and corresponding follow-up periods.

Assessing the Risk of Bias

Risk of bias was assessed according to the Cochrane Collaboration's revised domain-based evaluation framework for randomized trials[39] by 2 independent reviewers (N.C.P. and D.M. or A.T. or M.J.H.). The tool provides scoring for each outcome per trial at a selected time point on domains related to bias, focusing on aspects of trial design, conduct, and reporting. Based on the scoring of each domain and consideration of the impact of individual items, each study was independently graded to be of "low risk," "some concerns," or "high risk" by 2 reviewers. In cases of disagreement and when consensus could not be attained, a third reviewer was consulted (D.M. or A.T. or M.J.H.).

Assessing the Certainty of Evidence

The overall certainty of evidence was assessed for each outcome using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[13] Two reviewers (N.C.P. and M.J.H.) performed GRADE assessments for each treatment comparison, and disagreements were resolved by discussion. The GRADE classification was downgraded 1 level per study limitation, starting at high certainty, if any of the following were present:

1. Methodological quality: when greater than 50% of included participants in any comparison came from studies rated as having low methodological quality, that is, studies judged as "high risk" of bias
2. Inconsistency of results: based on observation of the variability of point estimates across individual trials and the I^2 statistic
3. Imprecision: based on inspection of the 95% confidence interval (CI) of the pooled estimate (or of individual studies when only 1 or 2 comparisons were available) to see whether it included values that would have different clinical implications (eg, CIs that included trivial effects and clearly important effects)
4. Publication bias: assessed using a funnel plot (conducted when greater than 10 eligible studies were included in the analysis) or other evidence of publication bias, including a majority of small studies with mostly positive results, industry sponsorship, or reported conflicts of interest
5. Indirectness: assessed by determining whether the population, intervention, comparison, and outcome were directly related to the aims of the current review

Statistical Analysis

Raw mean ± SD outcome data for the intervention group and control group were extracted at baseline and follow-up periods; alternatively, between-group change scores were extracted if available. When adequate data were not presented, a maximum of 2 e-mail attempts were made to authors to retrieve additional information, and 1 trial was excluded at full-text review for this reason.[9] A web-based tool (WebPlotDigitizer)[33] was used to accurately extract numerical data from figures when the information was not presented in text or tables.[11,16,29]

If the mean and SD were missing, these were estimated from other measures of effect and variability. If the SD was missing, we calculated this from 95% CIs,[8,19,22,27,28] standard errors,[16] or 25th-75th percentiles.[32] If no measure of variability was presented,[29] we estimated the SD from the most similar trial[7] in the review, based on intervention, outcome measure, and effect size, as recommended by the Cochrane Collaboration.[17]

When possible, we combined results in a meta-analysis where sufficient homogeneity existed in relation to intervention type (walking/running or cycling or swimming), comparison (alternate intervention or minimal/no intervention), outcome type (pain, disability, fear avoidance, or quality of life), and follow-up time point. To enable meta-analysis of the different scales used for study outcomes measuring the same construct (eg, the Roland-Morris Disability Questionnaire and Oswestry Disability Index for the outcome of disability), results were reported as standardized mean difference (SMD). For the outcome of disability, the Roland-Morris Disability Questionnaire and the Oswestry Disability Index were prioritized over other measures of disability and/or function if more than 1 was reported in the same trial. For trials including multiple treatment arms, we extracted data for each comparison that met the inclusion criteria and adjusted the numbers per group (sample size), as recommended in the *Cochrane Handbook for Systematic Reviews of Interventions*.[17]

Outcome assessment data were extracted for 3 time periods: short-term follow-up (collected up to 3 months following randomization), medium-term follow-up (collected from greater than 3 to 12 months), and long-term follow-up (collected greater than 12 months following randomization). In studies presenting multiple follow-up periods within the same category, we used the period closest to 6 weeks for the short-term, closest to 12 months for the medium-term, and the longest time point surpassing 12 months for the long-term follow-up.

Pooled effects using random-effects meta-analyses were expressed as SMD (computed using Cohen's d statistic) and 95% CI when more than 5 study comparisons were available. When few studies were available for pooling (ie, from 3 to 5 comparisons), the Knapp-Hartung method for calculating CIs was employed, per recommendations by the Cochrane Collaboration working group.[14] Negative SMD values represent an effect in favor of the experimental group (ie, walking/running, cycling, or swimming). Comprehensive Meta-Analysis Version 2.2.064 (Biostat Inc, Englewood, NJ) was used for all analyses.

To facilitate interpretation of the effect sizes, we re-expressed some of the key findings using a common scale for pain and disability. To do this, we used the most valid, widely used measurement tool of the included trials and multiplied the SMD by the weighted SD of the studies in the review that used that outcome, using the value reported at each follow-up.

Post Hoc Analyses

Many trials examined the effects of the interventions of interest when both intervention and control groups received a cointervention. The effects might have been different had the trials not included a cointervention. Therefore, we conducted post hoc sensitivity analyses excluding studies with a cointervention. This was only explored in the walking/running versus alternate intervention analyses, as too few trials existed to run the sensitivity analyses for the other comparisons.

RESULTS

Of the 7372 identified records, 308 were considered potentially eligible, and those full texts were reviewed. Of these, 19 published reports, representing 18 different randomized controlled trials, met the inclusion criteria and are reported in this review. **FIGURE 1** outlines the screening and selection process. A list of records that were excluded at full-text review, with reasons for exclusion, can be found in supplemental file 2 (available at www.jospt.org).

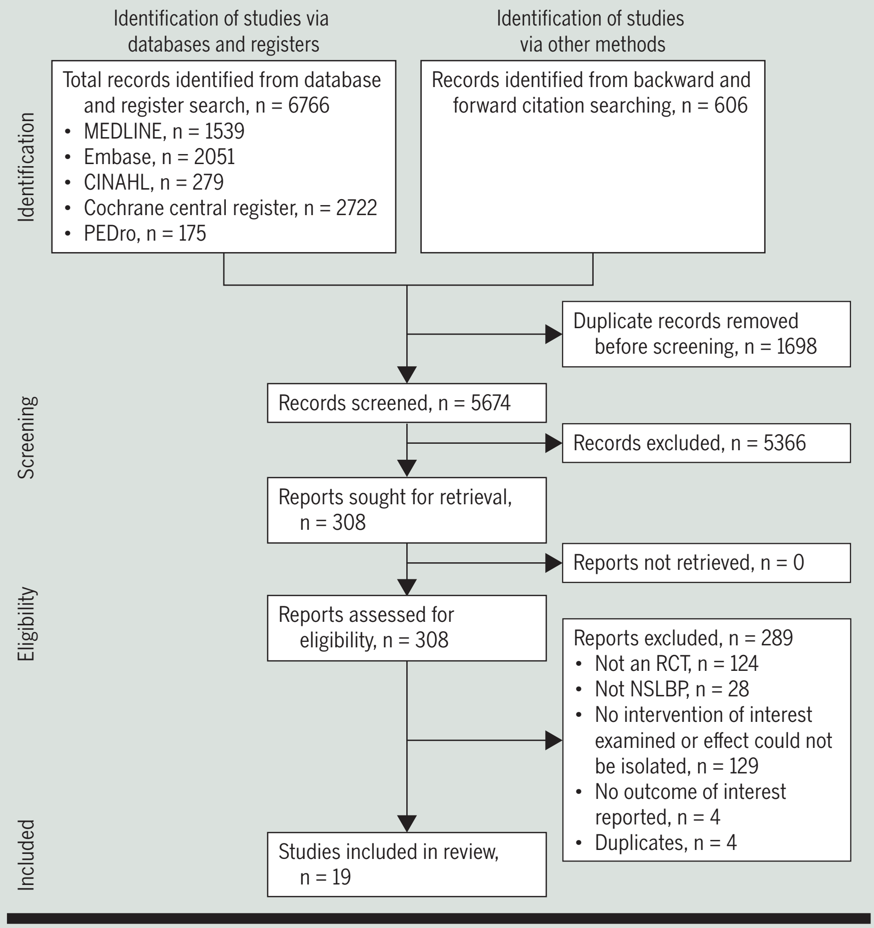


FIGURE 1. Flow diagram of study selection. Abbreviations: NSLBP, nonspecific low back pain; RCT, randomized controlled trial.

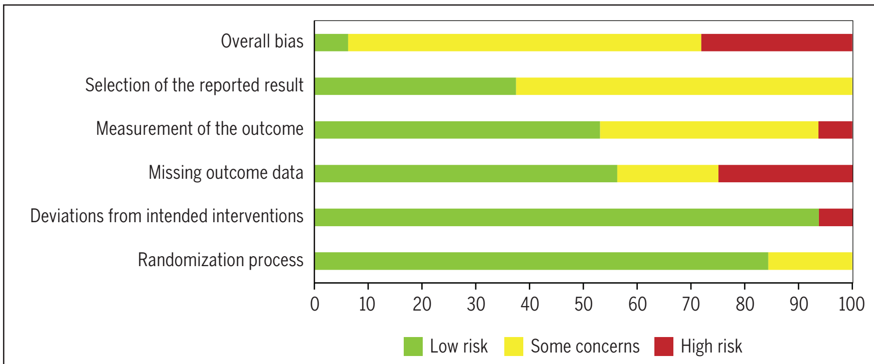


FIGURE 2. Percentage of outcomes with low risk of bias, some concerns, and high risk of bias for each domain of the revised Cochrane risk-of-bias tool.

TABLE 1 outlines the characteristics of included trials, with an accumulated sample size of 2362 individual participants. Our search yielded no trials investigating LBP prevention. All included trials focused on treating chronic or recurrent episodes of nonspecific LBP, with the shortest defined duration of recurrent LBP included being 3 weeks or longer.[25] All trials recruited adults over 18 years of age, with a mean age ranging from 28.4 to 54.8 years. Participants were primarily recruited from health care settings such as outpatient clinics, hospitals, rehabilitation centers, or primary care. Adherence was reported in very few trials; however, in those in which it was reported, compliance was reasonable, particularly in the short term (see supplemental file 3, available at www.jospt.org).[8,19,27,28,32]

Sixteen trials[3,5,7,8,16,19,20,22,25,28,29,32,36,41,42,44] investigated the effect of walking/running interventions, with walking being investigated by most trials and only 1 trial explicitly assessing the effects of running.[44] Two trials (with 3 published reports)[4,11,27] explored stationary cycling and 1 trial[44] examined swimming. Of the walking/running trials, 5 used a treadmill,[3,5,7,29,36] 1 supplied Nordic walking poles,[16] and the remaining 10 were structured around increasing walking in a community setting, with dosage goals achieved by either set times and frequencies or driven by step count as measured with a pedometer. Interventions were compared to a range of alternate treatments, with alternative exercise approaches (eg, the McGill protocol, Pilates, and trunk conditioning) and usual physical therapy being the most common comparisons. For the minimal or no intervention comparison, education and advice to remain active was most common. More details of the interventions and comparison groups are provided in **TABLE 1**.

The risk-of-bias assessment for each of our primary outcomes (pain and disability) in each study is presented in supplemental file 4 (available at www.jospt.org), with a summary in **FIGURE 2**. Short-, medium-, and long-term follow-ups were con-

TABLE 1 Characteristics of Randomized Controlled Trials Included in the Systematic Review

