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Exercise interventions to improve postural malalignments in head, neck, and trunk among adolescents, adults, and older people: systematic review of randomized controlled trials

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Despite the widespread use of postural correction in exercise interventions, limited experimental evidence exists for its effectiveness. The present study aimed to systematically review the literature on the efficacy of exercise interventions in improving postural malalignment in head, neck, and trunk. A systematic review was performed by screening four scientific databases (MEDLINE, Web of Science, EBSCO, and Cochrane database) for published randomized controlled trials (RCTs) in English from 1996–2019. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement guidelines. Two researchers independently performed study screening, extracting data and assessing the risk of bias for each included study using the Cochrane Collaboration tool for evaluating the risk of bias. A total of 22 RCTs comprising 1,209 participants were identified for in-

clusion in the review. There was a high risk of bias across most of the included studies (12 studies). Only two studies were classified as low risk of bias, and eight studies were classified as moderate risk of bias. The intervention duration ranged from 2 to 13 weeks, frequency from 2 to 4 days per week, and duration of each session between 15 to 60 min. The insufficiency and quality of included studies did not allow an integrated assessment of the efficacy of exercise interventions on postural malalignments; however, the positive effects noticed in most of the studies indicate some advantages but underscores the necessity of adequately designed RCTs in this field.

Keywords: Exercise, Posture, Malalignment, Adolescents, Adults


INTRODUCTION

Postural malalignment refers to a considerable displacement or deviations from the normal alignment in a kinetic chain resulting in abnormal biomechanical stress that can compromise the ability to deal with these forces (Schamberger, 2016). The occurrence of postural deviations is high in school-aged children and adolescents; while some changes are common in human growth and development, others may harm the quality of life (Schwanke et al., 2016). Besides, malalignment may occur among adults or during the ag-

ing process and may damage the pulmonary function and the quality of life (Bansal et al., 2014). Also, major deviations from optimal alignment can be aesthetically unpleasant for people, impact their efficiency of muscles, and predispose them to neurological or musculoskeletal disorders (Hrysomallis and Goodman, 2001).

Clinicians believe that it is essential to quantify head, shoulder, and spinal posture behavior because they influence and are influenced by many biomechanical, motor control and performance variables (Claus et al., 2016). In this regard, it has been assumed that exercise can correct the postural malalignment. Interestingly,

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despite the widespread inclusion of postural correction in exercise interventions, there is limited or contradictory experimental data to support its effectiveness, and little is known regarding which exercise is the most efficient intervention (Harman et al., 2005). Two previous review found little evidence to support this assumption due to insufficiency of reliable and valid data gathered in randomized controlled settings to help the dispute that exercise intervention will improve the postural malalignments (Bansal et al., 2014; Hrysomallis and Goodman, 2001). By contrast, two recent systematic reviews and meta-analysis found the effectiveness of exercise for improving postural malalignments (González-Gálvez et al., 2019; Sheikhhoseini et al., 2018). However, one suggested that the therapeutic exercises may result in changes in head posture deviation, but the precise nature of its improvement remains to be established (Sheikhhoseini et al., 2018). Therefore, it seems evidence-based recommendations for practitioners about effective exercises for individuals with postural malalignments are needed. Also, knowledge of feasible and efficient exercise intervention strategies with describing precise details to improving postural malalignments or prevent its consequences are, therefore, warranted by patients, practitioners, and rehabilitation centers.

Previous systematic reviews differ from our review in many aspects. Most of them had a narrower scope (Hrysomallis and Goodman, 2001) and/or were restricted to specific malalignments and participants (e.g., adolescents with scoliosis) (Romano et al., 2013) or older people with hyperkyphosis (Bansal et al., 2014). Also, there are some differences in the search strategy and inclusion criteria of our systematic review compared with theirs (González-Gálvez et al., 2019).

The current systematic review will focus on the effect of exercise interventions on different types of malalignments in adolescents, adults and older people and will, therefore, embrace a broader area than other systematic reviews.

This systematic review of RCTs aimed to evaluate the effectiveness of exercise interventions on improving postural malalignment in the head, shoulder, scapular, and spine among adolescent, middle-aged and older people. Subsequently, the key issues impacting on the outcome, including intervention type, volume, duration, and dose, will be identified.

MATERIALS AND METHODS

Protocol and registration

The protocol of this systematic review was registered in the international prospective register of systematic reviews (PROSPERO)

site on 07/06/2018 (CRD42018096531).

