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REVIEW ARTICLE

Describing the nonsurgical, nonpharmacological interventions offered to adolescents with persistent back pain in randomized trials: A scoping review

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Abstract

Background and Objectives: Persistent nonspecific back pain is now established as a biopsychosocial phenomenon that can be meaningfully affected by individuals' cognitions, emotions, lifestyle factors and family and social relationships. Recent guidelines for the treatment of adolescents with persistent nonspecific back pain, as well as those for youth with mixed chronic pain, strongly recommend interdisciplinary care in which adolescents receive treatment for both mind and body. The objective of this scoping review was to examine the interventions evaluated in randomized trials for adolescents with persistent back pain to determine whether they correspond to these guidelines and to reveal future research priorities.

Databases and data treatment: The review protocol was registered in March 2022. We followed the PRISMA guidelines for scoping reviews. Twelve electronic databases were searched for relevant study reports. Data were charted on study characteristics, participant characteristics and intervention details using the Template for Intervention Description and Replication (TIDieR) checklist.

Results: The search yielded 1952 records, of which eight reports representing seven randomized trials were eligible. The most common interventions were exercise therapy ($n = 6$) and back education ($n = 4$). Five studies employed multiple intervention components, but none was multidisciplinary. Studies primarily targeted posture or biomechanical factors. One study included an intervention addressing participants' fears and beliefs about pain.

Conclusions: Randomized trials for adolescents with persistent back pain have primarily relied upon an outdated, biomechanical explanation of persisting pain. Future randomized trials should align with current treatment recommendations and measure outcomes across multiple biopsychosocial domains.

Significance: This scoping review describes in detail the interventions included in randomized trials for adolescents with persistent, nonspecific back pain. The review is important because it reveals discrepancies between those interventions and the interventions recommended for this population.

Low back pain is a major cause of disability worldwide (Williamson & Cameron, 2021). Among adults, it is estimated to cost European countries 0.1% to 0.2% of gross domestic product annually due to medical costs and lost productivity (Williamson & Cameron, 2021). Back pain–related impairment and disability are also present in adolescent populations (Kamper et al., 2016). The lifetime prevalence of low back pain among adolescent populations is estimated to be 48%, with nearly 28% of those events being significantly disabling (Masiero et al., 2021). Because one of the main risk factors for reporting back pain as an adult is a previous episode of pain (Dunn et al., 2013), it would seem crucial to address back pain in the adolescent population before these young people reach adulthood.

Prospective research on adolescents suggests that the risk factors for chronic pain, including chronic back pain, include psychological, social and lifestyle factors such as poor sleep, anxiety, depression, low life satisfaction and low self-esteem (Beynon et al., 2020; Frosch, Mauritz, et al., 2022; Wager et al., 2020). In early 2022, an expert consensus group published the first evidence-based interdisciplinary guidelines for treating children and adolescents with nonspecific back pain (Frosch, Leinwather, et al., 2022). The group recommend interdisciplinary multimodal pain treatment, with both physical exercise and psychotherapy, for children and adolescents with chronic nonspecific back pain. These guidelines align with clinical practice guidelines for treating chronic pain (including musculoskeletal, abdominal and head pain) in children and adolescents (Ishizaki et al., 2012; Scottish Government, 2018; World Health Organization-WHO, 2020), which recommend nonsurgical, nonpharmacological approaches aligned with the biopsychosocial model (Engel, 1980). The WHO guidelines also emphasize that the family should be involved in the treatment of children with chronic pain. The family environment and relationships within the family are important factors in the 'social' element of the biopsychosocial model (Engel, 1980).

Two high-quality systematic reviews (Calvo-Muñoz et al., 2013; Michaleff et al., 2014), and a more recent overview of systematic reviews (Kamper et al., 2017) of back pain in adolescents, have shown that interventions tested in the small number of randomized clinical trials (RCTs) among this population had only moderate treatment effects. It would be beneficial to evaluate the specific interventions, which have been tested in RCTs to determine how they compared with current treatment recommendations, whether they addressed psychosocial risk factors for adolescent chronic back pain, and if they involved the family at any stage.

Our intent with this scoping review was to answer the following questions: (1) What nonsurgical, nonpharmacological interventions have been tested in RCTs for adolescents with back pain? (2) What specific components (e.g., physical activity, manual therapy and psychotherapy) make up those interventions? (3) What were the proposed targets of the interventions? (4) Were families involved in any stage of those interventions?

1 | LITERATURE SEARCH METHODS

The protocol for this review was published in March 2022 (Hauber et al., 2022). Peters et al.'s (2020) updated methodology for conducting a scoping review, and the PRISMA-ScR checklist (Tricco et al., 2018), guided the conduct and reporting of this review. Per Munn et al. (2018) this scoping review is designed 'to identify key characteristics or factors related to a concept', and 'to identify and analyze knowledge gaps' (p. 144).

1.1 | Information sources

Only RCTs were included because they represent the research upon which clinical practice guidelines are based and provide the most robust evidence of clinical effectiveness with the least bias. In addition, we felt it was more likely that the specific interventions tested in RCTs would be detailed in their trial registry documents and/or published protocol or results, which may not be the case for feasibility or observational studies. Surgical and pharmacological trials were not included, because such interventions are not recommended for children and adolescents with nonspecific back pain (Frosch, Leinwather, et al., 2022).

1.2 | Inclusion criteria

The inclusion criteria were randomized trials including adolescents with persistent or recurrent back pain (which was measurable at the time of study recruitment), with the majority of the sample aged between 12 and 17 years, written in English, with results published in a peer-reviewed journal, and in which the primary interventions were not surgical or pharmacological. No limit was set for the year of publication.

