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Systematic Review

Effectiveness of exercise interventions to improve motor coordination and manual dexterity of deaf children: A systematic review and meta-analysis of randomized controlled trials

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ABSTRACT

Background: Vestibular disorders are frequent findings in children with sensorineural hearing loss (SNHL), impairing the sensory regulation of postural control, and the spatiotemporal relationship, and triggering disturbances in balance, motor coordination, and gross and fine motor skills in these children.
Objective: To assess the certainty of evidence from randomized controlled trials (RCTs) that used exercise interventions to improve motor coordination and manual dexterity of children and/or adolescents with SNHL.
Methods: This systematic review searched for articles on the topic in 10 electronic databases: MEDLINE/Pubmed, SCOPUS, EMBASE, Web of Science, CINAHL, LILACS, CENTRAL (Cochrane Central Register of Controlled Trials), PEDro, SciELO and the Google Scholar. There was no restriction on publication time or languages for the selection of articles, and the last search took place on March 1, 2025. RCTs were included, with children and/or adolescents, diagnosed with bilateral SNHL in the age group between 6–19 years old, without physical, cognitive, and/or neurological problems, except vestibular dysfunction, and who used exercise interventions to improve motor coordination and manual dexterity. Three independent reviewers performed the extraction of trials, data, assessment of risk of bias, and certainty of evidence. The presence of risk of bias in RCTs was assessed using the Cochrane risk of bias (RoB) tool and the certainty of the evidence using the GRADE approach.
Results: Eleven RCTs were included in this review with a total of 475 volunteers. Five RCTs were included in the meta-analyses. One of the meta-analyses showed that practicing 18 weeks of exercise improved the general motor coefficient score of the Körperkoordinationstest für Kinder test by 9.08 more in children with SNHL, compared to those who did not exercise: (9.08 [CI:5.78, 12.3], $I^2 = 63$ %), based on low certainty evidence. Another meta-analysis observed that practicing exercise for 7 weeks improved the balance of children with SNHL by 6.69 more in the balance subtest of the Bruininks-Oseretsky test of Motor Proficiency, compared to children who did not exercise: (6.69 [CI:4.10, 9.28], $I^2 = 0$ %), based on very low certainty evidence.
Conclusion: Exercise interventions were effective in improving motor coordination and manual dexterity of children with SNHL. However, these findings are not consistent, as they are based on evidence of low or very low certainty. Due to the limitations and biases present in the RCTs analyzed, it is suggested that new RCTs on the topic be performed with greater methodological rigor, to encourage and guide clinical practice on the topic, based on high-certainty evidence.

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Introduction

Peripheral vestibular dysfunctions are frequent findings in children with sensorineural hearing loss (SNHL).[1–7] Evidence in the literature indicates that around 41–85 % of children and adolescents with SNHL have disorders in the vestibular system.[8–12] The presence of peripheral vestibular dysfunction in children with SNHL seems to be related to the degrees of hearing loss and, consequently, to the extent of the lesion in the inner ear, as investigations show that children with greater degrees of hearing loss have the highest prevalence of vestibular dysfunction.[13–16]

Inner ear injuries, which cause damage to the cochlea, can extend into the vestibular system, and because the cochlea and vestibule share the continuous membranous labyrinth of the inner ear, pre-, peri-, or post-natal injuries or trauma can occur, causing damage to one or both systems.[17] This also occurs because anatomically the vestibular system and the cochlea are very close organs and functionally they are related in terms of innervation and vascularization,[18] increasing the chances of the child presenting peripheral vestibular dysfunctions concomitant with SNHL.

The vestibular dysfunctions observed in children with SNHL can result in disorders of balance, spatial orientation, motor coordination, and motor skills that depend on balance and motor coordination to be performed with skill and quality of movement, as these are functions of the vestibular system.[19–21] In this sense, there is a significant number of studies that demonstrate that children with SNHL have worse spatial orientation and motor coordination,[21–27] in addition to changes in static and dynamic balance,[28–31] and gait,[32–36] when compared to hearing children.