Eligibility criteria for considering studies for this review

This systematic review was designed collectively by the members of the review team following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Shamseer et al., 2015). Studies were selected according to the criteria outlined below.

Study designs

We included only RCTs, and nonrandomized controlled trials were excluded.

Types of participants

We included studies in which all patients were diagnosed as having one or a combination of types of postural malalignments in their head, shoulder, scapular, and spine. In our protocol, we initially mentioned the scoliosis angle as one of our primary outcomes. After performing the initial study searches; however, we chose to remove this criterion due to the abundance of recently systematic reviews in which investigated the effectiveness of exercise intervention on the improvement of scoliosis. Also, we excluded studies in which patients had a specific condition or problem such as pregnancy, osteoporosis, spondylosis, and any neurological diseases, e.g., Parkinson. No restrictions regarding gender were made.

Types of interventions

All types of exercise interventions (such as strengthening, stretching, aquatic, yoga, and Pilates exercise or any other exercise with a focus on treatment or prevention of postural malalignment) were included as long as the participants performed at least a part of the exercises independently. Sport or active recreational activity was not considered as an exercise intervention for improving postural malalignments, and studies including these types of activity or active exercise interventions without any reported outcome measures for improving postural malalignment were excluded. No restrictions regarding clinical setting (in-patients or out-patients) were made.

Types of outcome

The primary outcome was the interventional effect on degrees of postural malalignments (forward head, round shoulder, thoracic kyphosis, lumbar lordosis, and scapular position) as measured by the observational or clinical methods. Studies were not excluded

based on the type of measurement used to assess postural malalignments. Secondary outcomes were the key issues impacting on the primary outcome, including intervention type, volume, duration, and dose.

Language and time frame

We included only articles written in the English language and published within the last 23 years were included.

Information sources and search strategy

Literature search strategies were developed using medical subject headings and text words related to exercise interventions AND postural malalignments within the last 23 years. The following databases were searched: Cochrane, Web of Science, MEDLINE, and EBSCO databases. These databases were chosen since they include many RCTs in the health field, including the leading journals publishing trials with exercise interventions. The search strategies used in databases are displayed in Supplementary material. A hand search of reference lists was also performed. The last search was run on April 20, 2019.

Study records

Literature search results were uploaded to EndNote Software, which facilitated collaboration among reviewers during the study selection process and was used for sorting and duplicate removal. The review authors (MB and MBS) independently screened the titles and abstracts yielded by the search against the inclusion criteria. Review author pairs then screened the full-text reports and decided whether these met the inclusion criteria. Any disagreement between the review authors was resolved by a third review-team member (ES).

Data collection process

Data extraction forms were developed based on the Cochrane Back Review Group (Van Tulder et al., 2003). The data extraction form was pilot-tested on four studies, and refined accordingly. The reviewers extracted data independently and in duplicate from each eligible study. Also, reviewers resolved any disagreements by discussion or by a third person if needed.

Risk of bias assessment from individual studies

The reviewer authors assessed the risk of bias assessment for all included studies. The information was collected using the Cochrane Collaboration tool for assessing the risk of bias (Table 8.5.a in the Cochrane Handbook for Systematic Reviews of Interventions), that includes: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other sources of bias (Higgins et al., 2011). A judgment as to the possible risk of bias on each of the six domains was made from the extracted information, rated as 'high risk,' 'low risk,' or 'unclear.' Then, each included study is assigned an overall grade of low, moderate or high risk of bias based on the evaluation of the six domains and according to the following criteria: low risk of bias if the first three domains are noted as 'yes,' and no serious concerns regarding the last three domains were identified; moderate risk of bias if one or two domains are noted as unclear; and high risk of bias if more than two domains are noted as unclear (Higgins et al., 2011). Two review authors made these judgments independently and any disagreement was discussed. A third review author consulted if disagreements persisted.