1.3 | Exclusion criteria

Any randomized trials exclusively addressing acute back pain (i.e., a single episode of nonrecurring pain) or pain associated with some other diagnosed disorder or medical

event (e.g., cancer, sickle cell disease, complex regional pain syndrome, spina bifida, scoliosis, spinal fusion surgery and spondylolisthesis) were excluded. In addition, studies of interventions including adolescents with a broad range of chronic pain conditions (e.g., headache, abdominal pain and musculoskeletal pain in various sites) were excluded if adolescents with back pain represented less than 75% of the sample.

1.4 | Search strategy

Academic Search Complete, Allied and Complementary Medicine Database (AMED), APA PsycArticles, APA PsycInfo, CINAHL Complete, MEDLINE, PubMed, Science Citation Index Expanded (SCI-EXPANDED), Scopus, Social Sciences Citation Index (SSCI) and SPORTDiscus were searched on 6–8 March 2022 for relevant articles. The Cochrane Central Register of Controlled Trials (CENTRAL) was searched on 14 March 2022 for registered trials as a means of double-checking that all eligible trials with results were found in the literature databases.

Combinations of the following search terms were used: (adolescen* OR youth OR teen* OR pediatr* OR child* OR *school*) AND (back OR lumbar OR spine OR spinal OR musculoskeletal) AND (pain OR complaint*) AND (random*). A complete search strategy for one database is shown in Methods S1. Results from all searches were imported into Zotero citation management software (version 6.0.8; Corporation for Digital Scholarship, Vienna, Virginia, USA) and duplicates removed.

In addition to the database searches, recently published systematic reviews on adolescent back pain (Brink et al., 2021; Calvo-Muñoz et al., 2013; Driehuis et al., 2019; Holsting et al., 2021; Hornsby & Johnston, 2020; Kamper et al., 2017; Kovacs et al., 2022; Michaleff et al., 2014; Miñana-Signes et al., 2021; Vaughn et al., 2012; Yamato et al., 2018), which included randomized trials up until 2018, and recent systematic reviews that included paediatric or adolescent participants with mixed chronic pain (Birnie, Ouellette, et al., 2020; Boulkedid et al., 2018; Eccleston et al., 2009; Fisher et al., 2014, 2018, 2019; Kichline & Cushing, 2019; Liossi et al., 2019), were hand-searched on 17 March 2022 to ensure that we included all trials matching our inclusion criteria that had been included in those reviews.

1.5 | Evidence screen

Two authors independently screened the titles and abstracts of all database search results and hand-searched the studies included in relevant systematic reviews. Disagreements about study eligibility were discussed and resolved, and the final selection was deemed eligible for full-text screen. Two authors independently screened each full-text article, with any disagreements arbitrated by a third author.

1.6 | Data items and charting

We extracted the following data, where available, from each study's report: (a) study characteristics (author, year, country and outcomes measured); (b) participant characteristics (sample size, age, gender, duration of pain, pain intensity, disability, comorbidities and mental health); (c) intervention characteristics (e.g., family involvement, Template for Intervention Description and Replication [TIDieR] checklist [Hoffman et al., 2014]). The TIDieR checklist notes whether and where several details of each intervention's implementation (e.g., who delivered the intervention components; how tailored were the intervention components) appear in an intervention's final report. We extracted the data relevant to the TIDieR items and completed a simple checklist to note whether all 12 items on the TIDieR had been reported. The corresponding author developed data tables in Word (Microsoft Corp., Redmond, WA, USA). All data were extracted by two authors independently to ensure accuracy. Any discrepancies were discussed and a consensus reached.

1.7 | Quality assessment

Although quality assessments are not required with a scoping review, we found it helpful to assess study quality when extracting data. Two authors independently searched the Physiotherapy Evidence Database (https://pedro.org.au) to determine each study's score on the 10-point PEDro scale, which is designed to measure the methodological quality of clinical trials (Maher et al., 2003; PEDro Physiotherapy Evidence Database, 1999). If a study did not appear in the database, each author independently scored the study, and scores were compared to ensure agreement.

2 | RESULTS

2.1 | Study selection

The initial database search returned 3763 reports, and a search of the CENTRAL trial registry returned an

PRISMA-ScR Flow Chart of Study Selection for Scoping Review on Adolescent Back Pain Interventions