Other motor disorders have also been reported in SNHL children and can delay the motor development and acquisition of motor skills in these children,[37–40] making them inferior to their hearing peers in terms of motor performance.[41] Especially regarding motor coordination and manual dexterity, evidence shows that there are delays in the acquisition of these two motor skills in children with SNHL.[42–47] Such motor delays lead children with SNHL to present worse manual dexterity and difficulties in motor skills, such as writing, painting, drawing, holding a racket, playing an instrument, buttoning a shirt, and skills with balls,[48–51] resulting in lower participation of these children in sports, recreational and school activities.[51,52]

Given this, there is a need to implement motor rehabilitation programs for children with SNHL, with an emphasis on motor coordination and manual dexterity, to improve the hand performance during activities of daily living, education, environmental and recreational experiences, to enhance the inclusion and permanence of children with SNHL in the school community.[52,53] Some trials have observed significant improvements in motor coordination and manual dexterity in other children, after interventions with therapeutic exercises, use of virtual reality-based games, and tasks such as: cutting with scissors, making paper balls, pasting, painting, mirror therapy and kinesio taping, respectively.[54–56]

Some studies used exercise interventions to improve motor coordination and manual dexterity in children with SNHL, however, there are still no systematic reviews published in the literature that analyzed the certainty of this evidence, justifying this study. Therefore, this systematic review aimed to assess the certainty of evidence from randomized controlled trials (RCTs) that used exercise interventions to improve motor coordination and manual dexterity in children and/or adolescents with SNHL.

Methods

This systematic review was conducted per the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement,[57] and its protocol was registered with PROSPERO under number (CRD42021273591).[58]

Identification and selection of the trials

Ten electronic databases were searched in this review to find RCTs: MEDLINE/Pubmed, SCOPUS, EMBASE, Web of Science, CINAHL, LILACS, CENTRAL (Cochrane Central Register of Controlled Trials), PEDro, SciELO, and Google Scholar. The last search took place on March 1, 2025, and there were no restrictions on languages or publication time for articles. A manual search was also conducted in the reference lists of the included RCTs, to ensure that all trials on the topic were included. The search strategies used in each of the databases are available in the Supplementary materials (Supplementary 1).

The RCTs found in each of the databases were analyzed by each of the three reviewers, independently (Melo RS, Oliveira CA, and Delgado A), who judged the relevance of the studies, by reading the titles and abstracts, in front of a computer, according to the following inclusion criteria: Studies should be RCTs, which used exercises as an intervention, volunteers should be children and/or adolescents, with a clinical diagnosis of bilateral SNHL, age ranges between 6–19 years, without physical problems, cognitive and/or neurological deficits, except vestibular dysfunction, and which had included motor coordination or manual dexterity as outcomes.

In this first analysis, the articles were divided into eligible or discarded for this review. Articles with questionable summaries or with the potential to be included in this systematic review were retained for further analysis, by reading the full text of the article. Possible disagreements about the inclusion or not of one of the RCTs for this systematic review were resolved by the three reviewers. For cases in which common sense was not obtained, the opinion of two other reviewers was requested (Ferraz KM and Belian RB).

For cases in which there was a lack of data information in the articles, the authors of this review sent an email to the corresponding author of the study to obtain the necessary information. We emphasize that we obtained responses from all the authors of the RCTs who had doubts about their inclusion or not in this systematic review.

Assessment of the presence of risk of bias and the certainty of the evidence

The certainty of the evidence from RCTs was assessed using the GRADE approach.[59] According to the GRADE approach, six factors can interfere with the certainty of an RCT's evidence: design, risk of bias, inconsistency, indirectness, imprecision, and others. For each of these items, the evidence was considered according to the following classification: no (no reduction of points), serious (reduction of 1 point), and very serious (reduction of 2 points), being scored according to the level of severity of the risk of bias present in RCTs.

For the specific GRADE 'risk of bias' item, the Cochrane "Risk of Bias" tool was used to assess the risk of bias in RCTs, which assesses the following items: randomization, allocation confidentiality, blinding of volunteer participants and outcome evaluators, losses or incomplete data, selective description of the outcome, and others (if any). Each of the items in the risk of bias instrument was evaluated in the RCTs, with the following opinion being given: low risk of bias (green), unclear risk of bias (yellow), and high risk of bias (red), according to the risk of bias presented by each study.[60]

Participants

RCTs were included if participants were children and/or adolescents, with a clinical diagnosis of bilateral SNHL, aged between 6–19 years, and were part of both groups (control and intervention). Exclusion criteria were physical problems, and cognitive and/or neurological deficits associated with SNHL, except vestibular dysfunction.