Study	Participants[a]	Outcome	Follow-up, wk	Intervention, Control	Dosage
Walking/running-based interventions					
Bello and Adeniyi[3]	n = 53 outpatient clinic attendees with chronic LBP; age, 44.36 ± 12.37; sex NR	LBP intensity: VAS LBP disability: ODI	8	I: treadmill walking C: McGill-based lumbar stabilization exercise	I: 30-40 min, 3 times per week for 8 wk C: 30 min, 3 times per week for 8 wk
Cho et al[5]	n = 20 hospital rehabilitation department attendees with chronic LBP; age, 28.4 ± 4.45; 0% female	LBP intensity: VAS LBP disability: ODI	8	I: treadmill walking and LBP rehabilitation program C: LBP rehabilitation program alone	I: 30 min on treadmill plus 30 min of the LBP rehabilitation program, 3 times per week for 8 wk C: 30 min of the LBP rehabilitation program, 3 times per week for 8 wk
Doğan et al[7]	n = 60 outpatient clinic attendees with chronic LBP; age, 40.2 ± 8.4; 75% female	LBP intensity: VAS LBP disability: RMDQ	6, 10	I: aerobic exercise on a treadmill plus an HEP C1: physical therapy plus an HEP C2: an HEP alone: mobilization and stretching exercise	I: 40-50 min, 3 times per week for 6 wk, plus the HEP C1: heat therapy (15 min), ultrasound (10 min), and TENS (15 min), 3 times per week for 6 wk, plus the HEP C2: 15-20 repetitions of each exercise daily for 6 wk
Eadie et al[8]	n = 60 outpatient clinic attendees with chronic/recurrent LBP; age, 44.93 ± 13.4; 61.7% female	LBP intensity: VAS LBP disability: ODI QoL: SF-36 Fear avoidance: FABQ Adherence Adverse events	12, 26	I: a walking program progressively guided by a physical therapist C1: a group-based exercise class C2: usual physical therapy	I: progressed to 30 min, 5 times per week for 8 wk C1: circuit of 15 progressive exercises, once per week for 8 wk C2: treatment and dosage at the discretion of the treating clinician
Hartvigsen et al[16]	n = 136 outpatient pain clinic attendees with chronic LBP; age, 46.69 ± 11.03; 71.6% female	LBP intensity: LBPRS (pain) LBP disability: LBPRS (function)	11, 26, 52	I1: supervised Nordic walking I2: unsupervised Nordic walking C: advice to stay active	I1: 45 min (3- to 4-km route), twice per week for 8 wk I2: single session to instruct on Nordic walking. Dose was based on participant discretion for 8 wk C: single advice session to remain active
Hurley et al[19]	n = 246 patients, referred to physical therapy by a general practitioner or hospital consultant, with chronic/recurrent LBP; age, 45.4 ± 11.4; 67.9% female	LBP intensity: NPRS LBP disability: ODI QoL: EQ-5D Fear avoidance: FABQ Adherence Adverse events	12, 26, 52	I: a pedometer-based walking program C1: a supervised group exercise class (aerobic/strength based) C2: usual physical therapy	I: progress to 30 min, 5 times per week for 8 wk C1: 60-min class, once per week for 8 wk C2: treatment and dosage at the discretion of the treating clinician
Idowu and Adeniyi[20]	n = 58 medical outpatient and physical therapy attendees with chronic LBP and type 2 DM; age, 48.3 ± 9.4; 64.7% female	LBP intensity: VAS	4, 8, 12	I: a pedometer-based walking program and graded activity program C: a graded activity program alone (aerobic/strength based)	I: recommend 5500 daily steps plus the graded activity program (60 min, twice per week) for 12 wk C: 60 min, twice per week for 12 wk
Lang et al[22]	n = 174 community-based adults with chronic LBP; age, 46.0 ± 16.5; 60.1% female	LBP intensity: MODI-P LBP disability: MODI QoL: EQ-5D Fear avoidance: FABQ Adverse events	12, 26, 52	I: a pedometer-based walking program guided by a physical therapist and education and advice C: education and advice alone	I: an individually tailored step target for 12 wk and a single standard package of education and advice C: a standard package of education and advice alone
Little et al[25]	n = 579 general practice clinic attendees with chronic/recurrent LBP; age, 45.5 ± 10.49; sex NR	LBP intensity: VPS LBP disability: RMDQ QoL: SF-36 Adverse events	12, 52	I: a walking program C: factorial design; no prescribed walking program	I: General practitioner prescription and up to 3 sessions of behavioral counseling with a practice nurse; duration was unclear C: unclear
McDonough et al[28]	n = 57 patients on a primary care referral list of 2 hospital physical therapy departments and local primary care practices with chronic LBP; age: I, 48 ± 5 and C, 51 ± 9; 55.0% female	LBP intensity: NPRS LBP disability: ODI QoL: EQ-5D Fear avoidance: FABQ Adherence Adverse events	9, 26	I: a pedometer-based walking program and education and advice C: education and advice alone	I: individualized dosage for 8 wk, based on previous-week pedometer reading, plus education and advice C: a single 60-min consultation on education and advice to remain active using "The Back Book"

Table continues on page 90.

TABLE 1 — Characteristics of Randomized Controlled Trials Included in the Systematic Review (continued)

Study	Participants[a]	Outcome	Follow-up, wk	Intervention, Control	Dosage
Mirovsky et al[29]	n = 84 patients with chronic LBP; age, 48.9; 45% female	LBP intensity: VAS Adverse events	4, 26, 52	I: treadmill walking with a VATD C: VATD alone: a dynamic-frame corset enabling traction between the hip and ribs	I: 15 min (3 km/h), once per day for 12 d, then 8 more sessions on alternating days with the VATD C: 20-30 min, once per day for 12 d, then 8 more sessions on alternating days
Rasmussen-Barr et al[32]	n = 71 private physical therapy clinic attendees with recurrent LBP; age, 38.5 ± 11.06; 50.7% female	LBP intensity: VAS LBP disability: ODI QoL: SF-36 Fear avoidance: FABQ Adherence	8, 26, 52, 156	I: walking at a pace without pain C: graded stabilization and strength exercise	I: two 45-min sessions with a physical therapist at baseline and 8-wk follow-up. Encouragement to walk daily C: 15 min of exercise, performed daily for 8 wk; a 45-min session once per week to progress exercise
Shnayderman and Katz-Leurer[36]	n = 52 outpatient physical therapy clinic attendees with chronic LBP; age, 45.3 ± 11.89; 79% female	LBP disability: ODI Fear avoidance: FABQ	6	I: treadmill walking C: active movement and strength exercise	I: progressed to 40 min, twice per week for 6 wk C: progressed to 40 min, twice per week for 6 wk
Suh et al[41]	n = 60 outpatient rehabilitation clinic attendees with intermittent chronic LBP; age, 54.81 ± 14.66; 68.75% female	LBP intensity: VAS LBP disability: ODI	6, 12	I1: walking alone I2: walking plus stabilization exercise C1: stabilization exercise C2: flexibility exercise	I1: 30 min, 5 times per week for 6 wk I2: 30 min, 5 times per week for 6 wk for stabilization exercise, plus 30 min of walking C1: 30 min, 5 times per week for 6 wk C2: 30 min, 5 times per week for 6 wk
Torstensen et al[42]	n = 208 patients sick listed with chronic LBP; age: I, 39.9 ± 11.4; C1, 42.1 ± 11.2; C2, 43.0 ± 12.0; 50.48% female	LBP intensity: VAS LBP disability: ODI	12, 52	I: walking group C1: progressively graded stabilizing exercises based on symptoms C2: usual physical therapy	I: 60 min, 3 times per week for 12 wk C1: 60 min, 3 times per week for 12 wk C2: treatment type and dosage at the discretion of the treating clinician
Cycling-based intervention					
Brooks et al[4b]	n = 64 patients with chronic LBP; age, 36.25 ± 7.25; 62.5% female	LBP intensity: VAS LBP disability: ODI	8	I: stationary cycle classes C: Pilates-based training	I: a 50- to 60-min session, 3 times per week for 8 wk C: a 50- to 60-min session, 3 times per week for 8 wk
Ganesh et al[11]	n = 60 patients with chronic LBP; age, 39.7 ± 8.3; 40.0% female	LBP disability: ODI	4, 16	I: stationary cycle and diagnostic-specific interventions (exercise, mobilization, traction, etc) C: strength and balance training and diagnostic-specific interventions	I: 15 min of cycling, 5 times per week for 4 wk C: once per day, 5 times per week for 4 wk
Marshall et al[27b]	n = 64 patients with chronic LBP; age, 36.25 ± 7.25; 62.5% female	LBP intensity: VAS LBP disability: ODI Fear avoidance: FABQ	8, 26	I: stationary cycle classes C: Pilates-based training	I: a 50- to 60-min session, 3 times per week for 8 wk C: a 50- to 60-min session, 3 times per week for 8 wk
Swimming-based intervention					
Weifen et al[44]	n = 320 retired athletes with chronic LBP; age, 37.6 ± 5.4; 40.0% female	LBP intensity: VAS	12, 26	I1: swimming plus physical therapy I2: jogging plus physical therapy C1: backward walking plus physical therapy C2: tai chi plus physical therapy C3: no exercise plus physical therapy	I1: 30 min of swimming, 5 times per week for 6 mo I2: 30 min of jogging, 5 times per week for 6 mo C1: 30 min of backward walking, 5 times per week for 6 mo C2: 45 min of tai chi, 5 times per week for 6 mo C3: NR

Abbreviations: C, control; DM, diabetes mellitus; EQ-5D, European Quality of Life-5 Dimensions; FABQ, Fear-Avoidance Beliefs Questionnaire; HEP, home exercise program; I, intervention; LBP, low back pain; LBPRS, Low Back Pain Rating Scale; MODI, Modified Oswestry Disability Index; MODI-P, Modified Oswestry Disability Index-pain question; NPRS, numeric pain-rating scale; NR, not reported; ODI, Oswestry Disability Index; QoL, quality of life; RMDQ, Roland-Morris Disability Questionnaire; SF-36, Medical Outcomes Study 36-Item Short-Form Health Survey; TENS, transcutaneous electrical nerve stimulation; VAS, visual analog scale; VATD, vertical ambulatory traction device; VPS, von Korff pain score.

[a]*Age values are mean or mean ± SD years.*

[b]*The studies by Brooks et al[4] and Marshall et al[27] reflect the same sample of participants. Marshall et al's paper[27] provided long-term data and was used in meta-analyses.*

sidered; however, little variability existed (eg, dropout rates), meaning that judgment did not change across time points for each included trial. Most trials were at low risk of bias regarding the randomization process (84%), deviations from the intended intervention (94%), and missing outcome data (56%). There were some concerns for the domain of measurement of the outcome, due to the inability to blind participants to the intervention received and the use of patient-reported outcomes (41% of trials). There were some concerns for the domain of selective reporting bias (66% of trials), due to the lack of published protocols or project registration of trials on public registries.

A report of all extracted data for both primary and secondary outcomes is included in supplemental files 3 and 5 (available at www.jospt.org).

TABLE 2 Summary of Pooled Effects for the Primary Outcomes of Pain and Disability in the Treatment of Chronic or Recurrent Nonspecific Low Back Pain

Comparison/Outcome/Follow-up[a]	Participants, n	SMD[b]	GRADE
Walking versus alternate treatment			
Pain intensity			
Short term	890[3,7,8,19,32,41,42,44]	0.81 (0.28, 1.34)	Low
Medium term	728[8,19,32,42,44]	0.80 (0.10, 1.49)	Low
Long term	56[32]	0.08 (−0.45, 0.61)[c]	Low
Disability			
Short term	669[3,7,8,19,32,36,41,42]	0.22 (0.06, 0.38)	High
Medium term	467[8,19,32,42]	0.28 (0.05, 0.51)	High
Long term	56[32]	0.36 (−0.18, 0.89)[c]	Low
Walking versus minimal/no treatment			
Pain intensity			
Short term	1025[5,7,16,20,22,25,28,29,41,44]	−0.23 (−0.35, −0.10)	High
Medium term	853[16,22,25,28,29,44]	−0.26 (−0.40, −0.13)	High
Disability			
Short term	869[5,7,16,22,25,28,41]	−0.19 (−0.33, −0.06)	High
Medium term	740[16,22,25,28]	−0.13 (−0.47, 0.21)[d]	High
Cycling versus alternate treatment			
Pain intensity			
Short term	64[27]	0.51 (0.01, 1.01)[c]	Low
Medium term	64[27]	0.19 (−0.30, 0.68)[c]	Low
Disability			
Short term	124[11,27]	NA[e]	Moderate
Medium term	124[11,27]	NA[e]	Moderate
Swimming versus alternate treatment			
Pain intensity			
Short term	265[44f]	−0.76 (−4.00, 2.48)[d]	Low
Medium term	265[44f]	−0.78 (−5.13, 3.57)[d]	Low
Swimming versus minimal/no treatment			
Pain intensity			
Short term	78[44]	−2.07 (−2.62, −1.52)[c]	Low
Medium term	78[44]	−2.36 (−2.94, −1.78)[c]	Low

Abbreviations: NA, not applicable; SMD, standardized mean difference.
[a]*Short term indicates follow-up assessment between 0 and 3 months, medium term indicates follow-up assessment between greater than 3 and 12 months, and long term indicates follow-up assessment greater than 12 months.*
[b]*Values in parentheses are 95% confidence interval. A negative estimate represents an effect in favor of the intervention group.*
[c]*The SMD and 95% confidence interval are representative of a single comparison.*
[d]*The Knapp-Hartung method was used to estimate confidence intervals, due to 3 to 5 comparisons present.*
[e]*Use of the Knapp-Hartung method provides uninformative estimates when 2 comparisons are being pooled; therefore, we did not generate a point estimate or confidence interval.*
[f]*A single trial with 3 comparison arms was available for pooling.*

Walking/Running Versus Alternate Intervention for Treating LBP

Pain Intensity Eight trials (n = 890)[3,7,8,19,32,41,42,44] investigated the short-term effects of walking/running compared to an alternate treatment (eg, stabilization exercises, physical therapy, tai chi, and general exercise programs). There was low-certainty evidence that walking/running was less effective than alternate interventions for reducing pain intensity (SMD, 0.81; 95% CI: 0.28, 1.34; I^2 = 91%) in the short term. This equates to an estimated mean difference of 14.2 points on a 0-to-100-point numeric pain-rating scale, in favor of the alternate intervention.