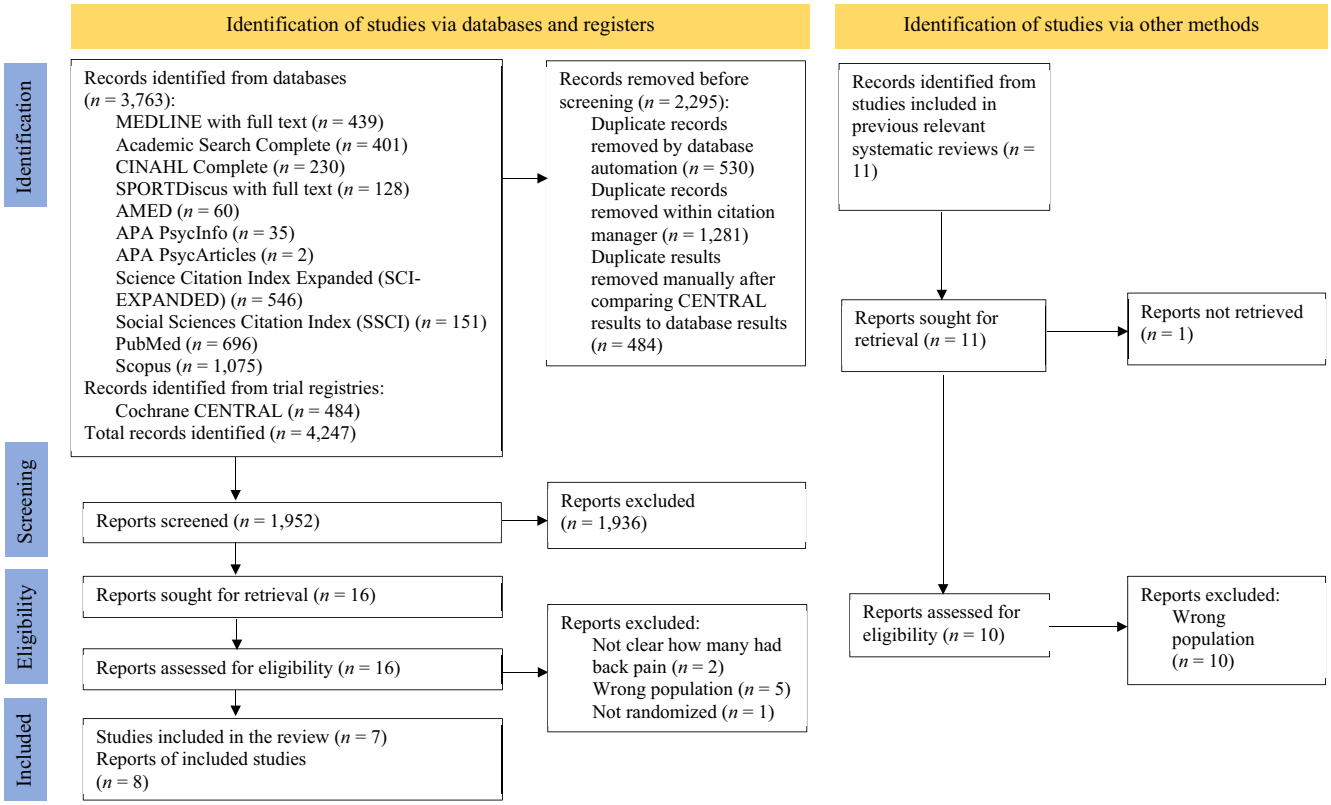

FIGURE 1 PRISMA-ScR flow chart of study selection for scoping review on adolescent back pain interventions.

additional 484 results. Thus, a total of 4247 records were identified. After duplicates were removed, 1952 reports remained. Title and abstract screening eliminated 1936 of those reports, leaving 16 reports for full-text screen. After full-text screening, seven studies, represented by eight published reports (Ahlqwist et al., 2008; Candy et al., 2012; Dudoniene et al., 2016; Evans et al., 2018; Fanucchi et al., 2009; Jones et al., 2007a, 2007b; Ng et al., 2015), were included. Jones et al., 2007a, reported slightly more outcome measures than Jones et al., 2007b, so both were reviewed. In addition, 19 systematic reviews were hand-searched for relevant trials to include in this review. Of the 11 studies that passed title and abstract screen, one was not available in full-text, and the other 10 were deemed ineligible (incorrect population). Thus, a total of seven studies (eight reports) were included in this review. The article selection process is illustrated in the PRISMA-ScR flow chart (see Figure 1).

2.2 | Study and participant characteristics

The seven studies were published between 2007 and 2018 (see Table 1) in six different countries, only one of which was a low–middle-income country. Sample sizes ranged from 36 to 185 (see Table 2). In four of the seven studies, most participants (59% to 70%) identified as female; one study included only males, and one did not report the gender of participants. Participants' average age ranged from 12.3 to 15.8 years. Most of the studies excluded adolescents with comorbid health complaints; only Evans et al. (2018) reported any comorbidities among participants.

Deciphering the clinical status of participants was difficult because pain duration (reported in only two studies), disability (reported in four studies) and mean pain intensity (reported in six studies) were not always reported. From the data reported, participants reported pain for >3 months, with pain intensity typically in the region of 2.4/10 to 6.5/10 at baseline (see Table 2).

2.3 | Quality assessment results

Scores for each of the seven studies included in our review were already posted to the Physiotherapy Evidence Database. Scores ranged from 3 to 8, with Evans et al. (2018) scoring the highest (8 of 10) and Dudoniene et al. (2016) scoring the lowest (3 of 10; see Table S1). We also tallied which of the TIDieR items each study's report included and assigned a score representing the completeness of reporting. See Table S2 for those scores.

TABLE 1 Characteristics of studies of interventions for adolescents with persistent back pain

First author	Year	Country	Outcome measures
Ahlqwist et al.	2008	Sweden	Pain intensity, quality, location, duration (Painometer) Disability (24-item RM, Swedish) Health-related QOL (CHQ-CF87) Hamstring flexibility (BSSR) Trunk muscle endurance
Candy et al.	2012	England	Pain intensity (NRS)
Dudoniene et al.	2016	Lithuania	Pain intensity (VAS) Disability (ODI)
Evans et al.	2018	USA	Pain intensity (NRS) Disability (18-item RM) QOL (PedsQL) Expectation of improvement (patient and parent) Frequency of medication use Satisfaction with care (patient and parent) Home exercise compliance Healthcare use Adverse events and bothersomeness of events
Fanucchi et al.	2009	South Africa	Pain intensity (VAS) Prevalence of low back pain Muscle length (hamstrings, iliopsoas, rectus femoris) Lumbar stability (ASLR) Neural mobility (PSLR) Proprioception Sense of well-being (MHI-5) Feelings about home and school (face scales)
Jones et al.	2007	England	Pain intensity Number of absences from physical activity[a] Number of absences from school[a] Frequency of pain Sit and reach Hip ROM Abdominal muscle endurance (number of sit-ups in 60 s) Lumbar-sagittal mobility (modified Schröber) Lateral flexion of the spine Average daily time spent: sitting, watching TV, working on a PC Hours of sports participation per week
Ng et al.	2015	Australia	Pain intensity (NRS) during rowing Disability (PSFS & 24-item RM) Lower limb muscle endurance (isometric squat test) Back muscle endurance (Biering-Sorenson test) Spinal kinematics (upper and lower lumbar angle during normal sitting and rowing)