Our systematic review included a variety of exercise interventions and participants (people with different kind of postural malalignments). Therefore, the gathered data is prone to high heterogeneity, which discourages a meta-analysis, and therefore, only a qualitative synthesis was considered in this review. The quality of evidence for all outcomes was rated based on the GRADE (Grading of Recommendations, Assessment, Development and Evaluations)

Analysis and GRADE approach

Our systematic review included a variety of exercise interventions and participants (people with different kind of postural malalignments). Therefore, the gathered data is prone to high heterogeneity, which discourages a meta-analysis, and therefore, only a qualitative synthesis was considered in this review. The quality of evidence for all outcomes was rated based on the GRADE (Grading of Recommendations, Assessment, Development and Evaluations)

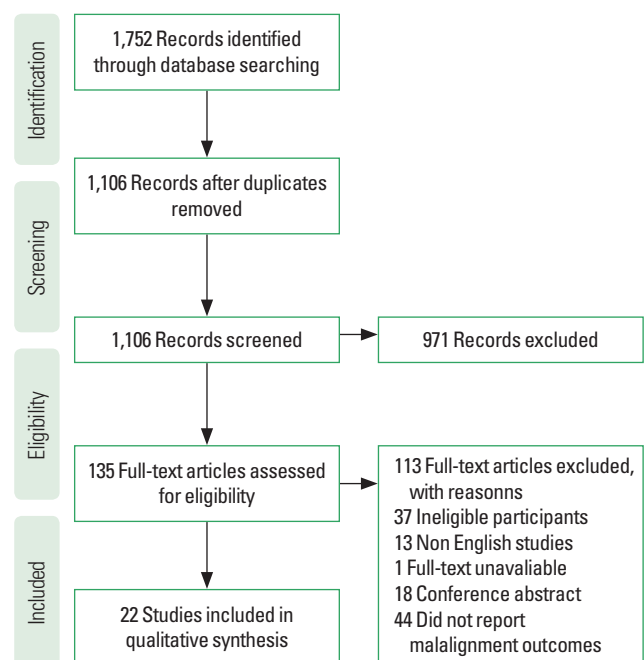


Fig. 1. Flow diagram.

Table 1. Characteristics of the included studies

Study	Study population/age	Type of malalignment	Sample size	Intervention (exercise)		Control/Comparator	Outcome measures	Results
				Type	Frequency			
Hamam et al., 2005	Adult 37.6±10.4	Forward head	41	Stretching and strengthening	4 Times per week	Without exercises	CVA measured by Biotonix Postural Analysis System	CVA was significantly different in the exercise group at posttest.
Vaughn and Brown, 2007	Adult 39.8±13.2	Kyphosis	71	Strengthening, stretching, and self-mobilization	4 Times per week	Without exercises	Kyphosis angle measured by flexicurve	Statistically significant impact on kyphosis angle change. However, the mean kyphosis angle changes are of marginal clinical significance.
Benadetti et al., 2008	Elder 70.9±5.1	Hyperkyphosis, forward head	28	Flexibility at pelvic and shoulder girdle and strengthening back extensor muscles	2 Times a week for 1 hr	Non-specific physical activity consisted of global posture exercises	Occiput-to-wall distance	Statistically significant improvement of the occiput to-wall distance only in intervention group.
Lynch et al., 2010	Adult 19.29±1.44	Forward head posture and round shoulder posture	28	Stretching and strengthening	3 Times a week	Without exercises	FHP, RSP measured by inclinometer, scapular distance, forward shoulder translation	Intervention significantly decreased cervical angle and forward shoulder translation.
Seidi et al., 2014	Adult 20.84±1.69	Hyperkyphosis, forward head, and forward shoulder	60	1. CCEP: stretching strengthening with performing chin tuck, erecting the thoracic spine and adduct scapulae. 2. LCEP: stretching, self-mobilization, and strengthening	3 Times per week	Without exercises	Kyphosis angle, FHP, FSP measured by flexicurve and photography	LCEP and CCEP groups demonstrated statistically significant reductions in the thoracic kyphosis, FHP and FSP angle compared to the control group.
Fatemi et al., 2015	Adolescents 15–18 years old	Increased lumbar lordosis	39	William's training protocol	3 Times per week for 1 hr	Without exercises	Lumbar lordosis measured by flexible ruler	William's back flexion exercises decreased lumbar angle.
Kim et al., 2015	Adults 20.5±1.2	Forward head posture	30	Kendall exercise: stretching and strengthening	3 Times a week for 30 min	Horse-riding simulator	CVA measured by photography	HRS and Kendall groups showed significant differences after the intervention in CVA, No significant difference between the groups.
Im et al., 2016	Adults 35.5±8.8	Forward head posture	15	Scapular stabilization exercise: postural and strengthening	3 Times a week for 30 min	Relaxation exercises	CVA	CVA increased significantly in the experimental group after training compared to the control group.
Kamali et al., 2016	Adults 18–30 years old	Hyperkyphosis	46	Stretching and strengthening	3 Times a week for 20–30 min	Manual therapy: massage, mobilization, muscle energy, myofascial release	Kyphosis angle measured by motion analysis system	Both exercise and manual therapy were effective in reducing thoracic kyphosis angle, no significant difference between the groups.