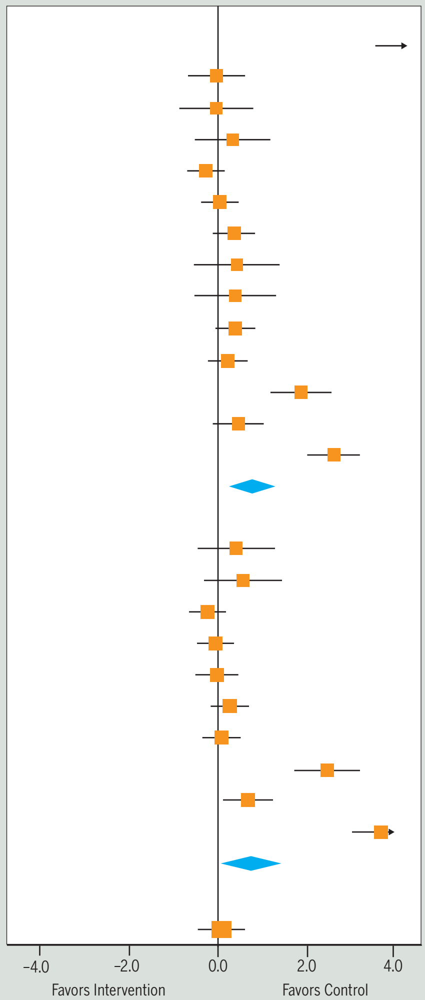
Five trials (n = 728)[8,19,32,42,44] investigated medium-term effects. There was low-certainty evidence of sustained benefits in favor of the alternate intervention (SMD, 0.80; 95% CI: 0.10, 1.49; I^2 = 94%). This equates to an estimated mean difference of 14.0 points on a 0-to-100-point numeric pain-rating scale, in favor of the alternate intervention. One trial (n = 56)[32] investigated long-term effects and produced low-certainty evidence of no difference in effectiveness between walking/running and an alternate treatment (SMD, 0.08; 95% CI: −0.45, 0.61). A summary of results is provided in **TABLE 2** and **FIGURE 3**.

Disability Eight trials (n = 669)[3,7,8,19,32,36,41,42] investigated the short-term effects of walking/running compared to an alternate treatment (eg, stabilization exercises, physical therapy, and general exercise programs). There was high-certainty evidence that walking/running was less effective than alternate interventions at reducing disability, though the effect size was small (SMD, 0.22; 95% CI: 0.06, 0.38; I^2 = 0%). This equates to an estimated mean difference of 3.8 points on a 0-to-100 Oswestry Disability Index scale, in favor of the alternate intervention.

Four trials (n = 467)[8,19,32,42] investigated medium-term effects. There was high-certainty evidence of sustained, though small, benefits in favor of the alternate intervention (SMD, 0.28; 95% CI: 0.05, 0.51; I^2 = 25%). This equates to an estimated mean difference of 4.1 points on a 0-to-100 Oswestry Disability Index scale, in favor of the alternate intervention. One trial (n = 56)[32] investigated long-term effects and produced low-certainty evidence that walking/running may be inferior to an alternate treatment (SMD, 0.36; 95% CI: −0.18,

Pain

Time Point/Study	Participants, n: Intervention	Participants, n: Control	*P* Value	SMD (95% Confidence Interval)
Short term				
Bello and Adeniyi[3]	25	25	<.001	4.57 (3.52, 5.63)
Doğan et al[7]	19	18	.987	0.01 (−0.64, 0.65)
Eadie et al (exercise class)[8]	9[a]	14	1.000	0.00 (−0.84, 0.84)
Eadie et al (physical therapy)[8]	9[a]	13	.392	0.37 (−0.48, 1.23)
Hurley et al (exercise class)[19]	32[a]	66	.276	−0.24 (−0.66, 0.19)
Hurley et al (physical therapy)[19]	32[a]	67	.700	0.08 (−0.34, 0.50)
Rasmussen-Barr et al[32]	35	36	.088	0.41 (−0.06, 0.88)
Suh et al (stability exercise)[41]	7[a]	10	.342	0.47 (−0.51, 1.45)
Suh et al (flexibility exercise)[41]	7[a]	13	.357	0.44 (−0.49, 1.37)
Torstensen et al (exercise class)[42]	29[a]	59	.057	0.44 (−0.01, 0.89)
Torstensen et al (physical therapy)[42]	29[a]	59	.248	0.26 (−0.18, 0.71)
Weifen et al (swimming)[44]	16[a]	38	<.001	1.93 (1.25, 2.62)
Weifen et al (backward walking)[44]	16[a]	47	.086	0.50 (−0.07, 1.08)
Weifen et al (tai chi)[44]	16[a]	132	<.001	2.68 (2.08, 3.29)
Subtotal[b]			.003	0.81 (0.28, 1.34)
Medium term				
Eadie et al (exercise class)[8]	8[a]	13	.332	0.44 (−0.45, 1.33)
Eadie et al (physical therapy)[8]	8[a]	13	.195	0.59 (−0.30, 1.49)
Hurley et al (exercise class)[19]	31[a]	62	.333	−0.21 (−0.65, 0.22)
Hurley et al (physical therapy)[19]	31[a]	60	.889	−0.03 (−0.46, 0.40)
Rasmussen-Barr et al[32]	29	32	1.000	0.00 (−0.50, 0.50)
Torstensen et al (exercise class)[42]	29[a]	59	.193	0.30 (−0.15, 0.74)
Torstensen et al (physical therapy)[42]	29[a]	59	.649	0.10 (−0.34, 0.55)
Weifen et al (swimming)[44]	16[a]	38	<.001	2.52 (1.77, 3.28)
Weifen et al (backward walking)[44]	16[a]	47	.016	0.71 (0.13, 1.29)
Weifen et al (tai chi)[44]	16[a]	132	<.001	3.75 (3.08, 4.42)
Subtotal[c]			.025	0.80 (0.10, 1.49)
Long term[d]				
Rasmussen-Barr et al[32]	25	31	.764	0.08 (−0.45, 0.61)



Abbreviation: SMD, standardized mean difference.
[a]*When trials included more than 1 comparison in the same meta-analysis, the sample size was split in the shared groups, as per Cochrane recommendations, to ensure participants were not double counted.*
[b]*Heterogeneity:* $\tau^2 = 0.95$, $I^2 = 91\%$.
[c]*Heterogeneity:* $\tau^2 = 1.08$, $I^2 = 94\%$.
[d]*No pooled estimate was provided when only 1 or 2 studies were available for the outcome.*

FIGURE 3. Meta-analysis of walking/running versus alternate interventions for the outcome of pain intensity for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

0.89). A summary of results is provided in **TABLE 2** and **FIGURE 4**.

Walking/Running Versus Minimal or No Treatment for LBP

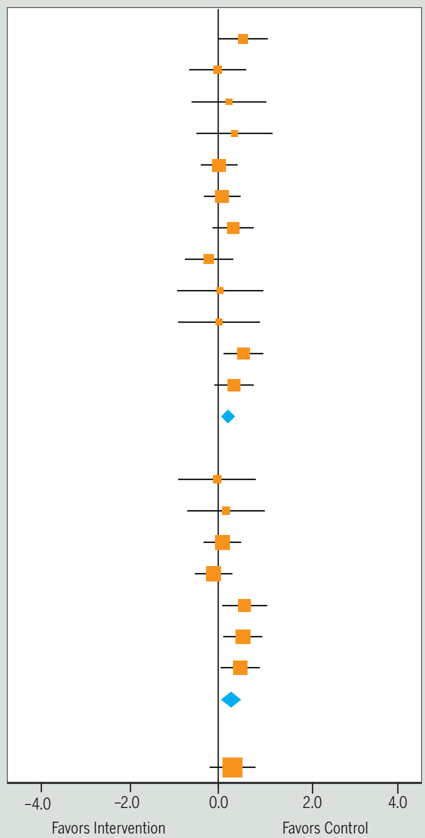
Pain Intensity Ten trials (n = 1025)[5,7,16,20,22,25,28,29,41,44] investigated the short-term effects of walking/running compared to either minimal or no treatment. There was high-certainty evidence that walking/running was more effective than minimal or no treatment for reducing pain intensity, though the effect size was small (SMD, −0.23; 95% CI: −0.35, −0.10; I^2 = 0%). This equates to an estimated mean difference of 4.4 points on a 0-to-100-point numeric pain-rating scale, in favor of walking/running.

Six trials (n = 853)[16,22,25,28,29,44] investigated medium-term effects. There was high-certainty evidence of sustained, though small, benefits in favor of walking/running (SMD, −0.26; 95% CI: −0.40, −0.13; I^2 = 0%). This equates to an estimated mean difference of 5.7 points on a 0-to-100-point numeric pain-rating scale, in favor of walking/running. No trials reported data on pain in the long-term period. A summary of results is provided in **TABLE 2** and **FIGURE 5**.

Disability Seven trials (n = 869)[5,7,16,22,25,28,41] investigated the short-term effects of walking/running compared to either minimal or no treatment. There was high-certainty evidence that walking/running was more effective than minimal or no treatment for reducing disability, though the effect size was small (SMD, −0.19; 95% CI: −0.33, −0.06; I^2 =

Disability

Time Point/Study	Participants, n: Intervention	Participants, n: Control	*P* Value	SMD (95% Confidence Interval)
Short term				
Bello and Adeniyi[3]	25	25	.052	0.56 (−0.01, 1.13)
Doğan et al[7]	19	18	1.000	0.00 (−0.65, 0.65)
Eadie et al (exercise class)[8]	9[a]	14	.555	0.25 (−0.59, 1.09)
Eadie et al (physical therapy)[8]	9[a]	13	.395	0.37 (−0.49, 1.23)
Hurley et al (exercise class)[19]	33[a]	68	.877	0.03 (−0.38, 0.45)
Hurley et al (physical therapy)[19]	33[a]	67	.634	0.10 (−0.32, 0.52)
Rasmussen-Barr et al[32]	35	36	.150	0.34 (−0.12, 0.81)
Shnayderman and Katz-Leurer[36]	26	26	.370	−0.25 (−0.80, 0.30)
Suh et al (stability exercise)[41]	7[a]	10	.910	0.06 (−0.91, 1.02)
Suh et al (flexibility exercise)[41]	7[a]	13	.946	0.03 (−0.89, 0.95)
Torstensen et al (exercise class)[42]	29[a]	59	.013	0.57 (0.12, 1.03)
Torstensen et al (physical therapy)[42]	29[a]	59	.112	0.36 (−0.09, 0.81)
Subtotal[b]			.006	0.22 (0.06, 0.38)
Medium term				
Eadie et al (exercise class)[8]	8[a]	13	.955	−0.03 (−0.91, 0.86)
Eadie et al (physical therapy)[8]	8[a]	13	.697	0.18 (−0.71, 1.06)
Hurley et al (exercise class)[19]	31[a]	64	.671	0.09 (−0.34, 0.52)
Hurley et al (physical therapy)[19]	31[a]	62	.648	−0.10 (−0.53, 0.33)
Rasmussen-Barr et al[32]	29	32	.023	0.60 (0.08, 1.11)
Torstensen et al (exercise class)[42]	29[a]	59	.016	0.55 (0.10, 1.01)
Torstensen et al (physical therapy)[42]	29[a]	59	.032	0.49 (0.04, 0.94)
Subtotal[c]			.015	0.28 (0.05, 0.51)
Long term[d]				
Rasmussen-Barr et al[32]	25	31	.189	0.36 (−0.18, 0.89)



Abbreviation: SMD, standardized mean difference.
[a]*When trials included more than 1 comparison in the same meta-analysis, the sample size was split in the shared groups, as per Cochrane recommendations, to ensure participants were not double counted.*
[b]*Heterogeneity: τ^2 = 0.00, I^2 = 0%.*
[c]*Heterogeneity: τ^2 = 0.15, I^2 = 25%.*
[d]*No pooled estimate was provided when only 1 or 2 studies were available for the outcome.*

FIGURE 4. Meta-analysis of walking/running versus alternate intervention for the outcome of disability for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

0%). This equates to an estimated mean difference of 2.3 points on a 0-to-100 Oswestry Disability Index scale, in favor of walking/running.

Four trials (n = 740)[16,22,25,28] investigated medium-term effects. There was high-certainty evidence that walking/running showed no difference in effect when compared to minimal or no intervention (SMD, −0.13; 95% CI: −0.47, 0.21; I^2 = 38%). This equates to an estimated mean difference of 1.7 points on a 0-to-100 Oswestry Disability Index scale, in favor of walking/running. No trials reported data on disability in the long term. A summary of results is provided in **TABLE 2** and **FIGURE 6**.

Cycling Versus Alternate Intervention for Treating LBP

One trial (n = 64)[27] investigated the effects of cycling compared to an alternate intervention for pain intensity, and 2 trials (n=124)[11,27] investigated disability. There was low-certainty evidence that cycling was less effective than alternate interventions at reducing pain in the short term (SMD, 0.51; 95% CI: 0.01, 1.01) and of no difference in effect in the medium term (SMD, 0.19; 95% CI: −0.30, 0.68). There was moderate-certainty evidence that cycling was less effective than alternate interventions at reducing disability in the short term (SMD, 1.13; 95% CI: 0.59, 1.68[11] and SMD, 0.55; 95% CI: 0.05, 1.05[27]) and medium term (SMD, 1.19; 95% CI: 0.64, 1.74[11] and SMD, 0.41; 95% CI: −0.09, 0.90[27]). A summary of results is provided in **TABLE 2** and **FIGURE 7**.