Abbreviations: ASLR, active straight leg raise; BSSR, Back Saver Sit and Reach; CHQ-CF87, Child Health Questionnaire-Child Form (Swedish version); MHI-5, Mental Health Inventory-5; NRS, Numeric Rating Scale; ODI, Oswestry Disability Index; RM, Roland & Morris Disability Questionnaire (Ahlqwist et al. used the Swedish translation; Evans et al. used a modified 18-item version); PedsQL, Pediatric Quality of Life; PSFS, Patient Specific Functional Scale; PSLR, passive straight leg raise; ROM, range of motion; VAS, Visual Analogue Scale.

[a]Jones et al. used number of absences from physical activity and from school as a proxy for disability.

2.4 | Research questions

2.4.1 | Interventions tested

Six different types of interventions were tested with at least one group of participants in at least one of the seven studies (see Table 3). The exercise interventions (n = 6 studies) included supervised and unsupervised, standardized and individualized programmes. Exercise interventions were delivered alone (n = 1 study) or in combination with either back education (n = 4 studies) or another body-based therapy, such as manual treatment (n = 2 studies) or a vibroacoustic

TABLE 2 Participant characteristics at baseline in randomized trials for adolescents with persistent back pain

Study	Sample size	Age range (*M*)	Gender *n* (%) female	Duration of pain >3 mo. *n* (%)	Pain intensity *M* (maximum possible)	Disability *M* (maximum possible)	Comorbidities	Mental health *M* (maximum possible)
Ahlqwist et al. (2008)	45 Group 1[a]: 23 Group 2[b]: 22	12–18 (15.0)	31 (69)[c]	Group 1: 23 (100) Group 2: 20 (91)	Group 1: 4.8 (10) Group 2: 5.0 (10)	Group 1 (RM): 6.5 (24) Group 2 (RM): 5.4 (24)	—	Mental health score on CHF-CF87[d] Group 1: 65.2 (—) Group 2: 69.4 (—)
Candy et al. (2012)	97 Intervention: 51 Control: 46	14–16 (14.8)	57 (59)	—	—[e]	—	—	—
Dudoniene et al. (2016)	40 Exercise + vibroacoustics: 20 Exercise only: 20	13–18 (15.4)	27 (66)	—	Exercise + vibroacoustics: 4.6 (10) Exercise only: 5.3 (10)	Exercise + vibroacoustics: 8.8 (50) Exercise only: 9.3 (50)	—	—
Evans et al. (2018)	185 ET + SMT: 93 ET: 92	12–18 (15.4)	ET + SMT: 65 (70) ET: 62 (67)	ET + SMT: 87 (94) ET: 90 (98)	ET + SMT: 5.3 (10) ET: 5.3 (10)[f]	ET + SMT (RM): 5.6 (18) ET (RM): 4.9 (18)[g]	ET + SMT: Depression 10% Other pain 56% ET: Depression 12% Other pain 48%	PedsQL ET + SMT: 74 (100) ET: 73 (100)
Fanucchi et al. (2009)	72 Experimental: 39 Control: 33	12–13 (12.3)	33 (46)	—	Experimental: 2.4 (10) Control: 2.6 (10)	—	—	Experimental: MHI-5: 22 (30) Face (general): 5.1 (6)[h] Face (school): 5.1 (6) Control: MHI-5: 21 (30) Face (general): 4.9 (6) Face (school): 4.8 (6)
Jones et al. (2007a, 2007b)	54 Experimental: 27 Control: 27	13–15 (14.6)	—	'Repeated acute spells'[i]	Experimental: 6.5 (10) Control: 5.3 (10)	—[j]	—	—

TABLE 2 (Continued)

Study	Sample size	Age range (*M*)	Gender *n* (%) female	Duration of pain >3 mo. *n* (%)	Pain intensity *M* (maximum possible)	Disability *M* (maximum possible)	Comorbidities	Mental health *M* (maximum possible)
Ng et al. (2015)	36 Intervention: 19 Control: 17	14 to 19 (15.8)	0 (0)	—	Intervention: 5.2 (10) Control: 6.0 (10)[k]	Intervention: PSFS 15.5 (30) RM 4.1 (24) Control: PSFS 18.0 (30) RM 3.4 (24)	—	—

Note: —, data were not reported.

Abbreviations: CHQ-CF87, Child Health Questionnaire-Child Form; ET, exercise therapy; MHI-5, Mental Health Inventory-5; PedsQL, Pediatric Quality of Life; PSFS, Patient Specific Functional Scale; RM, Roland & Morris Disability Questionnaire; SMT, spinal manipulation therapy.

[a]Group 1 received individualized exercise therapy.

[b]Group 2 received a standardized self-training programme.

[c]These are the data from the table and subsequent paragraph on page E723 of the paper; one sentence, however, states that there were '15 boys (33%) and 30 girls (67%)'.

[d]The CHQ-CF87 includes 87 total questions in 12 domains (physical functioning, role emotional, role behavioural, role physical, bodily pain, behaviour, mental health, self-esteem, general health, change in health, family activities and family cohesion). Ahlqwist et al. report baseline scores for all 12 domains for both groups. However, scoring in each domain is not explained, so scores cannot be interpreted. For example, the mean mental health score of Group 1 at baseline was 65.2, but the maximum possible score is not given.

[e]Candy et al. report a range of pain intensity from 0 to 7.6 (out of 10), but do not show baseline measures for control and intervention groups.