Interventions

The intervention group should have performed exercises of any

nature, such as using balls, modeling clay, paintings, balance boards, using cones, or any other device that stimulated the tonic-postural and vestibular system of children with SNHL, to improve their motor coordination and manual dexterity. Interventions for the control group could have occurred with activities of daily living, recreation, leisure, any other intervention, or without any intervention.

Outcomes evaluated

Two outcomes were evaluated in this systematic review: motor coordination, the primary outcome, and manual dexterity, a secondary outcome.

RCTs that assessed such outcomes using the following instruments were included: Bruininks-Oseretsky Test (BOT) of Motor Proficiency, Peabody Developmental Motor Scale, Stick Flip Coordination Test

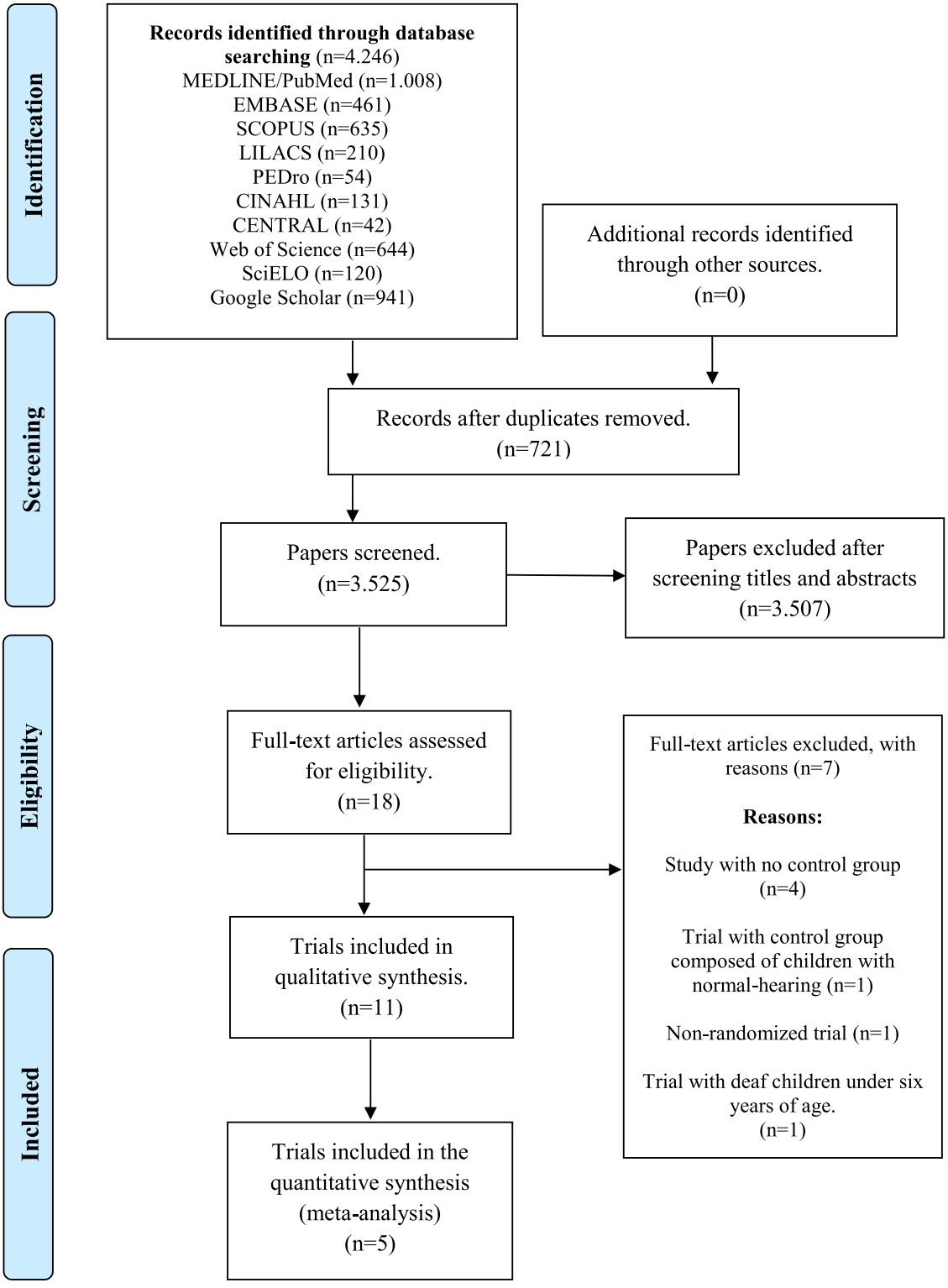

Fig. 1. Flowchart of the studies analyzed in this systematic review, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

(SFCT), Körperkoordinationstest für Kinder (KTK) Test, Test of Gross Motor of Development, Movement Assessment Battery for Children (MABC), and Motor Proficiency test (MPT), or by any other clinical tests or scales that have been used to assess children's motor coordination and manual dexterity.