(Continued to the next page)

Table 1. Continued

Study	Study population/age	Type of malalignment	Sample size	Intervention (exercise)		Control/Comparator	Outcome measures	Results
				Type	Frequency			
Lee et al., 2016	Adults 23–39 years old	Forward head posture	28	Plates: focused on balancing, stretching, strengthening, co-activation of the core muscles, breathing technique	3 Times a week for 50 min	Combined exercise: stretching and strengthening	CVA measured by X-ray	Significant improvement in CVA in the Pilates group and no significant improvement in the combined exercise group.
Thakur et al., 2016	Adults 18–30 years old	Scapular dyskinesis, forward head posture	40	Forward head correction exercise: stretching and strengthening	3 Times a week	Shoulder stabilizing exercises	Scapular inferior angle distance measured by tape and CVA measured by computer software MB ruler	FHP correction and shoulder stabilization exercises were equally effective in correction of scapular dyskinesia.
Pekyavas and Ergun, 2017	Elders 68.5 years old	Hyperkyphosis	32	Corrective exercises: stretching and strengthening	3 Times per week	Without exercises	Kyphosis angle measured by two inclinometers, FHP measured by photogrammetry	Kyphosis and forward head angles improved in experimental group.
Ruivo et al., 2017	Adults 18–60 years old	Scapular dyskinesis	30	Home exercise program: stretching, strengthening, mobility	2 Times per week for 45 min	Supervised virtual reality exergaming program: stretching, strengthening	Scapular dyskinesis measured by lateral scapular slide test, scapular retraction test, scapular assistance test	Virtual reality exergaming program has made significantly better improvement in decreasing the symptoms of SALS and scapular dyskinesis.
Ruivo et al., 2017	Adolescents 15–17 years old	Forward head posture, protracted shoulders	130	Stretching and strengthening	2 Times a week for 15–20 min	Physical education classes	Cervical and shoulder angles measured by photogrammetry	Significant differences were observed in cervical and shoulder angles in the intervention group.
Lee et al., 2017	Adults 19 years old or older	Forward head posture	28	McKenzie exercise: strengthening	3 Times a week for 25 min	Self-stretch exercise/Kendall exercise (Stretching and strengthening)	CVA measured by photography, RSP measured by scapular index	FHP and RSP were significantly different in all groups, no significant difference between groups.
Cho et al., 2017	Adults 23.8 ± 2.6	Forward head posture	32	Upper cervical mobilization and cervical retraction exercise	10 Times for 4 weeks	Upper thoracic mobilization and upper thoracic extension exercise	CVA measured by photography in both sitting and standing positions	Thoracic group indicating significantly better improvement in CVA than cervical group.
Katzman et al., 2017	Elders	Hyperkyphosis	99	Group spine-strengthening exercise and postural training	3 Times a week for 60 min	Four group health education meetings (without exercises)	kyphosis measured by radiography and Debrunner kyphometer	Significant differences were observed in kyphosis angles in the intervention group.
Katzman et al., 2017	Elders	Hyperkyphosis	112	Multimodal group-based kyphosis-specific exercise and posture training	2 Times a week for 60 min	Without exercises	kyphosis measured by 1: radiography and 2: Debrunner kyphometer	There was no statistically significant difference between groups in change in Cobb angle, however change in kyphometer-measured kyphosis differed, favoring the active group.