[f]Evans et al. use 'severity' rather than 'intensity' to label this measure.

[g]Evans et al. used a modified 18-item version of the Roland & Morris Disability Questionnaire. The original version has 24 items.

[h]Fanucchi et al. used two 'face scales' to represent happiness or sadness with life in general and with school. Scores of greater than 5 represented happiness.

[i]Jones et al. did not report how long the participants had these repeated acute spells of back pain.

[j]Jones et al. reported number of school absences as a proxy for disability: $M = 0.1$ for both groups.

[k]Ng et al. reported the mean maximum pain on a Numeric Pain Rating Scale during a 15-min ergometer rowing test. Inclusion criteria for the study were that rowers must have a self-reported Visual Analogue Scale score of 3 or more out of 10.

TABLE 3 Overview of the interventions tested in randomized trials for adolescents with persistent back pain

First author	Exercise therapy				Manual treatment	Ergonomic intervention	Vibroacoustic treatment	Back education	PS treatment[a]	Family intervention[b]
	Supervised	Unsupervised	Individualized	Standardized						
Ahlqwist et al.	Group 1	Both groups	Group 1	Group 2	Group 1 (optional)			Both groups		
Candy et al.						Group 1				
Dudoniene et al.	Both groups			Both groups			Group 1			
Evans et al.	Both groups	Both groups	Both groups		Group 1			Both groups		
Fanucchi et al.	Group 1	Group 1		Group 1				Group 1		
Jones et al.	Group 1	Group 1 (encouraged)		Group 1						
Ng et al.	Group 1	Group 1	Group 1					Group 1	Group 1[c]	

Note: Details about the interventions each group in each study received, where available, are included in Table 4. Group 1, the group in each study that received the experimental treatment (as opposed to a control or usual care condition) or the group that received a greater number of combined treatments (when both groups received some form of treatment); PS, psychosocial.

[a]Treatments that address psychosocial risk factors for back pain, such as cognitive behavioural therapy, other psychotherapies, emotion-focussed therapies, social support interventions and self-efficacy interventions.

[b]Interventions in which parents or caregivers received all or part of the treatment as well as the patient.

[c]We deem the cognitive functional approach partly 'psychosocial' due to the use of motivational interviewing (Rollnick et al., 2010) and intentional discussion of recognized psychosocial risk factors for back pain (e.g., sleep patterns and coping) in the initial interview.

lounge chair ($n = 1$ study). One study (Ng et al., 2015) incorporated some psychosocial components (motivational interviewing, discussion of factors such as sleep patterns and coping) within an exercise-focussed intervention. Only one study did not include an exercise-based intervention in either treatment arm (Candy et al., 2012), instead testing an ergonomic intervention. None of the interventions was multidisciplinary in nature: Each was delivered by one or two physiotherapists, exercise specialists or chiropractors.

2.4.2 | Components of the interventions

Apart from Candy et al.'s (2012) seating wedge intervention, the trials included exercise therapy alone or with additional components. Of the six studies that included exercise therapy, an in-depth description of exercises and treatment protocols was not always available. For example, Fanucchi et al. (2009) mentioned an eAddenda with the exercise protocol, but this document was not readily available. Jones et al. (2007b) named several exercises (e.g., cat stretch; see Table 4), but the authors did not respond to emails requesting the exercise schedule (p. 1683). Ahlqwist et al. (2008) stated that their standardized exercise programme included 'general and specific exercises ... to improve the general strength and endurance of regional stabilizing abdominal and back muscles' (p. E723) and Dudoniene et al. (2016) referred to 'core stabilization exercises' (p. 4730), but neither report described which exercises were performed. By contrast, Evans et al. (2018) stated that participants did 'bridge, abdominal crunches, quadruped, side bridge, back extensions' (p. 1298), and Ng et al. (2015) provided supplemental materials that included a detailed list of exercises, with images, that they gave to participants. In addition, this document included a brief description of the cognitive and motivational interviewing approaches they used.

Back education was included as a component in four studies, always in combination with exercise therapy. The back education provided in three studies (Ahlqwist et al., 2008; Evans et al., 2018; Fanucchi et al., 2009) included content explaining anatomy, ergonomics, self-care pain management, core musculature, spinal alignment and posture, while the education provided by Ng et al. addressed 'mechanisms underlying [each individual participant's] pain and disability' (Methods S1). Details of each study's intervention components can be found in the modified TIDieR table, Table 4.

2.4.3 | Targets of the interventions

We defined 'targets' as the things the intervention components were intended to modify so that changes in the outcome measures could be realized. The targets of most of the studies were related to physical factors: spinal alignment, posture, or muscular strength, endurance, or flexibility. For example, Jones et al. (2007a) indicated that spinal mobility, trunk muscle endurance and flexibility (p. 350) were the targets of the exercise intervention because they are biological risk factors for back pain. Fanucchi et al. (2009) stated that spinal and pelvic stability was necessary to handle increasing loads in adolescence. Dudoniene et al. (2016) stated that spinal stabilization and muscular relaxation were important, and Candy et al. (2012) exclusively targeted sitting posture/pelvic tilt with their ergonomic seating wedge intervention.

Three studies acknowledged some psychosocial factors. Ng et al. (2015) stated that 'cognitions, movement patterns, conditioning, and lifestyle factors' (p. 1125) were the targets of their intervention. Ahlqwist et al. (2008) targeted spinal mobility, trunk muscle strength and overall conditioning, while stating that exercise has an impact on several psychosocial factors for persistent back pain (e.g., sleep, self-esteem and depression). Evans et al. (2018) indicated the importance of spinal mobility while also asserting that exercise was important for increasing participants' self-efficacy and pain coping.