Data extraction and analysis

Data from the RCTs included in this systematic review were extracted and recorded in a standardized form created by the authors. These data were archived in the Review Manager (RevMan) version 5.4 program, by the reviewers, independently, for subsequent verification of the information, and discussion of possible discrepancies.

To perform the meta-analyses, the RevMan software was used. The homogeneity of the RCTs was analyzed using the heterogeneity test, with analyses considered homogeneous when the p-value assumed a value greater than 0.05 and when the heterogeneity index (I^2) presented values up to 30 %, classified as low heterogeneity. Initially, in the first statistical analysis, fixed-effect meta-analyses were considered; however, when the heterogeneity test proved to be positive, and/or when heterogeneities were identified between the intervention protocols of the RCTs, a random-effect meta-analysis was adopted.

Results

Search results

Were identified 4246 articles, according to the search strategies in the 10 electronic databases searched. After removing duplicate articles, 3525 articles remained, which were analyzed, one by one, by their titles and abstracts, leaving 18 articles to be read in full. After reading the articles in full, 11 RCTs were considered eligible for this systematic review,[61–71] as shown in Fig. 1, which shows the flowchart for extracting the studies from this review, as recommended by PRISMA.

Of the RCTs excluded, four were intervention studies, however, they did not contain a control group, thus mischaracterized as an RCT.[72–75] In one trial,[76] the control group was made up of hearing children, one of the studies was non-randomized,[77] and the other RCT was made up of children aged 3–6 years.[78]

Characteristics of the included RCTs

All RCTs included in this review analyzed the effectiveness of exercising to improve motor coordination and manual dexterity in children/adolescents with SNHL, compared to not exercising.

The characteristics of the RCTs regarding the characterization of children, methodological aspects, interventions, instruments used to evaluate outcomes, and their conclusions are described in Table 1 (Supplementary material) and in Table 2 (Supplementary material).

Risk of bias

The 11 RCTs included in this review mentioned having performed randomization in their study, however, only six RCTs mentioned how the randomization occurred.

None of the 11 RCTs mentioned sample allocation confidentiality. The same occurred concerning the blinding of children in the study, indicating an unclear risk of bias for the RCTs in these two items.

Nine trials did not mention blinding of outcome assessors,[62–65,67–71] and Mehrem et al[66] reported that they were unable to perform this step in their study. Only Hedayatjoo et al[61] reported that the outcome assessors were blinded in their study. In other words, of the 11 RCTs analyzed, in 10 the evaluators were aware of which group the children being evaluated belonged to (control or intervention), representing an unclear risk of bias for nine trials and a high risk of bias for Mehrem's trial et al.[66]

There were no sample losses in any of the RCTs analyzed, and in only one study there was a selective description of the outcome. Mehrem et al[66] evaluated the motor skills of children with SNHL of both sexes, however, they did not present the results for the entire group, they presented only the results for each sex, representing a high risk of bias for this study.

The trial[61] grouped children with SNHL with and without cochlear implants into the same group. This is a bias because children with cochlear implants have a high prevalence of vestibular dysfunction, which was not controlled by this study.

There is evidence that children and adolescents with SNHL and associated vestibular dysfunction present worse performance in motor skills. This could underestimate the effect size of the interventions, resulting in a high risk of bias for this study, as shown in Figs. 2a and 2b, and Table 3, which provide the assessment of the risk of bias of RCTs (in general and isolated) and GRADE evidence certainty table, respectively.

Participants

The 11 RCTs included in this review involved a total of 475 volunteers and observed the effectiveness of exercise interventions to improve motor coordination and manual dexterity in children and/or adolescents with SNHL, compared to children with SNHL who did not do exercises.

Interventions

Of the RCTs included in this systematic review, all performed the intervention through sensorimotor balance and motor coordination exercises,[61–71] however, they used different modalities for this purpose.