(Continued to the next page)

Table 1. Continued

Study	Study population/age	Type of malalignment	Sample size	Intervention (exercise)			Control/Comparator	Outcome measures	Results
				Type	Frequency	Duration			
Kang et al., 2018	Adults 32–52 years old	Lumbar lordosis	66	Deadlift exercise	2 Times a week in the first month and once per week in the second month	8 Weeks	Low-load motor control exercises	Lumbar lordosis angle measured by radiography	Lumbar lordosis did not change significantly from baseline to follow-up in both groups.
Kang et al., 2018	Adults 25–50 years old	Forward head posture	30	Scapular stabilization exercise	3 Times a week for 30 min	4 Weeks	Neck stabilization exercise group	CVA measured by radiography	Within-group changes in CVA were statistically significant in both groups and CVA had a statistically significant between-group differences.
Feng et al., 2018	Adolescents	Hyperkyphosis	164	Functional exercise program: ROM, strength	2 Times a week for 15–20 min	8 Weeks	Exercise program designed according to the state-regulated curriculum which included abdominal curls, pushups with the toes or knees, a 50-m run, and squats	Kyphosis angle measured by Spinal mouse	Functional exercise program achieved a clinically significant decrease in TKA and was significantly different compared to control group.
Fathol-lahnejad et al., 2019	Adults 32–42 years old	Forward head posture and round shoulder posture	60	Group 1: stabilizing exercises and manual therapy Group 2: only Stabilizing exercises	3 Times a week for 30 min	6 Weeks	Home exercises	FHA and FSA measured by Biotonix Postural Analysis System	There were significant within-group improvements in head and shoulder posture in groups 1 and 2. There were significant between-group differences in both intervention groups versus the control group.

FHP, forward head posture; RSP, round shoulder posture; CCEP, comprehensive corrective exercise program; LCEP, local corrective exercise program; CVA, cervicovertebral angle; HRS, horse-riding simulator; SAIS, subacromion impingement syndrome; LBP, low back pain; ROM, range of motion; TKA, thoracic kyphosis angle; FHA, forward head angle; FSA, forward shoulder angle.

approach (Balslem et al., 2011). The quality rating of the evidence started at high. It was rated down to moderate, low or very low evidence according to the following guidelines: (a) risk of bias – this rated down if more than 25% of the subjects were from studies with a high risk of bias; (b) inconsistency of results – this was downgraded if significant differences in magnitude and direction of effects between included studies was present; (c) indirectness – this rated down if more than 50% of the subjects were outside the target group; and (d) imprecision- following Rubinstein et al. (2013), single studies with <400 subjects for continuous outcomes or <300 subjects for dichotomous outcomes were considered as ‘low-quality evidence,’ and ‘very low-quality evidence’ if there were further limitations (of high risk of bias, inconsistency, or indirectness) on the GRADE approach.

RESULTS

Study selection and characteristics

A total of 22 RCTs were identified for inclusion in the review. The flow diagram in Fig. 1 illustrates the selection pro-

cess and characteristics of the 22 included studies can be seen in Table 1.

Risk of bias and quality of evidence within studies

The results of assessing the risk of bias within studies are shown in Table 2. To determinate the interrater reliability for authors, Cohen Kappa was calculated (Kappa=0.891) and found a high level of agreement (McHugh, 2012). Moreover, Tables 3 shows the synthesized results based on the GRADE approach described above. Overall, there was very low- to moderate-quality evidence to suggest that exercise interventions can improve postural malalignments in adolescents, adults, and older people.

DISCUSSION

The current systematic review of RCTs was conducted to investigate the effects of exercise interventions on improving postural malalignments among adolescents, adults, and older people. Secondly, to explore the influence of intervention type, volume, duration, and the dose of exercise. Our systematic review showed

Table 2. Results of assessing risk of bias within studies

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias	Overall grade of risk of bias
Harman et al., 2005	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Moderate
Vaughn and Brown, 2007	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Moderate
Benedetti et al., 2008	Unclear	Unclear	Unclear	Yes	Yes	Yes	Yes	High
Lynch et al., 2010	Yes	Unclear	No	No	Yes	Yes	Yes	High
Seidi et al., 2014	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	High
Fatemi et al., 2015	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	High
Kim et al., 2015	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	High
Im et al., 2016	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Unclear	High
Kamali et al., 2016	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Moderate
Lee et al., 2016	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	High
Thakur et al., 2016	Unclear	Unclear	No	Unclear	Yes	Yes	Yes	High
Bahrekeazemi et al., 2017	Unclear	Unclear	Unclear	No	Yes	Yes	Yes	High
Pekyavas and Ergun, 2017	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	High
Ruivo et al., 2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low
Lee et al., 2017	Unclear	Unclear	Unclear	Unclear	Yes	No	Unclear	High
Cho et al., 2017	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Moderate
Katzman et al., 2017	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Moderate
Katzman et al., 2017	Yes	Unclear	Unclear	Unclear	Yes	Yes	Yes	Moderate
Berglund et al., 2018	Yes	Unclear	Yes	Yes	Yes	Yes	No	Moderate
Kang et al., 2018	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Yes	High
Feng et al., 2018	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	Moderate
Fathollahnejad et al., 2019	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low