Cycling Versus Minimal or No Treatment for LBP

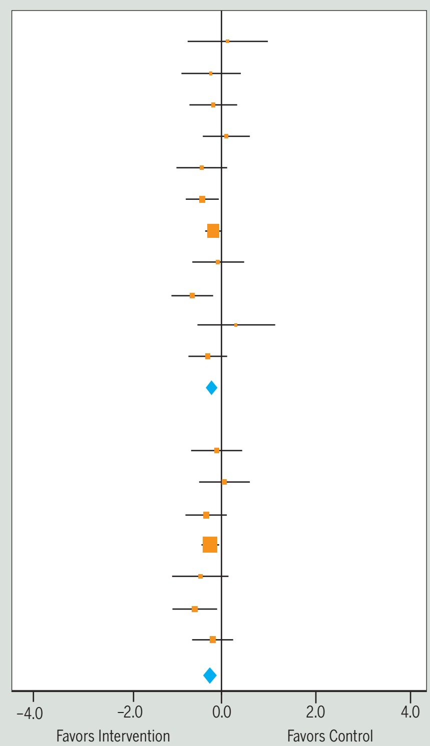
No trials compared the effectiveness of cycling to either minimal or no intervention for treating LBP.

Swimming Versus Alternate Intervention for Treating LBP

Only 1 trial (n = 265)[44] with multiple arms investigated the effects of swimming on pain intensity compared to an

Pain

Time Point/Study	Participants, n: Intervention	Control	*P* Value	SMD (95% Confidence Interval)
Short term				
Cho et al[5]	10	10	.783	0.12 (−0.75, 1.00)
Doğan et al[7]	19	18	.487	−0.23 (−0.88, 0.42)
Hartvigsen et al (supervised NW)[16]	40	22[a]	.501	−0.18 (−0.70, 0.34)
Hartvigsen et al (unsupervised NW)[16]	42	22[a]	.711	0.10 (−0.42, 0.61)
Idowu and Adeniyi[20]	25	26	.130	−0.43 (−0.98, 0.13)
Lang et al[22]	96	42	.025	−0.42 (−0.78, −0.05)
Little et al[25]	206	206	.069	−0.18 (−0.37, 0.01)
McDonough et al[28]	39	17	.786	−0.08 (−0.65, 0.49)
Mirovsky et al[29]	35	41	.008	−0.63 (−1.09, −0.17)
Suh et al (walking and stability exercise)[41]	12	10	.471	0.31 (−0.53, 1.16)
Weifen et al[44]	47	40	.166	−0.30 (−0.72, 0.12)
Subtotal[b]			<.001	−0.23 (−0.35, −0.10)
Medium term				
Hartvigsen et al (supervised NW)[16]	40	22[a]	.654	−0.12 (−0.64, 0.40)
Hartvigsen et al (unsupervised NW)[16]	42	22[a]	.886	0.04 (−0.48, 0.55)
Lang et al[22]	64	32	.132	−0.33 (−0.76, 0.10)
Little et al[25]	206	206	.010	−0.25 (−0.45, −0.06)
McDonough et al[28]	39	17	.128	−0.45 (−1.02, 0.13)
Mirovsky et al[29]	35	41	.018	−0.56 (−1.01, −0.10)
Weifen et al[44]	47	40	.352	−0.20 (−0.62, 0.22)
Subtotal[c]			<.001	−0.26 (−0.40, −0.13)



Abbreviations: NW, Nordic walking; SMD, standardized mean difference.
[a]*When trials included more than 1 comparison in the same meta-analysis, the sample size was split in the shared groups, as per Cochrane recommendations, to ensure participants were not double counted.*
[b]*Heterogeneity:* $\tau^2 = 0.00$, $I^2 = 0\%$.
[c]*Heterogeneity:* $\tau^2 = 0.00$, $I^2 = 0\%$.

FIGURE 5. Meta-analysis of walking/running versus minimal/no intervention for the outcome of pain intensity for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

alternate intervention. There was low-certainty evidence that swimming was no more effective than alternate interventions in the short or medium term (SMD, −0.76; 95% CI: −4.00, 2.48 and SMD, −0.78; 95% CI: −5.13, 3.57). A summary of results is provided in **TABLE 2** and **FIGURE 8**.

Swimming Versus Minimal or No Treatment for LBP

One trial (n = 78)[44] investigated the effect of swimming compared to minimal or no treatment for the outcome of pain intensity. There was low-certainty evidence that swimming was more effective than minimal or no treatment in the short term (SMD, −2.07; 95% CI: −2.62, −1.52) and medium term (SMD, −2.36; 95% CI: −2.94, −1.78). A summary of results is provided in **TABLE 2** and **FIGURE 8**.

Results of Post Hoc Analyses

When we excluded trials with a cointervention (eg, a daily home exercise program[7] or physical therapy[44]) (supplemental file 6, available at www.jospt.org) for the comparison of walking/running versus alternate interventions, there was a small difference in our point estimates for the outcome of pain intensity in the short term (original analysis: SMD, 0.81; 95% CI: 0.28, 1.34 compared to sensitivity analysis: SMD, 0.59; 95% CI: 0.07, 1.12) and disability in the short term (original analysis: SMD, 0.22; 95% CI: 0.06, 0.38 compared to sensitivity analysis: SMD, 0.24; 95% CI: 0.07, 0.40).

For the comparison of walking versus alternate interventions for the outcome of pain intensity in the medium term, removing a trial[44] with multiple comparisons substantially reduced the point estimate, from an SMD of 0.80 (95% CI: 0.10, 1.49) in the original analysis to no apparent difference between groups, with an SMD of 0.07 (95% CI: −0.12, 0.27), in the sensitivity analysis.

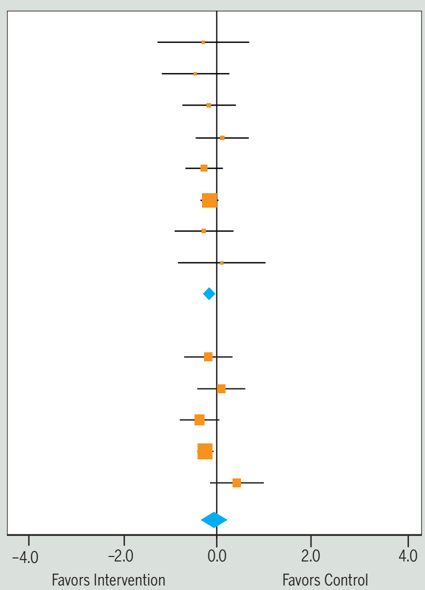
Secondary Outcome Measures

The effects on quality of life were investigated in 6 included trials.[8,19,22,25,28,32] Due to heterogeneity of interventions, comparisons, and outcome measures, meta-analysis was conducted for only 1 measure of quality of life (Medical Outcomes Study 36-Item Short-Form Health Survey [SF-36] role physical). Walking/running was less effective than an alternate intervention for improving quality of life in the short and medium term (SMD, 1.16; 95% CI: −2.15, 4.46; I^2 = 91% and SMD, 0.48; 95% CI: −0.39, 1.35; I^2 = 0%, respectively).

Fear avoidance was investigated in 7 included trials.[8,19,22,27,28,32,36] Due to het-

Disability

Time Point/Study	Participants, n: Intervention	Participants, n: Control	*P* Value	SMD (95% Confidence Interval)
Short term				
Cho et al[5]	10	10	.512	−0.30 (−1.17, 0.59)
Doğan et al[7]	19	18	.179	−0.45 (−1.10, 0.21)
Hartvigsen et al (supervised NW)[16]	40	22[a]	.475	−0.19 (−0.71, 0.33)
Hartvigsen et al (unsupervised NW)[16]	42	22[a]	.811	0.06 (−0.45, 0.58)
Lang et al[22]	96	42	.130	−0.28 (−0.65, 0.08)
Little et al[25]	206	206	.050	−0.18 (−0.36, 0.00)
McDonough et al[28]	39	17	.329	−0.29 (−0.86, 0.29)
Suh et al (walking and stability exercise)[41]	12	10	.901	0.05 (−0.79, 0.89)
Subtotal[b]			<.01	−0.19 (−0.33, −0.06)
Medium term				
Hartvigsen et al (supervised NW)[16]	40	22[a]	.494	−0.18 (−0.70, 0.34)
Hartvigsen et al (unsupervised NW)[16]	42	22[a]	.724	0.09 (−0.42, 0.61)
Lang et al[22]	64	32	.095	−0.36 (−0.79, 0.06)
Little et al[25]	206	206	.008	−0.25 (−0.43, −0.06)
McDonough et al[28]	39	17	.152	0.42 (−0.15, 1.00)
Subtotal[c]			.359	−0.13 (−0.47, 0.21)

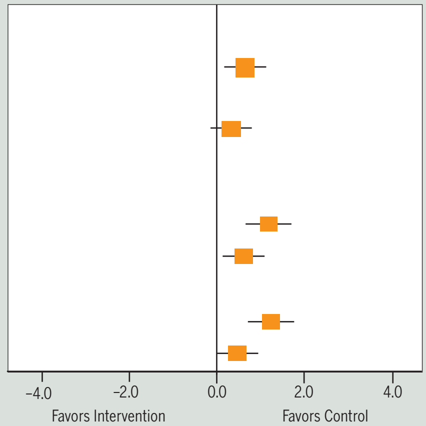


Abbreviations: NW, Nordic walking; SMD, standardized mean difference.
[a]*When trials included more than 1 comparison in the same meta-analysis, the sample size was split in the shared groups, as per Cochrane recommendations, to ensure participants were not double counted.*
[b]*Heterogeneity: τ^2 = 0.00, I^2 = 0%.*
[c]*Heterogeneity: τ^2 = 0.16, I^2 = 38%. The Knapp-Hartung method was used to estimate confidence intervals, due to 3 to 5 comparisons present.*

FIGURE 6. Meta-analysis of walking/running versus minimal/no intervention for the outcome of disability for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

Pain and Disability

Outcome/Time Point/Study	Participants, n: Intervention	Participants, n: Control	*P* Value	SMD (95% Confidence Interval)
Pain				
Short term[a]				
Marshall et al[27]	32	32	.046	0.51 (0.01, 1.01)
Medium term[a]				
Marshall et al[27]	32	32	.445	0.19 (−0.30, 0.68)
Disability				
Short term[a]				
Ganesh et al[11]	30	30	<.01	1.13 (0.59, 1.68)
Marshall et al[27]	32	32	.031	0.55 (0.05, 1.05)
Medium term[a]				
Ganesh et al[11]	30	30	<.01	1.19 (0.64, 1.74)
Marshall et al[27]	32	32	.108	0.41 (−0.09, 0.90)

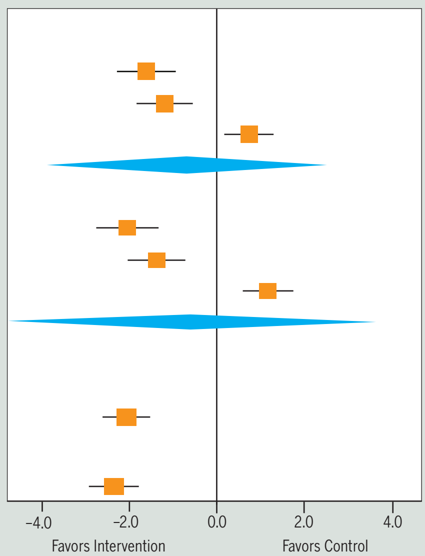


Abbreviation: SMD, standardized mean difference.
[a]*No pooled estimate was provided when only 1 or 2 studies were available for the outcome.*

FIGURE 7. Meta-analysis of cycling versus alternate intervention for the outcomes of pain and disability for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

Pain

Comparison/Time Point/Study	Participants, n: Intervention	Participants, n: Control	*P* Value	SMD (95% Confidence Interval)
Alternate intervention				
Short term				
Weifen et al (jogging)[44]	13[a]	47	<.01	−1.69 (−2.38, −1.01)
Weifen et al (backward walking)[44]	13[a]	47	<.01	−1.28 (−1.93, −0.62)
Weifen et al (tai chi)[44]	13[a]	132	.025	0.66 (0.08, 1.23)
Subtotal[b]			.418	−0.76 (−4.00, 2.48)
Medium term				
Weifen et al (jogging)[44]	13[a]	47	<.01	−2.07 (−2.79, −1.36)
Weifen et al (backward walking)[44]	13[a]	47	<.01	−1.41 (−2.08, −0.75)
Weifen et al (tai chi)[44]	13[a]	132	<.01	1.12 (0.54, 1.70)
Subtotal[c]			.521	−0.78 (−5.13, 3.57)
Minimal/no intervention				
Short term[d]				
Weifen et al[44]	38	40	<.01	−2.07 (−2.62, −1.52)
Medium term[d]				
Weifen et al[44]	38	40	<.01	−2.36 (−2.94, −1.78)



Abbreviation: SMD, standardized mean difference.
[a]*When trials included more than 1 comparison in the same meta-analysis, the sample size was split in the shared groups, as per Cochrane recommendations, to ensure participants were not double counted.*
[b]*Heterogeneity: $\tau^2 = 1.26$, $I^2 = 94\%$. The Knapp-Hartung method was used to estimate confidence intervals, due to 3 to 5 comparisons present.*
[c]*Heterogeneity: $\tau^2 = 1.71$, $I^2 = 96\%$. The Knapp-Hartung method was used to estimate confidence intervals, due to 3 to 5 comparisons present.*
[d]*No pooled estimate was provided when only 1 or 2 studies were available for the outcome.*

FIGURE 8. Meta-analysis of swimming versus alternate or minimal/no intervention for the outcome of pain intensity for the treatment of low back pain. All data extracted from each trial can be found in supplemental file 5.

erogeneity, meta-analysis was conducted for only 1 measure of fear avoidance (the Fear-Avoidance Beliefs Questionnaire physical activity subscale). Walking/running was less effective than an alternate intervention for improving fear avoidance in the short term (SMD, 0.25; 95% CI: 0.04, 0.47; I^2 = 0%), and neither more nor less effective in the medium term (SMD, 0.08; 95% CI: –0.26, 0.42; I^2 = 0%) (supplemental file 3).