Five RCTs used balance and motor coordination exercises included in physical education classes for the intervention group.[65,67–70] Four RCTs used sensorimotor and balance exercises, and two RCTs used Hemsball.[62,63]

All RCTs analyzed compared their results with a control group, which did not exercise. However, in the study by Mehrem et al.,[66] there were three groups: one group with the intervention with balance exercises, another group with balance exercises and manual skills, and a control group that did not practice exercises.

Outcomes evaluated

Nine RCTs[61,63,64,65,67–71] evaluated motor coordination, opting to evaluate this outcome using different instruments: five RCTs used the KTK test,[65,67–70] two RCTs used the BOT of Motor Proficiency,[61,63] one trial used the SFCT,[64] and another trial the Continuous Bimanual Coordination Task.[71]

Manual dexterity was assessed by three RCTs, and all of them opted for the BOT of Motor Proficiency.[62,63,66]

Meta-analyses

Five RCTs were included in the meta-analyses. Due to the homogeneity between the characteristics of the RCTs, it was possible to carry out six meta-analyses in this systematic review, five of them on motor coordination and one meta-analysis on body balance.

Three RCTs[65,67,70] with a total sample of 87 children with SNHL, of both sexes (exercise group: $n = 49$ and non-exercise group: $n = 38$), demonstrated that practicing 18 weeks of exercises improved the following outcomes of KTK test:

- **Balance Beam:** Balance of children with SNHL improved by 2.78 more in the balance Beam, compared to those who did not exercise: (MD: 2.78 [CI:1.65, 3.91], I^2=0 %), based on low certainty evidence, as shown in Fig. 3 and Table 3, respectively.
- **Single-leg Jump:** The single-leg jumping performance of children with SNHL improved by 1.73 more, compared to those who did not

Fig. 2. a) Risk of bias summary of the included trials assessed using the Cochrane Risk of Bias tool; b) Risk of bias of each included trial assessed using the Cochrane Risk of Bias tool.

practice exercises: (MD: 1.73 [CI:0.40, 3.06], $I^2 = 0$ %), based on low certainty evidence, as illustrated in Fig. 4 and Table 3, respectively.

- **Lateral Jump:** There was no difference between children who practiced exercises or not, concerning the lateral jump outcome: (MD: 2.81 [CI:−0.94, 6.56], $I^2 = 78$ %), based on evidence of very low certainty, as shown in Fig. 4 and Table 3, respectively.
- **Transfers on Platforms:** The performance of children with SNHL in this test improved by 1.91 more, compared to those who did not practice exercises: (MD: 1.91 [CI:0.46, 3.35], $I^2 = 55$ %), based on low certainty evidence, according to Fig. 4 and Table 3, respectively.
- **General Motor Coefficient:** Their general motor coefficient improved by 9.08 more compared to those who did not practice exercise: (MD: 9.08 [CI:5.78, 12.3], $I^2 = 63$ %), based on low certainty evidence, as shown in Fig. 4 and Table 1, respectively.

Two RCTs[61,63] including a total sample of 56 children with SNHL, of

Table 3
Certainty of the evidence of the RCTs that used exercise interventions to improve motor coordination and manual dexterity (fine motor skills) of children and adolescents with sensorineural hearing loss.

Certainty assessment							Nº of patients		Effect		Certainty	Importance
Nº of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Exercise Group	Non-exercise Group	Relative (95% CI)	Absolute (95% CI)		
Balance Beam (follow-up: mean 18 weeks; assessed with: Körperkoordinationstest für Kinder (KTK) test.												
03 [65,67,70]	RCT	very serious [a, b]	not serious	not serious	not serious	none	49	38	-	**2.78** (1.65 to 3.91)	⨁⨁◯◯ Low	CRITICAL
Unipodal Jump (follow-up: mean 18 weeks; assessed with: Körperkoordinationstest für Kinder (KTK) test.												
03 [65,67,70]	RCT	very serious [a, b]	not serious	not serious	not serious	none	49	38	-	**1.73** (0.40 to 3.06)	⨁⨁◯◯ Low	CRITICAL
Lateral Jump (follow-up: mean 18 weeks; assessed with: Körperkoordinationstest für Kinder (KTK) test.												
03 [65,67,70]	RCT	very serious [a, b]	serious [c]	not serious	not serious	none	49	38	-	**2.81** (-0.94 to 6.56)	⨁◯◯◯ Very Low	CRITICAL
Transfer on Platforms (follow-up: mean 18 weeks; assessed with: Körperkoordinationstest für Kinder (KTK) test.												
03 [65,67,70]	RCT	very serious [a, b]	not serious	not serious	not serious	none	49	38	-	**1.91** (0.46 to 3.35)	⨁⨁◯◯ Low	CRITICAL
General Motor Coefficient (follow-up: mean 18 weeks; assessed with: Körperkoordinationstest für Kinder (KTK) test.												
03 [65,67,70]	RCT	very serious [a, b]	not serious	not serious	not serious	none	49	38	-	**9.08** (5.78 to 12.3)	⨁⨁◯◯ Low	CRITICAL
Balance (follow-up: mean 7 weeks; assessed with: Balance Subtest of the Bruininks-Oseretsky test of Motor Proficiency.												
02 [61,63]	RCT	very serious [a, b]	serious [d]	not serious	not serious	none	28	28	-	**6.69** (4.10 to 9.28)	⨁◯◯◯ Very Low	CRITICAL