Table 3. GRADE (Grading of Recommendations, Assessment, Development and Evaluations) evidence profile: exercise intervention for people with postural malalignments

Outcome (No. of studies)	Quality assessment					Summary of findings Quality
	Limitations of study design	Inconsistency	Indirectness	Imprecision	Publication bias	
All types of malalignments	Serious	Serious	No serious	No serious	Undetected	⊕⊕○○ Low
Forward head posture (13)	Serious	No serious	No serious	No serious	Undetected	⊕⊕⊕○ Moderate
Forward/round shoulder posture (4)	Serious	No serious	Unclear	Serious	Undetected	⊕⊕○○ Low
Scapular dyskinesis (2)	Serious	No serious	Unclear	Serious	Undetected	⊕⊕○○ Low
Hyperkyphosis (8)	No serious	Serious	No serious	No serious	Undetected	⊕⊕⊕○ Moderate
Hyperlordosis (2)	Serious	Serious	Unclear	Serious	Undetected	⊕○○○ Very low

that the available evidence on the efficacy of exercise in postural malalignments is insufficient and mainly of low or moderate quality. However, 21 included studies showed a significant improvement after conducting the exercise intervention, and only one study did not show a significant improvement (Berglund et al., 2018). Also, no evidence was identified that the exercises negatively or harmfully affect postural malalignments. Although we included RCTs in order to assess only high-quality studies, there was a moderate or high risk of bias and poor reporting across most of the studies.

It has been postulated that if some segments of the body are maintained out of the optimal posture for a long time, the muscles may remain in shortened or lengthened positions. These positions may result in adaptive lengthening or shortening over time (Hrysomallis and Goodman, 2001). Therefore, it has been assumed that corrections in the poor posture would be reached with improved muscle strength and length or other factors related to malalignments, such as related movement patterns and improved postural awareness. While a causal association may not necessarily exist between this postulation and hypothesis, all reviewed exercise interventions focused, in part, on improving malalignments by stretching the shortened muscles and strengthening the weakened muscles in the involved area based on the traditional approach (Sahrmann et al., 2017). Few included RCTs in this review evaluated the effectiveness of the exercise interventions on muscle weakness or shortness (Benedetti et al., 2008; Fatemi et al., 2015); therefore, it is unclear whether participants had related weak or short muscles at baseline or if the intervention had a significant effect on muscle weakness or shortness, or whether such a phenomenon as

‘shortened muscles’ due to certain exposures is real. In fact, studies using stretching exercise shows no change in muscle length, but rather improved tolerance to stretching (Magnusson, 1998; Magnusson et al., 1997). Besides, the researchers employing the neurological approach generally believe that the basis of the functional approach in musculoskeletal problems is the interaction of all central and peripheral nervous systems, muscular and skeletal structures in the production and control of motion (Hamill et al., 1999; Morris et al., 2006). Further, they believe that it is essential considering to the individual’s aspects of posture, muscle activation, and movement pattern (Hodges et al., 2019). While none of the RCTs reviewed assessed the muscle activation and related movement patterns as an initial strategy to provides information for prescribing the exercise intervention.

Comparison with other systematic reviews

Three systematic reviews and a narrative review were identified in which it has been examined a comparable research question (Bansal et al., 2014; González-Gálvez et al., 2019; Hrysomallis and Goodman, 2001; Sheikhhoseini et al., 2018). Although one would hope that multiple systematic reviews would make higher clarification on the effects of exercise interventions on improving postural malalignments, we also discovered some discrepancies. The explanations for the discordances from these systematic reviews in comparison with our systematic review are regarding the methodology.

In a recent systematic review, Sheikhhoseini et al. (2018) have examined the effectiveness of exercise interventions on improving forward head posture. His review suggested there is strong evi-

dence showing an improvement in forward head posture in response to exercise intervention. Therefore, there were some differences in the final messages explained by: (a) the restriction to only forward head posture in Sheikhoseini et al. (2018) whereas we used broader inclusion criteria of malalignments, (b) the current review was restrict to malalignment outcomes whereas Sheikhoseini et al. (2018) added neck pain outcomes in addition to forward head angle, (c) in our review we excluded studies in which patients had a specific problem whereas Sheikhoseini et al. (2018) included participants with cervical spondylotic radiculopathy and myofascial pain, (d) additional articles published since the review of Sheikhoseini et al. (2018) was conducted, (e) progress of quality evaluation criteria that resulted in several contrasts in quality assessment scoring.