Adverse events were reported in 6 walking trials. The numbers of adverse events were low, similar between the walking and control groups, and tended to be minor events that were musculoskeletal in nature, that is, lower-limb or back pain (2 versus 0,[8] 8 versus 0,[28] 7 versus 0,[19] 0 versus 1,[25] 0 versus 0,[29] and 0 versus 0,[22] respectively).

DISCUSSION

Key Findings

We found low- to high-certainty evidence that walking/running was less effective than alternate treatments in reducing pain and disability, but these differences were relatively small. When walking/running was compared to minimal/no intervention, there was high-certainty evidence that walking/running was slightly more effective for reducing pain across all time points and for reducing disability in the short term.

Few studies reported the treatment effects of cycling or swimming, although the findings were not dissimilar to those for walking/running. Results from 2 trials suggested that cycling was less effective than alternate interventions for reducing disability in the short and medium term. Results from a single trial suggested that swimming was no more effective than alternate interventions for reducing pain in the short and medium term, but was substantially superior when compared to minimal/no intervention.

There was an absence of trials investigating walking/running, cycling, or swimming for preventing LBP.

Comparison to Previous Literature and Meaning of the Findings

Two previous systematic reviews with meta-analysis concluded that walking was as effective as other interventions in reducing pain and disability in adults with chronic LBP.[37,43] We found walking/running to be inferior to alternate interventions for reducing pain and disability, although our estimates were imprecise and the CIs include very small differences. The difference between our results and those of previous reviews could be because we ran 2 separate meta-analyses, where we compared our intervention of interest to either alternate interventions or minimal/no intervention. Therefore, some studies that we analyzed in separate meta-analyses were combined in previous reviews.

Our results showing that the effect of walking/running is different when compared to alternate interventions versus minimal or no intervention represent an important new finding. In addition, the systematic reviews of both Sitthipornvorakul et al[37] and Vanti et al[43] included 9[5,7,16,21,24,26,28,36,42] and 5[5,16,19,28,36] walking trials, respectively, while our review included 16.

Characteristics of the included walking/running studies are also an important consideration when interpreting our findings. Across the included studies, there was considerable heterogeneity in the walking/running interventions provided, including variations in dose (15-60 minutes), frequency (2-7 sessions per week), and the type of programs provided (eg, treadmill-based, Nordic pole–assisted, or pedometer-driven programs, etc). At present, there is limited guidance as to whether treatment effects are impacted by these features, and there are too few trials to investigate this further in our review.

An important finding of our review was the scarce evidence for swimming and cycling, despite anecdotal reports by patients and clinicians that these strategies are helpful to treat and prevent LBP. No previous reviews have investigated the effects of cycling or swimming on LBP. We identified only 2 trials (3 articles)[4,11,27] comparing cycling to an alternate intervention and 1 study comparing swimming to an alternate intervention. A previous review identified that aquatic exercise significantly reduced pain and increased physical function in patients with LBP.[35] However, aquatic exercises included any exercise in water, including deep-water running, stretching, strengthening, range of motion, etc. We specifically sought the effects of swimming, thus we excluded all studies in the aquatic therapy review.

Key Messages for Clinicians

Walking/running, cycling, and swimming appear to be slightly less effective than alternate interventions for treating LBP. Walking and possibly swimming provide small benefits when compared to minimal or no intervention for treating chronic or recurrent nonspecific LBP. Some patients may choose walking over alternative interventions, given the accessibility, flexibility, low cost, and general health benefits. However, other patients may choose a slightly more effective intervention, even if it is more costly and less flexible.

Limitations

No trials explored interventions for preventing LBP. We could only include a small number of trials in comparisons for cycling and swimming for treating LBP. These important gaps in the literature warrant further investigation.

Many trials examined the effects of the interventions of interest when both groups received a cointervention. It is possible that the effects could be different when no cointervention is included, and therefore post hoc analyses were conducted, excluding studies with a cointervention for the comparison of walking versus alternate interventions. These are reported in addition to the main results (supplemental files, available at www.jospt.org). Another potential criticism could be our decision to pool all alternate interventions as a comparison, despite these potentially having different effects. However, this approach is common and enables us to provide clinicians with the best estimate of the effectiveness of walking/running, cycling, or swimming compared to alternate options. Details regarding the comparison interventions are provided for each study, so readers can make an informed interpretation of the pooled results.

The majority of included studies recruited patients with chronic LBP. However, 1 study[25] included people with chronic and recurrent LBP, and another included only people with recurrent LBP.[32] We do not believe that this substantially impacted our results, as the baseline characteristics of participants in these 2 studies, including the duration of pain, are similar to those of the other included studies.

Despite our efforts to obtain data through contacting authors, some data were unattainable due to the age of the trial,[9] and in other cases SDs were not published and had to either be calculated based on other relevant measures of effect and variability (eg, mean and 95% CI or median and interquartile range) or estimated based on a similar included trial, as recommended by the Cochrane Collaboration. Finally, only 5 of the included trials made comments about adherence to the intervention,[8,19,27,28,32] making it difficult to determine whether compliance levels impacted results.

CONCLUSION

WALKING/RUNNING WAS SLIGHTLY less effective than alternate treatments, and slightly more effective than minimal/no intervention, for improving disability in the short term and pain across all time points. Cycling was slightly less effective than alternate interventions for reducing disability in the short and medium term. There was scarce evidence, but 1 trial indicated that swimming was more effective than minimal/no intervention in reducing pain in the short and medium term. ◉

KEY POINTS

FINDINGS: Accessible and common forms of exercise (walking/running, cycling, and swimming) were inferior to alternate treatments, but slightly superior to minimal/no intervention, for treating low back pain. It is unclear whether walking/running, cycling, and swimming are effective for preventing low back pain.
IMPLICATIONS: Clinicians should discuss these results with patients as part of shared decision making around care plans for low back pain. Some patients may choose walking/running, cycling, or swimming over alternate interventions, given the accessibility, flexibility, low cost, and general health benefits. However, other patients may choose a slightly more effective intervention, despite additional cost and less flexibility.
CAUTION: Certainty of the evidence ranged from high to low, and only a small number of trials investigated cycling and swimming for treating low back pain. Few trials reported on adherence, making it difficult to determine whether this impacted the results.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Natasha C. Pocovi and Dr de Campos and Prof Hancock had full access to all data in this systematic review and take responsibility for the integrity of the data and the accuracy of the data analysis. Natasha C. Pocovi and Prof Lin and Prof Hancock contributed to study concept and design and provided study supervision. Natasha C. Pocovi and Prof Hancock drafted the manuscript and performed statistical analysis. All authors contributed to the acquisition, analysis, or interpretation of data; provided critical revision of the manuscript for important intellectual content; and provided administrative, technical, or material support.
DATA SHARING: All data relevant to the study are included in the article or are available as supplemental files.
PATIENT AND PUBLIC INVOLVEMENT: No patient and/or public involvement was required for this review.

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Exercise Descriptors That Determine Muscle Strength Gains Are Missing From Reported Anterior Cruciate Ligament Reconstruction Rehabilitation Programs: A Scoping Review of 117 Exercises in 41 Studies

Muscle weakness after anterior cruciate ligament reconstruction (ACLR) is persistent and associated with abnormal biomechanics,[48,61] poor knee function,[5,14,44-46] new knee injury,[27,42] and development of osteoarthritis.[49,60]

OBJECTIVE: To (1) describe which strength training exercise descriptors are reported in anterior cruciate ligament reconstruction (ACLR) rehabilitation research, and (2) compare the current standards of reporting ACLR strength training exercise descriptors to international best-practice strength training guidelines.

DESIGN: Scoping review.

LITERATURE SEARCH: We searched the MEDLINE, PsycINFO, CINAHL, SPORTDiscus, Academic Search, ERIC, Health Source: Nursing, Health Source: Consumer, MasterFILE, and Africa-Wide Information databases.

STUDY SELECTION CRITERIA: We included level I to IV studies of ACLR rehabilitation programs with 1 or more reported strength training exercise descriptors. We used a predefined list of 19 exercise descriptors, based on the American College of Sports Medicine (ACSM) exercise recommendations, the Consensus on Exercise Reporting Template (CERT), and the Toigo and Boutellier exercise descriptor framework.

DATA SYNTHESIS: Completeness and the standard of reporting exercise descriptors in ACLR rehabilitation programs were assessed by means of international best-practice strength training standards.

RESULTS: We extracted data on 117 exercises from 41 studies. A median of 7 of the 19 possible exercise descriptors were reported (range, 3-16). Reporting of specific exercise descriptors varied across studies, from 95% (name of the strength training exercise) to 5% (exercise aim, exercise order). On average, 46%, 35%, and 43% of the exercise descriptors included in the ACSM, CERT, and Toigo and Boutellier guidelines were reported, respectively.

CONCLUSION: Key exercise descriptors for muscle strength gains are not reported in studies on ACLR rehabilitation. Only the exercise name, number of exercises, frequency, and experimental period were reported in most of the studies. *J Orthop Sports Phys Ther 2022;52(2):100-112. Epub 16 Nov 2021. doi:10.2519/jospt.2022.10651*

KEY WORDS: *anterior cruciate ligament reconstruction, CERT, exercise descriptors, intervention reporting, strength training*

Six months after ACLR, up to 40% of patients have side-to-side differences in quadriceps strength.[45] Additionally, patients had moderate side-to-side differences in isometric and concentric quadriceps strength, significant differences in eccentric quadriceps strength, and moderate differences in isometric hamstring strength 2 years after ACLR.[77] The proposed drivers of persistent muscle weakness after ACLR are changes in muscle morphology,[10,58] atrophy-inducing cytokines in the knee joint,[55,85] and neurological alterations at cortical and spinal levels.[65]

The most accessible approach to target muscle weakness is to use various types of strength training exercises.[51,63] Because muscle weakness persists after rehabilitation, standard strength training may not be sufficient, and clinicians should target the neurophysiological origins of weakness with, for example, joint aspiration, corticosteroid injection, or electromagnetic modalities.[48] However, another explanation for persistent weakness after ACLR rehabilitation could be

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that programs are not following best practice for strength training.[21]

To improve muscle performance outcomes, a strength training program should follow the proposed laws of mechanotransduction,[39] exercise specificity,[40] and the specific adaptations to imposed demands principle. Failure to improve muscle strength after ACLR could, therefore, be caused by faulty programming of exercise descriptors (eg, exercise type, frequency, and load).[54] To determine whether the full potential of strength training was realized in previous literature, we need more knowledge about the exercise descriptors that are reported in ACLR rehabilitation studies.

Exercise descriptors that impact the result of strength training are well described in key exercise physiology publications. In 2006, Toigo and Boutellier[79] (T&B) reviewed mechanobiological determinants of muscle hypertrophy and presented exercise descriptors that target these determinants. Ratamess et al[66] proposed guidelines and progression models for resistance training in the position stand statement of the American College of Sports Medicine (ACSM). Slade et al[74] developed the Consensus on Exercise Reporting Template (CERT) to improve the reporting of essential exercise components across all evaluative study designs.

These international standards collectively cover a comprehensive list of exercise descriptors that influence the outcomes of strength training programs.

Therefore, the primary aim of this scoping review was to determine which strength training exercise descriptors are reported in ACLR rehabilitation research. Our secondary aim was to evaluate how the reporting in these studies compares to international standards of reporting strength training exercise descriptors.