The most common outcome measures were pain intensity (all studies), disability ($n = 5$ studies), hamstring length/flexibility ($n = 3$ studies), muscular endurance ($n = 3$ studies) and health-related quality of life ($n = 2$ studies; see Table 1).

2.4.4 | Family involvement

Apart from providing consent for their adolescent children to participate in these studies, parents or guardians were only minimally involved in two of these seven studies. Evans et al. (2018) asked parents/guardians to provide assessments of their adolescents' improvements during the intervention, as well as report their perceived satisfaction with the programme. Ng et al. (2015) asked a parent or a coach to attend the adolescent's training sessions and encourage them to complete the training programme. However, none of the studies involved parents or caregivers as participants.

3 | DISCUSSION

Exercise therapy was the primary intervention in six of the seven RCTs, with muscle strength, endurance and function as the main targets of rehabilitation. Despite three studies measuring mental health or health-related QOL as outcomes (Ahlqwist et al., 2008; Evans et al., 2018;

TABLE 4 Modified TIDieR (template for intervention description and replication) describing intervention components of RCTs for adolescents with persistent back pain

Study items[a]	Detail	Where found?
Ahlqwist et al. (2008)		
3 and 4. What materials and/or procedures	Group 1: Individualized, supervised exercise (both active and passive movements for conditioning, mobility, strength and coordination; exercises to improve the general strength and endurance of regional stabilizing abdominal and back muscles; body weight or circuit training equipment for resistance training, with resistance gradually increased). Optional manual therapy or mechanical diagnostic therapy was provided as needed. Stationary bicycle or treadmill for at least 20 min Group 2: Brisk walks, jogging, bicycling or swimming (unsupervised) 3 times/week for at least 20 min Both groups: Self-training at home with a standardized back-exercise programme; one in-person back-education session about functional anatomy, ergonomics and pain management	p. E723
5. Who provided	Two licensed physiotherapists	p. E722
6 and 7. How (modes of delivery) and where	Group 1: Exercise supervised in a physical therapy clinic and done individually (unsupervised) at home Group 2: Exercise individually (unsupervised) at home Back education (both groups): In person; location unclear, but likely at the physical therapy clinic	p. E723
8. When and how much	Group 1: Supervised exercise, once per week; unsupervised (home) exercise, twice per week; for a total of 3 exercise sessions per week for 12 weeks. Total time per session not specified, but at least 20 min. of aerobic conditioning and 2 sets of 10 body-weight exercises (unsupervised) or 15 times at 60% of 1 RM on circuit training equipment or using body weight for resistance (supervised). They may have also gotten orthopaedic manual therapy or mechanical diagnostic therapy, as needed, although how much was not reported Group 2: Three standardized, unsupervised exercise sessions per week for 12 weeks. Total time not specified, but at least 20 min. of aerobic conditioning in addition to 2 sets of 10 body-weight exercises	p. E723
9. Tailoring	Group 1: Supervised exercises were tailored to be 60% of the participant's 1 RM, and resistance was gradually increased; each supervised session was entirely tailored to the needs of the participants and may have included body weight or circuit training machines, orthopaedic manual therapy or mechanical diagnostic therapy. Unclear which factors led to manual therapy being used Group 2: None	p. E723
Candy et al. (2012)		
3 and 4. What materials and/or procedures	Group 1: High-density foam setting wedge, 30 cm (depth) × 35 cm (width) × 5 cm (weight) with a 10° inclination and an instruction sheet on its use; pain diaries for reporting daily pain intensity, cause and location, and whether they had used the seating wedge Group 2: Pain diaries only (no intervention)	p. 301–302
5. Who provided	Foam wedges and pain diaries were provided by the study team and distributed to students by link teachers	p. 302
6 and 7. How (modes of delivery) and where	Group 1 used the foam wedges independently while seated in school during all lessons except for science laboratory, where the wedges did not fit onto stools. Students completed pain diaries on their own time	p. 301–302
8. When and how much	Group 1 were expected to use the foam wedges each school day and record their pain intensity in the pain diary each morning and evening on school days	p. 301–302
9. Tailoring	None	
Dudoniene et al. (2016)		
3 and 4. What materials and/or procedures	Group 1: 30-min exercise session featuring core stabilization exercises, every working day (16 total) for 3 weeks, plus sixteen 20-min sessions on a vibroacoustic lounge chair (Zen Evolution, model ZK2, ZAV2, DVP3520/8, HD202 II West) that transmitted prerecorded music and low-frequency sound along with vibrations at 4–8 Hz frequency Group 2: 30-min exercise session every working day (16 total) for 3 weeks (the same core stabilization exercises as Group 1)	p. 4730

TABLE 4 (Continued)