Two previous reviews have been studied the effectiveness of exercise intervention on improving hyperkyphosis malalignment (Bansal et al., 2014; Hrysomallis and Goodman, 2001). A recent systematic review by Bansal et al. (2014) summarized that the insufficiency and quality of included studies did not allow an integrated assessment of the efficacy of exercise interventions on improving thoracic kyphosis angle. However, due to the presence of positive effects in high-quality studies, it seems that there are some advantages, and they indicate the necessity of adequately designed RCTs examining the effectiveness of exercise intervention on hyperkyphosis (Bansal et al., 2014). Despite that both our review and Bansal et al. (2014) have a similar conclusion, there were some differences related to population and study design. Our review included studies in which participants were adolescents, adults and older people without specific diseases. In contrast, in Bansal review, the inclusion of individuals aged ≥ 45 was used to review studies of postmenopausal women with osteoporosis. Also, we only included RCTs whereas the Bansal et al. (2014) included both RCTs and nonrandomized intervention trials.

The other review identified, Hrysomallis and Goodman (2001), was not a systematic review. Here, the authors conducted a review of improving postural malalignment and resistance exercise (Hrysomallis and Goodman, 2001). They found the insufficiency of reliable and valid data gathered in randomized controlled settings to help the dispute that exercise intervention will improve the postural malalignments such as hyperkyphosis. The same, objective data to demonstrate that exercise intervention will result in postural malalignments was not available. Similarly, our review found considerable evidence about the effectiveness of exercise intervention on postural malalignments such as hyperkyphosis and hyperlordosis to be scarce and mainly of low or moderate quality.

Another recent systematic review by González-Gálvez et al. (2019) summarized there were significant effects of the exercise intervention on decreasing the angle of thoracic kyphosis, although there were no considerable effects on the lumbar lordosis angle (González-Gálvez et al., 2019). Despite their review compared with ours had the same number of included studies and considerable overlap between them with four of 10 studies (40%) regarding the kyphosis and lordosis malalignments, there were still some differences in the conclusion. Our different inclusion criteria can explain some of these differences. The review of González-Gálvez et al. (2019) only examined the effect of exercise programs on the angle of kyphosis and lordosis, not the improvement of hyperkyphosis and/or hyperlordosis angle in people with these malalignments. Most of the participants of included studies in a review of González-Gálvez et al. (2019) did not have the hyperkyphosis or hyperlordosis malalignments (Ko et al., 2018; Muyor et al., 2012). It seems that they have been included only because of the kyphosis and lordosis angles was measured. In addition, although he included only RCTs, the study of Jang et al. (2019) was not an RCT.

Regarding scapular dyskinesis, despite many observational and experimental studies and some review articles in this field (Cools et al., 2007; Cools et al., 2014), to best of our knowledge, a systematic review to investigate the effect of exercise on improving scapular dyskinesis has not previously been performed. Therefore, this current review remains the only review and we could not compare our results with others.

The key issues impacting on the outcome

For another aim of the current review, the studies reviewed will be discussed regarding the undertaken frequency of exercises, the performed intensity of exercises, the duration of exercises, and the type of exercises.

The frequency of exercises differed in reviewed studies (Table 1) with exercise protocol ranging from 2 to 4 sessions weekly with profits visible from all frequencies. Many of the included studies demonstrating significant improvement in the postural malalignment, used the frequency of 2 to 4 sessions per week. Two studies with high quality applied 2 and 3 sessions per week (Fathollahnejad et al., 2019; Ruivo et al., 2017). It seems that exercise protocols of at least 2 to 3 times a week presented gains in neuromuscular adaptations, which is in accordance with recognized exercise advantages and its efficiency as accepted by the American College of Sports Medicine guidelines (Garber et al., 2011). Moreover, the frequency of exercise was defined per the study design (e.g., 2 sessions/wk.), but the adherence to the intervention found to differ

considerably and previous studies, therefore, looked at issues related to exercise compliance. Harman et al. (2005) demonstrated a 91% compliance rate with exercises intervention frequency of 4 sessions over 10 weeks. However, an exercise protocol with high frequency maybe not assume suitable for participants with postural malalignments due to the barriers of adherence. Therefore, findings suggest that the most effective exercise frequency to aim improving postural malalignments is ranging from 2 to 4 sessions with an average of 3 times a week.