METHODS

Protocol and Registration

A scoping review design was used due to the exploratory nature of the research question, where the aim was to determine which strength training exercise descriptors are reported in ACLR rehabilitation research. Study quality and risk-of-bias assessments do not influence scoping review outcomes and were therefore not performed.[1] We followed the 5-stage methodological framework proposed by Arksey and O'Malley,[1] using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[80] guidelines to map the available ACLR exercise descriptors. The review was registered prospectively through the Joanna Briggs Institute web page (https://joannabriggs.org/systematic-review-register) and the Open Science Framework online platform (https://doi.org/10.17605/OSF.IO/62VYA).

Eligibility Criteria

We included randomized trials, cohort studies, cross-sectional studies, case reports, and case-control studies in the scoping review. The search was limited to studies published in the English language. Studies that reported ACLR strength training exercise descriptors between January 1990 and April 2021 as part of rehabilitation were included. We chose this time frame to limit the review to recent studies and thereby reflect current clinical practice.

Inclusion in this scoping review was based on the following eligibility criteria.

Participants Men and women (aged 16 years and older) with ACLR in isolation or in combination with meniscus repair/resection or cartilage surgery were included. The ACLR could be performed with either patellar tendon or hamstring tendon autografts. Studies that included patients who had ACLR with allografts and anterior cruciate ligament (ACL) repair were excluded, as differences in graft strength, fixation strength, and functional tension can influence rehabilitation.[28] Articles were excluded if the studied participants were nonsurgically treated after ACL injury, had other associated grade lll ligamentous knee injuries combined with ACL injury, or had significant concomitant injuries to any area other than the knee.

Exercise Intervention We included studies that described strength training exercises, defined as exercises with a fixed mass as the means of resistance (eg, ankle weights, plate-loaded resistance training machines, free weights, or resistance bands). A priori defined strength training descriptors are described in **TABLE 1**. We excluded studies that described strength training only in combination with supplementary modalities, such as neuromuscular electrical stimulation, blood flow restriction training, isokinetics, or cryotherapy.

Time At least 1 strength training exercise descriptor had to be reported in the rehabilitation program between 2 and 12 months post ACLR.

Context We included studies in which rehabilitation was performed in any setting (home-based, gym-based, or clinic-based rehabilitation).

Information Sources and Search

The librarian and first author (A.V.) compiled key phrases and words to search the different databases (supplemental file 1, available at www.jospt.org). A librarian-assisted computer search of MEDLINE, PsycINFO, CINAHL, SPORTDiscus, Academic Search, ERIC, Health Source: Nursing, Health Source: Consumer, MasterFILE, and Africa-Wide Information was conducted in October 2019 and updated in April 2021. The first author (A.V.) did a hand search of all references in all included papers to identify potentially eligible articles that were missed during the electronic database search.

Study Selection

All references were downloaded into an Excel (Microsoft Corporation, Redmond, WA) spreadsheet screening tool, specifically developed by a librarian (Helena VonVille) for literature reviews. All duplicates were removed before the screening process. Two independent screeners (A.V. and D.C.) conducted the level 1 initial screening process of each article. To ensure interscreener reliability, the reviewers performed 1 training session before the screening process. Two reviewers (A.V. and D.C.) independently screened titles and abstracts for relevance. We compared and summarized the results within the customized Excel spreadsheet workbook. The remaining studies were independently screened by the same reviewers in full text to determine eligibility, and reasons for exclusion were reported (supplemental file 2, available at www.jospt.org). Any disagreements between reviewers were resolved in a consensus meeting. Duplicate interventions were excluded, and we included the intervention with the most comprehensive description of exercises. The scoping review focused only on the extent to which studies reported the strength training exercise descriptors. The review did not focus on the outcome (efficiency or effectiveness) of any intervention.

Data Extraction

We reviewed full-text articles, supplementary files, and referenced articles to locate data for extraction. Data extraction was primarily performed by 1 reviewer (A.V.) and verified by a second (D.C.). To ensure that the data extraction was consistent, a random sample of the included studies (ie, 5% of the complete list of retrieved studies) was extracted in duplicate (A.V. and D.C.).

The 19 descriptors (**TABLE 1**) obtained from different sources (ACSM, T&B, and CERT) were extracted as the primary strength training descriptors. Two of these templates (T&B and CERT) have previously been used in studies evaluating exercise descriptors.[3,12,29] We composed the list of descriptors based on available guidelines on strength training recommendations (ACSM),[66] strength training exercise physiology (T&B),[79] and consensus recommendations for reporting exercise interventions (CERT).[74] The screening authors reviewed and selected 19 descriptors a priori for data extraction through a consensus approach (**TABLE 1**).

For all studies included in the review and for all strength training exercise descriptors (**TABLE 1**), the presence of a given exercise descriptor in a given study was coded as binary data (1 is present, 0 is absent). Additionally, we extracted data that described any clinical indicators that would cause adjustment to the strength training program (eg, pain or effusion).

Data Management and Analysis

The percentage of studies that reported the exercise descriptor (out of the total number of studies included) was calculated. In addition, we calculated the percentage of exercise descriptors reported in a given study (out of the total number of exercise descriptors stipulated in each of the 3 guidelines). These percentages were calculated as averages for each publication year in the period from 1992 to

TABLE 1 DEFINITION OF STRENGTH TRAINING EXERCISE DESCRIPTORS

Descriptor	Definition	Checklist or Recommendation: ACSM	T&B	CERT
Exercise name	The name of the exercises prescribed	x	x	
Experimental period	The duration of the entire program (eg, 12 weeks)		x	x
Number of exercises	The number of exercises prescribed per session	x		
Frequency	The number of sessions per week	x	x	x
Adherence	The extent to which the patient performed the prescribed program			x
Repetitions	The number of movements in a set	x	x	x
Exercise progress	The progression of individual exercises (eg, increase in repetitions, load, and speed)	x		x
Exercise type	The mode of exercise selected for a training program (eg, neuromuscular control exercises or strength training)	x		
Program progress	The progression of the entire program (eg, increase in the number of exercises or sessions per week)			x
Sets	The number of cycles of repetitions performed. Sets are separated by a rest interval	x	x	x
Load	The amount of resistance assigned to an exercise set	x	x	x
Range of motion	The degree of movement around a specific joint during an exercise		x	x
Rest	The duration of recovery time between sets	x	x	x
Tempo	The velocity at which an exercise is performed	x		x
Muscle action	The type of muscle action during a repetition (eg, concentric, isometric, or eccentric)	x	x	
Muscular voluntary failure	Whether exercises should be performed to the point of muscular voluntary failure (eg, repetitions performed until exhaustion)		x	x
Training duration	The duration of each session (eg, 45 minutes)			x
Exercise order	The sequence of exercises performed in a session (eg, multijoint exercises before single-joint exercises)	x		
Exercise aim	The specific purpose of the exercise (eg, hypertrophy or maximum strength)			x

Abbreviations: ACSM, American College of Sports Medicine; CERT, Consensus on Exercise Reporting Template; T&B, Toigo and Boutellier.

2020, together with rolling averages, using a window size of 5 (**FIGURE 1**).

RESULTS

THE SEARCH YIELDED 754 STUDIES after 7 hand-searched articles were added. After duplicates were removed, 420 studies remained for title and abstract screening. After applying the eligibility criteria, a total of 41 studies were included in the review (**FIGURE 2**).

Baseline Study Characteristics

The demographic characteristics of the 41 studies included in the analysis are summarized in **TABLE 2**. In total, 28 randomized controlled trials (68%), 6 prospective cohort studies (15%), 3 cross-sectional studies (7%), 3 case reports (7%), and 1 case series (2%) were included. Collectively, the studies represent 1964 individuals who underwent rehabilitation after ACLR, 1492 (76%) men and 472 (24%) women aged 16 to 56 years. The ACLR was performed with either a patellar tendon (63%) or hamstrings tendon (37%) autograft.

Rehabilitation Setting

Experienced clinicians supervised the majority (30/41 studies, 73%) of ACLR rehabilitation programs in sports clinics, gyms, or hospital-based facilities. Fewer rehabilitation programs were entirely unsupervised: home based (9/41 studies, 22%), or home based combined with supervised booster sessions (2/41 studies, 5%).

Reported Strength Training Exercise Descriptors in ACLR Rehabilitation Research

A total of 117 ACLR strength training exercises were described in the 41 studies. The studies reported between 3 and 16 of the 19 exercise descriptors (**FIGURE 3**), with a median of 7 exercise descriptors reported. The name of the strength training exercises, number of exercises, and the experimental period were the descriptors most often documented in the included studies (**FIGURES 3** and **4**). The number of exercises used and the frequency of sessions were reported 71% to 83% of the time (**FIGURE 4**). Across the different studies, experimental periods most often lasted 3 to 6 months (24/41, 59%), and patients most often performed 2 to 3 exercise sessions per week (20/41, 49%). Supervised sessions varied from 2 (8/41 studies, 20%) to 3 sessions (17/41 studies, 41%) per week. There was, however, a considerable variation in sessions per week, from 2 to 10. The most frequently prescribed exercises to improve muscle strength were leg press (19/41 studies) and leg extension (20/41 studies).

Fewer than half of the studies reported exercise type, exercise progress, program progress, repetitions, sets, adherence, range of motion, and magnitude of load (**FIGURE 4**). Collectively, 44% to 46% of studies described number of repetitions, exercise progress, exercise type, program progress, and sets (**FIGURE 4**). Of the 117 exercises described across the studies, 53 (45%) included information on the number of repetitions. Tempo, rest, range of motion, and load magnitude were all reported in 20% to 34% of the studies. Only 34% (14/41) of the studies specified the magnitude of load, which was com-

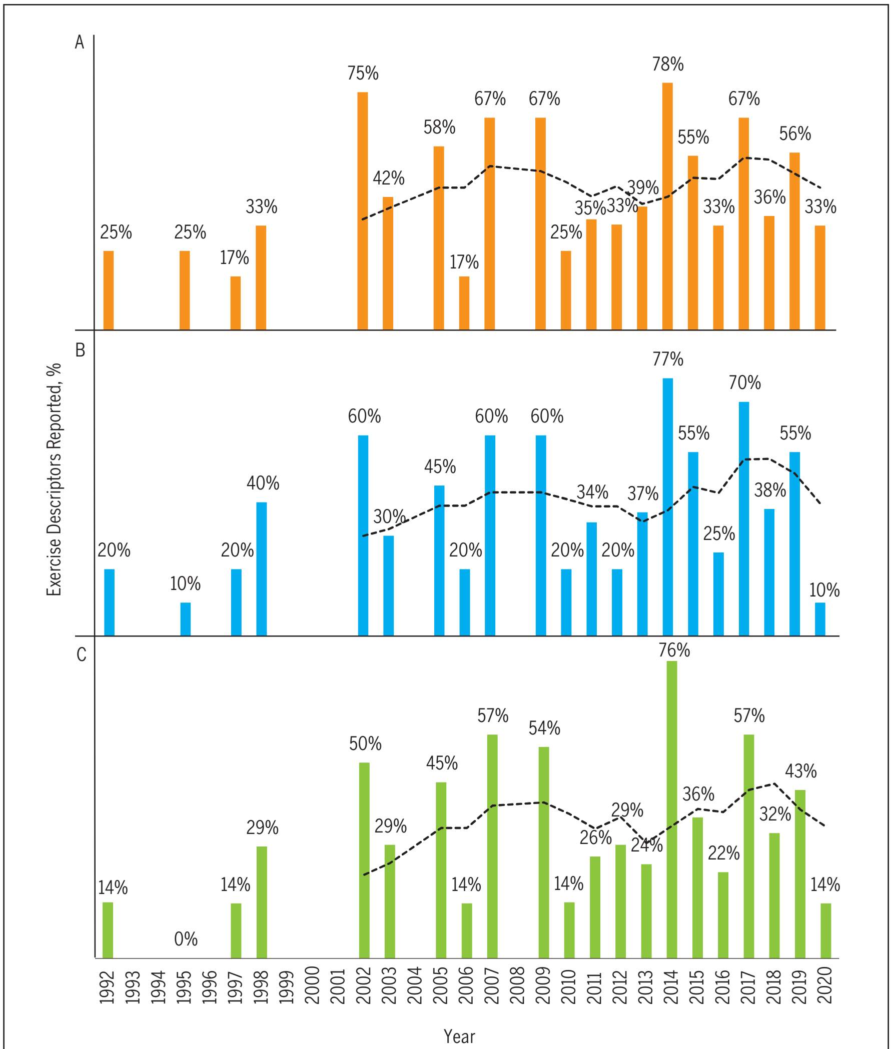

FIGURE 1. Average percentage of reported (A) ACSM, (B) T&B, and (C) CERT exercise descriptors from 1992 to 2020. Lines indicate rolling averages. Abbreviations: ACSM, American College of Sports Medicine; CERT, Consensus on Exercise Reporting Template; T&B, Toigo and Boutellier.

monly 50% to 80% of 1-repetition maximum (1RM).

Only 5% to 15% of studies reported the exercise descriptors of muscular voluntary failure, exercise aim, training duration, muscle action, and exercise order (**FIGURE 4**).