Study items[a]	Detail	Where found?
5. Who provided	Not specified	
6 and 7. How (modes of delivery) and where	Not specified	
8. When and how much	Group 1: 30-min exercise session every working day (16 total) for 3 weeks, plus sixteen 20-min sessions on a vibroacoustic chair. Not clear if the exercise occurred before the vibroacoustic session Group 2: 30-min exercise session every working day (16 total) for 3 weeks	p. 4730
9. Tailoring	Participants in Group 1 determined a comfortable vibration level and sound volume	p. 4730
Evans et al. (2018)		
3 and 4. What materials and/or procedures	Group 1: Individualized spinal manipulation. High-velocity, low-amplitude SMT was preferred, but low-velocity, low-amplitude SMT, mobilization, flexion-distraction mobilization or drop table–assisted SMT were used as needed—as were ice, heat and light soft tissue massage. The ET was the same for both groups (see below) Both groups: Supervised ET sessions with 5-min light aerobic warm-up followed by stretching and strengthening exercises (bridge, abdominal crunches, quadruped, side bridge and back extensions). Participants were given printed instructions for performing these same exercises at home, along with a modified *Back in Action* book. Self-care education with patient-centred goal setting, emphasizing 'the importance of movement and activity, pain management and spinal postural awareness with basic activities of daily living (e.g., sitting, getting out of bed and using a backpack)'	p. 1298–99
5. Who provided	Exercise therapist or licensed chiropractor	p. 1298
6 and 7. How (modes of delivery) and where	SMT took place in person in two clinical research centres in Minneapolis, Minnesota and Portland, Oregon Both groups: Supervised ET took place in person in the same two clinical research centres as SMT. Home exercise and reading of the *Back in Action* book took place at each participant's home	p. 1298
8. When and how much	SMT sessions were 10–20 min and occurred before or after the supervised ET session (described below), according to participant needs and abilities ET (supervised; both groups): 8 to 16, 45-min sessions (up to two times per week for 12 weeks) ET (home; both groups): Participants expected to do the same exercises at home, as well as 20–40 min of aerobic exercise, twice per week	p. 1298
9. Tailoring	Group 1: The dose, spinal level(s) treated and techniques were individualized for each participant Both groups: Exercises were progressed and, dose was individualized according to participant fitness level. (Unclear who determined when and how to progress the exercises, or what inputs determined that progression was needed)	p. 1298
Fanucchi et al. (2009)		
3 and 4. What materials and/or procedures	Group 1: A 10–15-min educational session with explanation of the core musculature, correct posture and spinal alignment, plus a 40- to 45-min supervised exercise session (explanation of exercises not provided). Exercises were 'progressed' over 8 weeks. Instructions for home exercise were also given Group 2: No intervention	p. 98
5. Who provided	Physiotherapist	p. 98
6. and 7. How (modes of delivery) and where	Group 1 received in-person education and exercise instruction in two primary schools in Ekhuruleni West District of Guateng, South Africa	p. 98
8. When and how much	One exercise class per week for 8 weeks, made up of 10–15 min of back education and 40–45 min of exercise, during school hours. It is not clear how much home exercise was expected	p. 98
9. Tailoring	None	

(Continues)

TABLE 4 (Continued)

Study items[a]	Detail	Where found?
Jones et al. (2007a) and (2007b)		
3 and 4. What materials and/or procedures	Group 1: Standardized group exercise sessions included a combination of strength, flexibility and aerobic exercises that encouraged motion of the lumbar spine to reduce joint stiffness and relax elastic structures (e.g., 'cat stretch'); flexibility exercises for the hip and knee (e.g., knees to the chest and knees to the side); reconditioning exercises to increase endurance of lumbar stabilizers and help to encourage appropriate motor control of muscle recruitment (e.g., horizontal side support [on knees], various forms of bent knee curl-ups, single-leg extension holds 'superman'). Home exercise encouraged, not required. Exercises were 'progressed' over 8 weeks Group 2: No intervention	p. 1683 (2007b)
5. Who provided	Not specified	
6. and 7. How (modes of delivery) and where	In-person group exercise sessions in 'a school-based setting' (specific location unclear)	p. 353 (2007a)
8. When and how much	Two 30-min sessions per week for 8 weeks	p. 1683 (2007b)
9. Tailoring	None	
Ng et al. (2015)		
3 and 4. What materials and/or procedures	Group 1: Cognitive functional approach including patient-centred education about their pain and disability, addressing participants' beliefs and fears about their pain and radiological findings and using motivational interviewing to engage in an open discussion about how participants might influence their pain. Movement training included instruction on how to move the thoracic and lumbopelvic region independently of each other and how to maintain a neutral spine, and training on how to do previously pain-provoking movements in a nonpainful way. Photographs and videos of the sessions were provided to help participants integrate these new ways of moving. Conditioning exercises included a circuit to improve lower limb and back muscle endurance using functional exercises (e.g., forward reach, sit to stand, squats and single-leg squats). Exercises were designed to eliminate pain while rowing, and each participant was instructed on exercises specific to their own needs. Exercise sheets were provided to participants after each session so they could perform exercises on their own. Participants were expected to record their home exercise in an exercise diary provided Group 2: Usual activity (free to seek help elsewhere)	p. 1128 and Suppl. materials
5. Who provided	Sports physiotherapist	
6. and 7. How (modes of delivery) and where	In-person initial assessment at a local rowing club or university laboratory convenient to the participant. Home exercise was apparently expected	P. 1127
8. When and how much	One initial 60-min session, one 30-min session 1 week later and 3 additional 30-min sessions (one each fortnight) over the following 6 weeks. No details were provided about the length and number of home exercise sessions expected	p. 1127
9. Tailoring	The entire intervention was tailored according to the participants' conditioning, movement patterns and abilities	p. 1127

Note: As in Table 3, ET, exercise therapy; Group 1, the group in each study that received the experimental treatment (as opposed to a control or usual care condition) or the group that received a greater number of combined treatments (when both groups received some form of treatment); PT, physical therapy; RM, repetition maximum (the maximum weight a person can lift once and only once without failing to complete the movement); SMT, spinal manipulation therapy.

[a]Item numbers refer to the TIDieR Checklist; see Hoffmann et al. (2014) for a complete description of each item.

Fanucchi et al., 2009), only one of the reviewed studies (Ng et al., 2015) employed an approach to explicitly address participants' beliefs and fears about persistent back pain. Parents and caregivers did not participate in any of the interventions, other than to answer surveys or encourage their child.