It seems to be difficult determining the real-time spent for exercises throughout intervention because there was a lack of adherence by subjects when a supervised training protocol was entirely done. The duration of the exercise session was between 15 to 60 min in the reviewed studies; whereas, exercise protocols were between 2 to 24 weeks (Table 1). Many studies have shown that at least 4 to 8 weeks' resistance training is the best time to obtain positive exercise characteristics such as strength, endurance, and neuromuscular changes (Eklund et al., 2015). Most of the included studies in our systematic review also were in this range. However, there were two studies with a short duration (2 weeks) (Thakur et al., 2016) or a long duration (24 weeks) (Katzman et al., 2017). When formulating an optimally effective intervention, the essential thing that must be considered is that how likely an individual is to adhere entirely to a long duration program, or the short duration may be insufficient in inducing significant and clinical effects. Therefore, when assessing the spending time of an exercise and the whole duration of a training intervention to produce the best results, it is suggested that exercise protocol should last at least 6 weeks for occurring the neuro-physiological advantages. Exercising between 15 and 60 min provides the most optimal results with 30 to 45 min being a reasonable and mainly achievable exercise session duration.

Regarding the type of exercise, although there has been much argument as to which type of exercise is most effective, a combination of both stretching and strengthening obtains the most considerable advantages for subjects. The studies demonstrated immediate and some long-term advantages in improving postural malalignments resulting in increased muscle length or strength, because it is widely postulated that some muscles are substantially weaker or shorter in those with postural malalignments (Sahrmann et al., 2017). However, the researchers using a neurological approach believe that changes subsequent to the postural malalignments are based on the interaction of the central and peripheral nervous systems, as well as the muscular and skeletal structures (Hamill et al., 1999; Morris et al., 2006). In this functional ap-

proach, the musculoskeletal problems are thought to be due to the role of muscles in motor function; furthermore, changes in the alignment are not only a change in the muscle length and strength, but represent more important changes in muscle neuromuscular factors, such as muscle recruitments (Janda, 1983). Therefore, it seems that the best result would occur when an applied strengthening/stretching intervention can focus on both the neural as well as muscular components of the malalignment.

Future research priorities

While there is a lack of high-quality study in this field, those reviewed in the current study would demonstrate that it is a field of research worth pursuing. It seems to be advantageous to investigate the effectiveness of exercise interventions in improving postural malalignments, especially with a long period of intervention and follow-up measurements. Future RCTs should be more precise on detailed allocation concealment and blinding. Moreover, they should report effect size for the primary interventional outcome in addition to statistically significant differences. Also, it would be useful to study the effectiveness of exercise interventions in improving postural malalignments with assessment methods related to muscle activations and movement patterns in addition to alignments before and after an exercise intervention. While it may be challenging to recruit a large number of people for each study, many high-quality RCTs can be pooled subsequently in a meta-analysis.

Limitations

This is the first systematic review that included studies with five different postural malalignments based on a broad search design. However, it may also consider as a limitation so that, due to the heterogeneity in terms of interventions and outcome measurements of the reviewed studies, performing a meta-analysis was not meaningful. The inclusion of only English written literature, which might have led to the exclusion of important findings and the exclusion of the gray literature were the limitations of the current study. However, RCTs are seldom published only in the gray literature. Also, due to time restrictions, the review authors could not request specific information about the studies from the study authors.

CONCLUSIONS

The majority of the RCTs published within the last 23 years found some positive effects of exercise interventions for postural

malalignments. However, most of the studies were rated poorly in terms of quality assessment when using the Cochrane Collaboration tool for assessing the risk of bias and GRADE approach for quality of evidence. This supports the need for an adequately designed high-quality RCTs examining the effect of exercise on postural malalignments. Moreover, the best result for improving postural malalignments would occur when an applied strengthening/stretching intervention can focus on both the neural and muscular components and last at least 6 weeks with an average of 3 times a week, between 15 and 60 min.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

SUPPLEMENTARY MATERIAL

Supplementary material can be found via <https://doi.org/10.12965/jer.2040034.017>.

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