Clinical Status of ACLR Knee During the Rehabilitation

Fewer than half of the studies (18/41, 44%) reported that exercises were adjusted based on the clinical status of the knee. Pain and effusion were 2 key indicators that were noted in 16/41 (39%) studies.

Reporting of ACLR Rehabilitation Research Compared With International Strength Training Standards

The average annual reporting values of the strength training exercise descriptors for the time period of 1992 to 2020 for the ACSM (**FIGURE 1A**), T&B (**FIGURE 1B**), and CERT (**FIGURE 1C**) guidelines were summarized in **FIGURE 1**. Average annual ACLR exercise descriptor reporting varied between 17% and 78% when compared to ACSM guidelines. There was a 10% increase in the reporting of ACSM exercise descriptors from 2002 (rolling average, 35%) to 2020 (rolling average, 45%). For the T&B framework, ACLR exercise descriptor documentation varied between 10% and 77%.

The reporting of items 5, 7, 11, and 13 of the CERT guidelines (adapted for this study; **TABLE 1**) is presented in **FIGURE 1C**, with 13 descriptors to evaluate the ACLR intervention programs' reporting quality. Exercise descriptor reporting using the CERT guidelines varied between 0% and 76%. The rolling averages demonstrated large variability in the reporting of the exercise descriptors for all 3 guidelines (**FIGURE 1**). The average percentages of ACLR exercise descriptors documented (1992-2020) for each source were 46% (ACSM), 35% (CERT), and 43% (T&B).

DISCUSSION

In studies on ACLR rehabilitation, the exercise name, the duration of the rehabilitation period, the number of exercises in the program, and the frequency of training sessions per week were frequently reported. The remaining 15 exercise descriptors included in international standards of strength training were infrequently reported (by 5% to 49% of studies).

How Is Strength Training Prescribed in ACLR Rehabilitation Studies?

Only 4 of the 19 exercise descriptors were consistently documented in our sample (**FIGURE 4**), and it is difficult to interpret or reproduce ACLR strength training programs when so few exercise descriptors are reported. The poor reporting also means that we cannot conclude that muscle weakness persists in patients who follow best practice for strength training.[21] Clinicians should therefore not discount strength training as a main factor to regain muscle strength after ACLR.

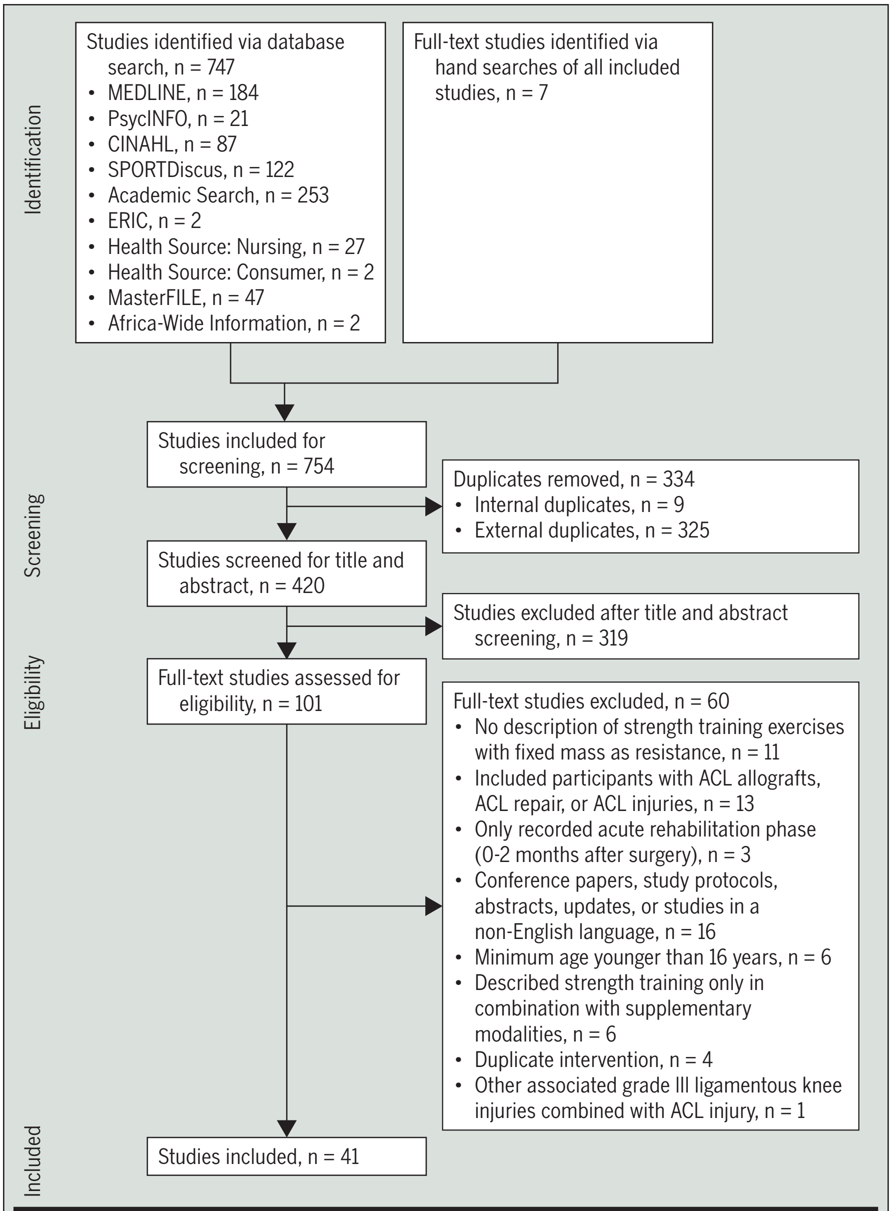

FIGURE 2. Flow chart of the study selection process according to the PRISMA extension for Scoping Reviews guidelines. Abbreviation: ACL, anterior cruciate ligament.

Strength Training and Muscle Weakness After ACLR

Although many factors influence successful rehabilitation and return to sport post ACLR,[59] muscle weakness after ACLR is driven by 2 main factors: a decrease in the cross-sectional area (atrophy) and arthrogenic muscle inhibition (quadriceps activation failure).[38,56,78] According to the ACSM best-practice strength training guidelines, strength training to increase the cross-sectional area should be performed with 6 to 12 repetitions, 2 to 4 sets, 60 to 120 seconds of rest between sets, and a load magnitude of 60% to 80% of 1RM. Exercises should include concentric, isometric, and eccentric muscle actions. The program's proposed duration should be 8 to 12 weeks, with a frequency of 2 to 4 sessions per week.[40] It should be noted, however, that more recent research has found that hypertrophy can be achieved with both low-load and high-load strength training.[71]

Of the studies on ACLR rehabilitation, 90% reported the experimental period's duration and 71% included frequency. However, only 44% of studies reported sets, 46% reported repetitions, 34% reported load magnitude, 20% reported rest, and 15% reported muscle action. Strength training exercise descriptors are important if we are to understand the impact of exercise selection on cross-sectional area in ACLR rehabilitation programs. Few studies report all exercise descriptors included in international standards for strength training, which impedes any interpretation of whether study participants received an adequate strength training stimulus to reduce muscle atrophy. In addition, low-intensity strength training post ACLR leads to lower muscle power response in leg extension when compared to high-intensity training.[9]

Activating the high-threshold motor units with maximal strength training is one way to target quadriceps muscle inhibition.[54] Exercise prescription for maximal strength training should involve a load magnitude of greater than 80% of 1RM, 1

TABLE 2 — Demographic Characteristics of Study Participants

Study, Year, Study Design	Sample Size (Sex), Age[a]	Preinjury TAS Score[b]	Start of post-ACLR Rehabilitation	Graft Type
Wilk et al[84] 1992 CSS	n = 250 (all male) 24 ± 8	...	Day 1	Patellar, n = 250
Bynum et al[11] 1995 RCT	n = 97 (88 male, 9 female) 27	4	Day 2	Patellar, n = 97
De Carlo and Sell[17] 1997 RCT	n = 180 (130 male, 50 female) 28	...	Week 2	Patellar, n = 180
Beard and Dodd[4] 1998 RCT	n = 26 (21 male, 5 female) 28	...	Day 3	Patellar, n = 26
Tsaklis and Abatzides[81] 2002 RCT	n = 45 (all male) 25 ± 6	...	Week 1	Patellar, n = 45
Liu-Ambrose et al[51] 2003 RCT	n = 10 (4 male, 6 female) 25 ± 3	9 ± 1[c]	...	Hamstring, n =10
Beynnon et al[8] 2005 RCT	n = 22 (11 male, 11 female) 33	...	Week 1	Patellar, n = 22
Perry et al[64] 2005 RCT	n = 49 (37 male, 12 female) 33 ± 7	...	Day 1	Hamstring, n = 21; patellar, n = 28
Roi et al[70] 2005 CR	n = 1 (male) 35	...	Day 8	Hamstring, n = 1
Cooper et al[13] 2005 RCT	n = 29 (20 male, 9 female) 30 ± 7	...	Days 45-50	Hamstring, n = 26; patellar, n = 3
Gerber et al[24] 2007 RCT	n = 32 (18 male, 14 female) 30 ± 9	>4	Week 3	Hamstring, n = 20; patellar, n = 12
Risberg et al[69] 2007 RCT	n = 74 (47 male, 27 female) 28	...	Week 2	Patellar, n = 74
Morrissey et al[57] 2009 RCT	n = 24 (not reported) 31 ± 7	...	...	Hamstring, n = 6; patellar, n = 18
Revenäs et al[67] 2009 RCT	n = 38 (26 male, 12 female) 23	...	Week 1	Hamstring, n = 15; patellar, n = 23
Grant and Mohtadi[26] 2010 RCT	n = 88 (all male) 31 ± 11	...	...	Patellar, n = 88
Beynnon et al[7] 2011 RCT	n = 36 (22 male, 14 female) 30 ± 10	>5	Day 1	Patellar, n = 36
Feil et al[20] 2011 RCT	n = 96 (22 male, 74 female) 33 ± 2	...	Day 1	Hamstring, n = 96

Table continues on page 106.

TABLE 2 Demographic Characteristics of Study Participants (continued)

Study, Year, Study Design	Sample Size (Sex), Age[a]	Preinjury TAS Score[b]	Start of post-ACLR Rehabilitation	Graft Type
Hohmann et al[34] 2011 RCT	n = 40 (30 male, 10 female) 20	...	Day 10	Patellar, n = 40
Lemiesz et al[43] 2011 CSS	n = 18 (13 male, 5 female) 24	...	Week 2	Hamstring, n = 18
Souissi et al[75] 2011 RCT	n = 16 (all male) 22 ± 3	...	...	Patellar, n = 16
Silva et al[73] 2012 CS	n = 7 (6 male, 1 female) 27 ± 4	...	...	Patellar, n = 7
Ericsson et al[19] 2013 PC	n = 65 (42 male, 23 female) 26 ± 5	...	Day 1	Hamstring, n = 36; patellar, n = 25
Fukuda et al[23] 2013 RCT	n = 45 (29 male, 16 female) 25 ± 7	...	Week 2	Hamstring, n = 45
Taradaj et al[76] 2013 RCT	n = 80 (all male) 22 ± 6	...	Week 2	Hamstring, n = 80
Berschin et al[6] 2014 RCT	n = 40 (29 male, 11 female) 28 ± 6	...	Week 2	Patellar, n = 40
Bieler et al[9] 2014 RCT	n = 50 (31 male, 19 female) 29 ± 1	...	Day 1	Hamstring, n = 23; patellar, n = 27
Horschig et al[36] 2014 CR	n = 1 (male) 17	...	...	Patellar, n = 1
Harput et al[31] 2015 PC	n = 24 (all male) 28 ± 8	...	Week 1	Hamstring, n = 24
Lepley et al[47] 2015 PC	n = 36 (23 male, 13 female) Not reported	...	Week 6	Hamstring, n = 5; patellar, n = 31
Hadizadeh et al[30] 2016 PC	n = 22 (13 male, 9 female) 23 ± 4	...	Day 3	Hamstring, n = 22
Luo et al[52] 2016 RCT	n = 40 (27 male, 13 female) 43 ± 14	...	Week 1	Hamstring, n = 40
Kuenze et al[41] 2017 PC	n = 10 (1 male, 9 female) 22 ± 3	8 ± 1[c]	...	Hamstring, n = 5; patellar, n = 5
Friedmann-Bette et al[22] 2018 RCT	n = 68 (55 male, 13 female) 25 ± 5	...	...	Hamstring, n = 26; patellar, n = 32
Machado et al[53] 2018 CSS	n = 34 (26 male, 8 female) 35 ± 10	...	Week 1	Hamstring, n = 17; patellar, n = 17

Table continues on page 107.

to 6 repetitions across 3 to 5 sets, a rest period of 3 to 5 minutes, and a frequency of 2 to 3 times per week.[66] Due to Henneman's size principle, muscle contractions should be completed to the point of muscular voluntary failure to activate the high-threshold motor units.[33] However, only 15% of ACLR rehabilitation studies described whether exercises were performed to muscular voluntary failure, and 49% described the participants' adherence to the intervention program (**FIGURE 4**). Therefore, for most of these studies, we do not know whether these strength training principles were followed.