Although there have been many trials of psychological or multidisciplinary interventions for children and adolescents with mixed chronic pain (Fisher et al., 2018; Liossi et al., 2019; Palermo, 2020), no RCTs matching our inclusion criteria engaged a psychologist or multidisciplinary team. Ng et al. (2015), as well as Ahlqwist et al. (2008) and Evans et al. (2018), speculated that decreases in pain may reflect increased pain-related coping and self-efficacy, or the time and attention focussed on participants, respectively. Yet, these RCTs did not conduct mediation analyses, and these psychological or social factors were not measured. These factors are worth systematically exploring, because self-efficacy (van Hooff et al., 2021) and social and relational factors (Day et al., 2020; Fuentes et al., 2014; Oraison & Kennedy, 2021) do affect back pain. This focus on body-based intervention components, targets and outcomes may be due to the 'siloed' nature of healthcare, in which adolescents presenting with back pain are primarily seen by practitioners traditionally trained to focus their efforts on treating the musculoskeletal system (such as general practitioners, physiotherapists and chiropractors; Bath et al., 2018) and who, thus, design interventions primarily focussed on modifying the musculoskeletal system.

These studies show that exercise therapy alone or in combination with education or manual therapy can have moderate effects. However, their incomplete reporting represents an important gap. The ergonomic seating wedge in Candy et al. (2012) and the vibroacoustic lounge chair in Dudoniene et al. (2016) were thoroughly described. Most reports, however, lacked clear descriptions of the specific content of the back education components, the training of intervention providers, the methods of delivery of the exercise therapy components or even the specific exercises participants performed (see Table 4). Of the seven included studies, only Candy et al.'s (2012) ergonomic seating wedge study could be replicated, based on the completeness of reporting.

Finally, the lack of parental involvement in these RCTs deserves attention. Parents' physical and mental health (Birnie, Heathcote, et al., 2020) and parents' pain catastrophizing (Donnelly et al., 2020) have been shown to impact children's pain-related disability. Because parents or caregivers comprise a major part of an adolescent's psychosocial environment, the WHO (2020) guidelines for the treatment of children and adolescents with chronic pain strongly emphasize the involvement of parents in interventions. However, parents were only minimally engaged in two of our seven reviewed studies. Unless parental factors are measured and addressed in rigorously designed and delivered back pain interventions engaging both adolescents and their parents, the potentially large contribution of social factors to adolescents' persistent back pain will remain unaddressed.

The WHO (2020) guidelines for paediatric chronic pain treatment and 7 of 11 European clinical practice guidelines for adults with persistent low back pain (Corp et al., 2021) recommend multidisciplinary biopsychosocial treatment, and Frosch, Leinwather, et al. (2022) emphasize the importance of interdisciplinary, multimodal (i.e., physical and psychological) interventions for youth with chronic courses of nonspecific back pain. If multidisciplinary care is not feasible, it may be necessary to design and implement interventions for adolescents with persistent back pain in which physiotherapists, occupational therapists or chiropractors assess and target factors in all three biopsychosocial domains. However, additional training and education are likely necessary (Laekeman et al., 2021).

3.1 | Limitations

This scoping review was limited in that we only included studies of adolescents between 12 and 17, whereas studies of younger cohorts may have demonstrated the biopsychosocial approach seen in several paediatric mixed chronic pain RCTs (Birnie, Ouellette, et al., 2020). In addition, RCTs for mixed chronic pain were excluded unless >75% of their samples were adolescents with back pain. Finally, we only included studies written in English.

3.2 | Clinical implications

This review confirms that the only rigorously designed studies of interventions for adolescents with persistent back pain have been exercise- or posture-centred, with limited descriptions of the intervention components. These study reports offer clinicians no clear explication of the mechanisms of action or the impact of clinician, parent or other psychosocial factors on outcomes. Randomized trials including psychotherapeutic or psychosocial components, or involving a multidisciplinary team, have not been completed for this population. Thus, whether the multidisciplinary biopsychosocial interventions shown to be moderately more effective than exercise therapy alone for adults with nonspecific low back pain (Kamper et al., 2015) would also be moderately more effective for adolescents is currently unclear. Frosch, Leinwather, et al. (2022) base their recommendation for multimodal, interdisciplinary treatments on the paediatric chronic

pain literature, while emphasizing that no high-quality research on such treatments has been done for adolescents with persistent back pain.

3.3 | Research implications

Treatments centred on the biopsychosocial model are recommended for adults with chronic low back pain and paediatric chronic pain populations, but such interventions have not been rigorously designed or tested for adolescents with persistent back pain. Research must evaluate what type(s) of such interventions are feasible, effective and acceptable to adolescents and their caregivers (Pate et al., 2021). Concurrently, much work needs to be done to determine how exercise-focussed interventions work and to explore the role of potential mediating factors such as catastrophizing (Smeets et al., 2006) or the therapeutic alliance (Fuentes et al., 2014).

4 | CONCLUSIONS

The interventions tested in randomized clinical trials of adolescents with persistent back pain overwhelmingly focussed on addressing physical factors such as muscle strength, endurance, flexibility or posture. Only one study explicitly targeted participant beliefs and fears. None of the interventions was multidisciplinary in nature and none involved parents and caregivers. Future interventions need to better reflect the biopsychosocial nature of persistent pain, involve patients and families to a greater extent and measure outcomes in all three biopsychosocial domains if meaningful effects are to be realized and mechanisms of action understood.

AUTHOR CONTRIBUTIONS

SDH, KR and KOS developed the scoping review topic and wrote the criteria; SK edited the criteria; SDH, KR, NNL and KOS completed article screening; SDH and EK completed data extraction; SDH, SK, KR, KOS, EK, NNL discussed the results of the review, edited drafts of the manuscript and approved the final draft.

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CONFLICT OF INTEREST

KOS provides continuing education workshops for healthcare professionals on the assessment and management of persistent back pain. SDH offers online exercise programmes for adults with persistent back and neck pain at haubermethod.com. No other conflicts declared.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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