Poor Functional Outcomes and Exercise Progression Principles

The ACSM recommendations for increasing strength involve implementing basic exercise progression principles (progressive overloading), such as increases in loads, repetitions, or sets. To improve functional performance and prepare patients with ACLR for the demands of cutting and pivoting sports, ACLR rehabilitation should include progressive overload.[68] Although this strength training principle has been described in some ACLR strength training programs, many patients continue to struggle with asymmetrical knee function and muscle weakness after ACLR.[18,27,68,83] Fewer than half of the studies reported exercise descriptors for progressive overload (exercise progress and program progress) (**FIGURE 4**). Exclusion of the exercise descriptors for progressive overload could indicate a lack of emphasis on loading in the programs. It is imperative that descriptors for progressive overload are reported, as underloading in ACLR strength training programs might contribute to the persistent muscle weakness observed in the studies. Muscle weakness, and particularly quadriceps weakness, after ACLR is associated with numerous complications, such as poor patient-reported outcomes,[45] gait asymmetries,[72] and altered knee joint biomechanics.[62] Knee osteoarthritis may also develop as a long-term consequence of quadriceps muscle weakness.[60]

TABLE 2 Demographic Characteristics of Study Participants (continued)

Study, Year, Study Design	Sample Size (Sex), Age[a]	Preinjury TAS Score[b]	Start of post-ACLR Rehabilitation	Graft Type
Damian and Damian[16] 2018 CR	n = 1 (male) 18	...	Day 7	Hamstring, n = 1
Lim et al[50] 2019 RCT	n = 30 (19 male, 11 female) 32 ± 11	...	Week 2	Hamstring, n = 30
Harput et al[32] 2019 RCT	n = 48 (not reported) 30 ± 7	>5	Week 1	Hamstring, n = 48
Hughes et al[37] 2019 RCT	n = 24 (17 male, 7 female) 29 ± 7	7 ± 2[c]	...	Hamstring, n = 24
Welling et al[83] 2019 PC	n = 38 (all male) 24 ± 4	...	Week 2	Hamstring, n = 24; patellar, n = 14
Vidmar et al[82] 2020 RCT	n = 30 (all male) 24 ± 6	...	Day 45	Hamstring, n = 30
Cristiani et al[15] 2021 RCT	n = 160 (115 male, 45 female) 29 ± 6	...	Weeks 1-3	Hamstring, n = 80; patellar, n = 80

Abbreviations: CR, case report; CS, case series; CSS, cross-sectional study; PC, prospective cohort; RCT, randomized controlled trial; TAS, Tegner activity scale.
[a]*Age values are mean or mean ± SD years. The SD for age was only included if it was reported in the original study.*
[b]*Values are mean ± SD or the score defined in the inclusion criteria.*
[c]*The Cochrane formula to combine groups was used to calculate the mean ± SD.*

Is the Reporting Improving?

Despite the popularity of the ACSM guidelines for strength training purposes, these guidelines are not reflected in our findings on rehabilitation strength training exercise descriptors (**FIGURE 1A**). Similarly, descriptors included in the T&B and CERT guidelines were also inconsistently used (**FIGURES 1B** and **1C**, respectively). Rehabilitation studies published after the publication of the T&B[79] framework and the CERT[74] guidelines did not show markedly higher standards of reporting compared to studies published before these guidelines existed (**FIGURES 1B** and **1C**). These findings suggest that reporting of exercise descriptors is still not highly prioritized in this field of research. It is beyond the scope of our study to determine the reasons for poor reporting. However, we call on authors and editors to ensure that exercise descriptors in rehabilitation programs are reported along with other study details (eg, design and surgical procedures), and to make use of appendices if the level of reported detail is restricted by article word limits. Only with reported exercise descriptors can study results be fully interpreted and rehabilitation research replicated. For clinicians, reported exercise descriptors are also key to successfully transfer rehabilitation programs from research to practice.

Is the Lack of Reporting Unique to ACLR Rehabilitation?

The inadequate intervention reporting is not a phenomenon related exclusively to ACLR rehabilitation studies. None of the interventions used to develop knee osteoarthritis exercise recommendations were reported in enough detail to allow replication in clinical practice.[3] Exercise descriptors in patellofemoral pain and Achilles tendon rupture intervention studies are also poorly documented.[12,35] Our findings expand on those of 2 other reviews, which concluded that acute program variables (exercise order, tempo, rest, frequency) are inadequately described in tibiofemoral joint soft tissue injuries[25] and that the reporting of ACLR rehabilitation programs lacks specificity.[2]

Strengths and Limitations

We assessed 117 ACLR strength training exercises across 41 studies for reporting quality and compared ACLR strength training exercise reporting with international standards for strength training, a novel approach in scoping reviews on ACLR rehabilitation interventions. The search was limited to the last 30 years, and we assessed development over time, which strengthens our ability to draw conclusions on contemporary ACLR rehabilitation programs. We only included studies on rehabilitation after ACLR with autografts, and our conclusions may not apply to rehabilitation programs after ACLR with allografts and to nonsurgical ACL rehabilitation programs.

CONCLUSION

Most strength training exercise descriptors that determine muscle strength gains are inadequately reported in studies on ACLR rehabilitation. Only the exercise name, number of exercises, frequency, and the duration of the experimental period were reported in most of the studies. ◉

KEY POINTS

FINDINGS: The only exercise descriptors frequently reported in studies on anterior cruciate ligament reconstruction (ACLR) rehabilitation were the exercise name, the number of exercises in the program, the duration of the rehabilitation period, and the frequency of training sessions per week. Over the past 3

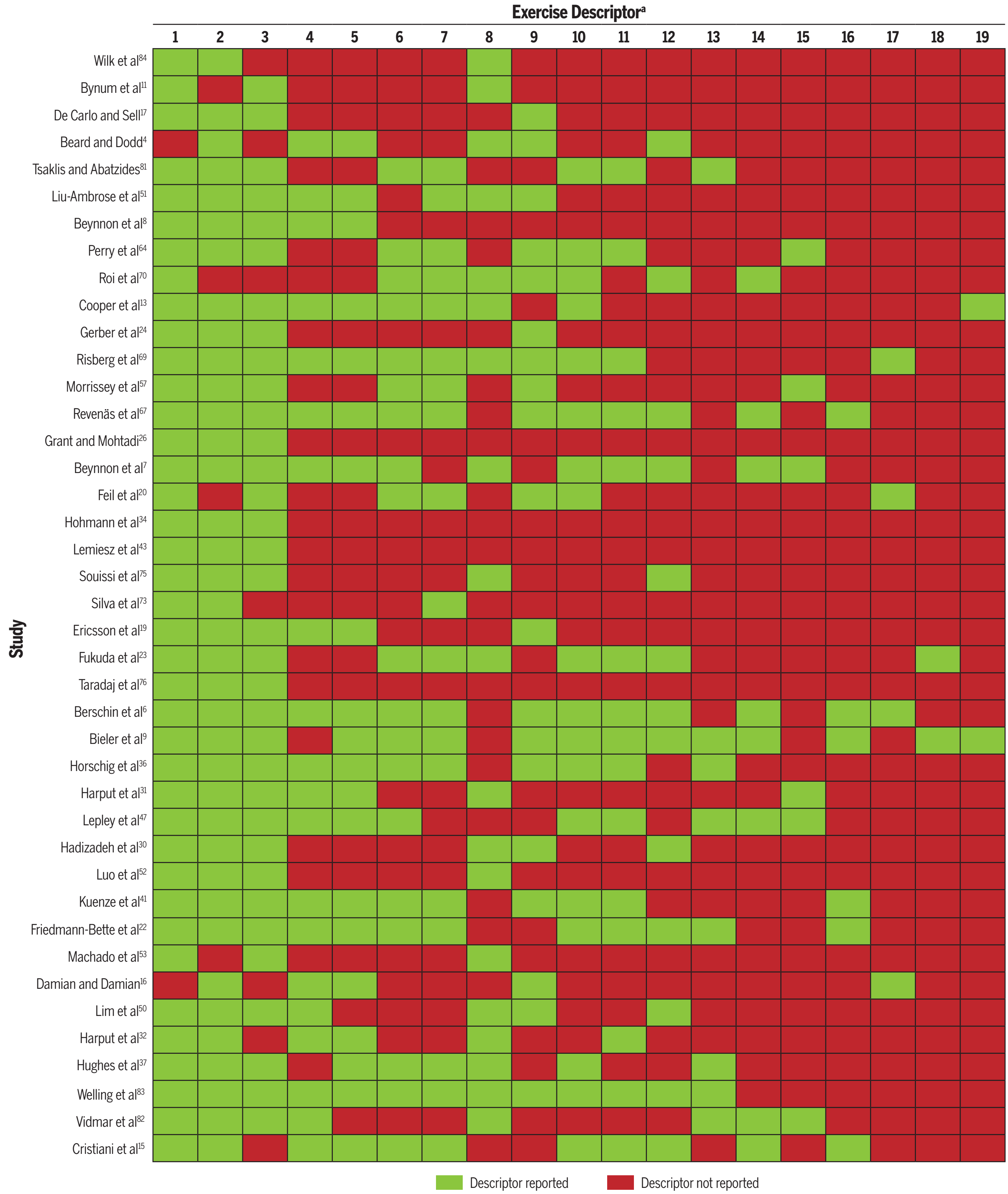

FIGURE 3. Exercise descriptors reported in studies on rehabilitation after anterior cruciate ligament reconstruction. [a]1, Exercise name; 2, Expermental period; 3, Number of exercises; 4, Frequency; 5, Adherence; 6, Repetitions; 7, Exercise progress; 8, Exercise type; 9, Program progress; 10, Sets; 11, Load; 12, Range of motion; 13, Rest; 14, Tempo; 15, Muscle action; 16, Muscular voluntary failure; 17, Training duration; 18, Exercise order; 19, Exercise aim.

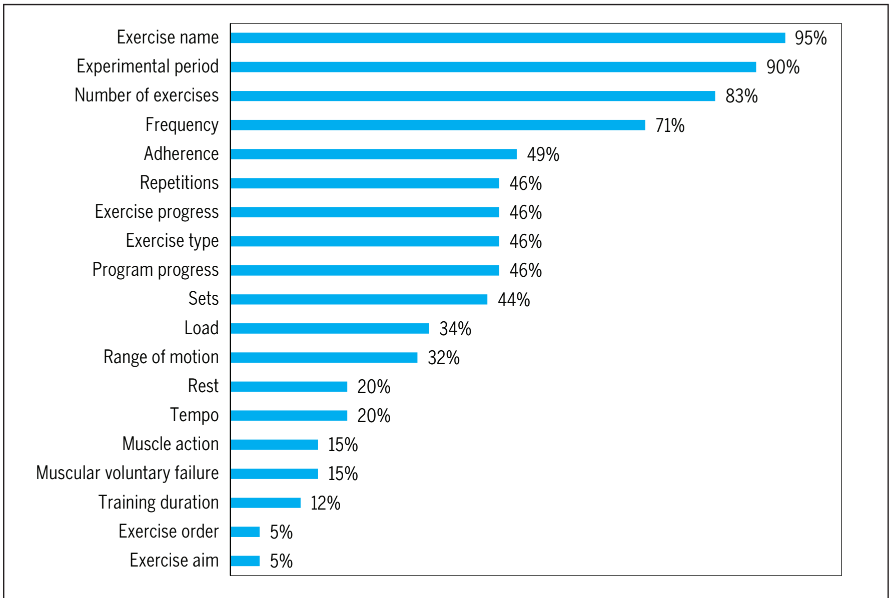

FIGURE 4. Percentage of studies that reported strength training exercise descriptors in rehabilitation programs after anterior cruciate ligament reconstruction.

decades, there has been no apparent improvement in the reporting of exercise descriptors included in the American College of Sports Medicine, Consensus on Exercise Reporting Template, and Toigo and Boutellier strength training guidelines.

IMPLICATIONS: Persistent muscle weakness is reported after ACLR rehabilitation, but how the strength training was performed is poorly reported. Clinicians should therefore not discount strength training, performed as per best-practice guidelines, as a main factor to regain muscle strength after ACLR.

CAUTION: Readers should be careful to generalize these results to other conditions and injuries.

STUDY DETAILS

AUTHOR CONTRIBUTIONS: Arnold Vlok contributed to study concept and design, data collection, data synthesis, and the outline and editing of the manuscript. Dr Grindem contributed to study concept and design and the editing of the manuscript. Dr van Dyk contributed to study concept and the outline, writing, and editing of the manuscript. Dr Coetzee contributed to data collection, data synthesis, and the outline and editing of the manuscript. All authors approved the final version.

DATA SHARING: Data are available on request.

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

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