RCT: Randomized controlled trial; a: No allocation secrecy; b: There was no blinding of the outcome evaluators; c: Confidence interval was null; d: Trial that included children with and without cochlear implants in the same sample.

both sexes (exercise group: $n = 28$ and non-exercise group: $n = 28$), demonstrated that exercising for 7 weeks improved by 6.69 more the balance score of children with SNHL, in Balance sub-test - BOT of Motor Proficiency, when compared to children who did not practice exercises: (MD: 6.69 [CI:4.10, 9.28], I^2=0 %), based on evidence of very low certainty, as shown in Fig. 4 and Table 3, respectively.

Discussion

Eleven RCTs on the topic were analyzed and, although the trials observed that the motor coordination and manual dexterity of children with SNHL improved after the interventions, the certainty of this evidence is low or very low due to methodological biases and limitations found in the RCTs analyzed.

The main methodological limitations and biases observed in the evaluated trials were related to three categories: biases in sample selection, methodological biases, and biases related to children's characteristics. Therefore, we decided to point them out and discuss them separately below.

Limitations of the RCTs analyzed

Randomization was mentioned by the 11 RCTs analyzed, but five RCTs did not inform how randomization was carried out,[62–64,71] five trials reported that randomization occurred by simple draw,[65,67–70] and in one trial randomization occurred by coin toss.[66] None of these methods is the correct way to carry out the randomization of an RCT, as researchers must give study volunteers the same chance of being in one group or the other, which does not occur, for example, in a simple draw, or at the launch of a coin. At a given time, one of the groups will be complete, and the last person left to complete the group will only have the chance to be part of one of the groups.

Therefore, future RCTs on the topic should opt for computer-generated randomization, or a table of random numbers, whether or not carried out in blocks. Randomization is an important step that must be prioritized in a RCT, as it guarantees the homogeneity of the groups (intervention and control), controlling selection bias.

Another aspect absent in all RCTs analyzed in this review was the secrecy of sample allocation, a methodological process adopted to prevent researchers from knowing, in advance, the allocation of volunteers to the study groups. The trials analyzed did not present rigorous control in these two stages, especially in allocation secrecy, demonstrating that these selection biases should be better controlled by future RCTs on the topic, as trials with the absence of sample allocation secrecy overestimate the effect size of the intervention by up to 30 %.[79]

Failure to control for blinding of outcome assessors was an important bias identified in the RCTs analyzed by this systematic review. This methodological step demonstrates a strong idea of the reliability of the findings presented by the trials, to prevent the possibility of prior knowledge about sample allocation interfering with its response to treatment (conduction bias), or in the assessment of outcomes (detection bias).[80–82] The lack of control in the blinding of outcome evaluators makes the certainty of the evidence presented by the trial reduced, and its findings questionable, as trials that are not double-blind overestimate the effect size of interventions by up to 17 %,[79] justifying why there must be greater rigor and control over the blinding of outcome evaluators in future RCTs on the topic.

Furthermore, it is worth highlighting that blinding volunteers in RCTs, whose intervention involves physical exercise, is impossible. If asked whether they were in the group with or without exercising, volunteers would be able to say which of the two groups they were allocated to. Therefore, we inform that the RCTs analyzed in this review did not make it clear whether or not they blinded the volunteers in their studies when assessing the risk of bias in this review; however, these trials were not scored in this aspect in the assessment of the certainty of the evidence, as we understand that blinding volunteers in these RCTs

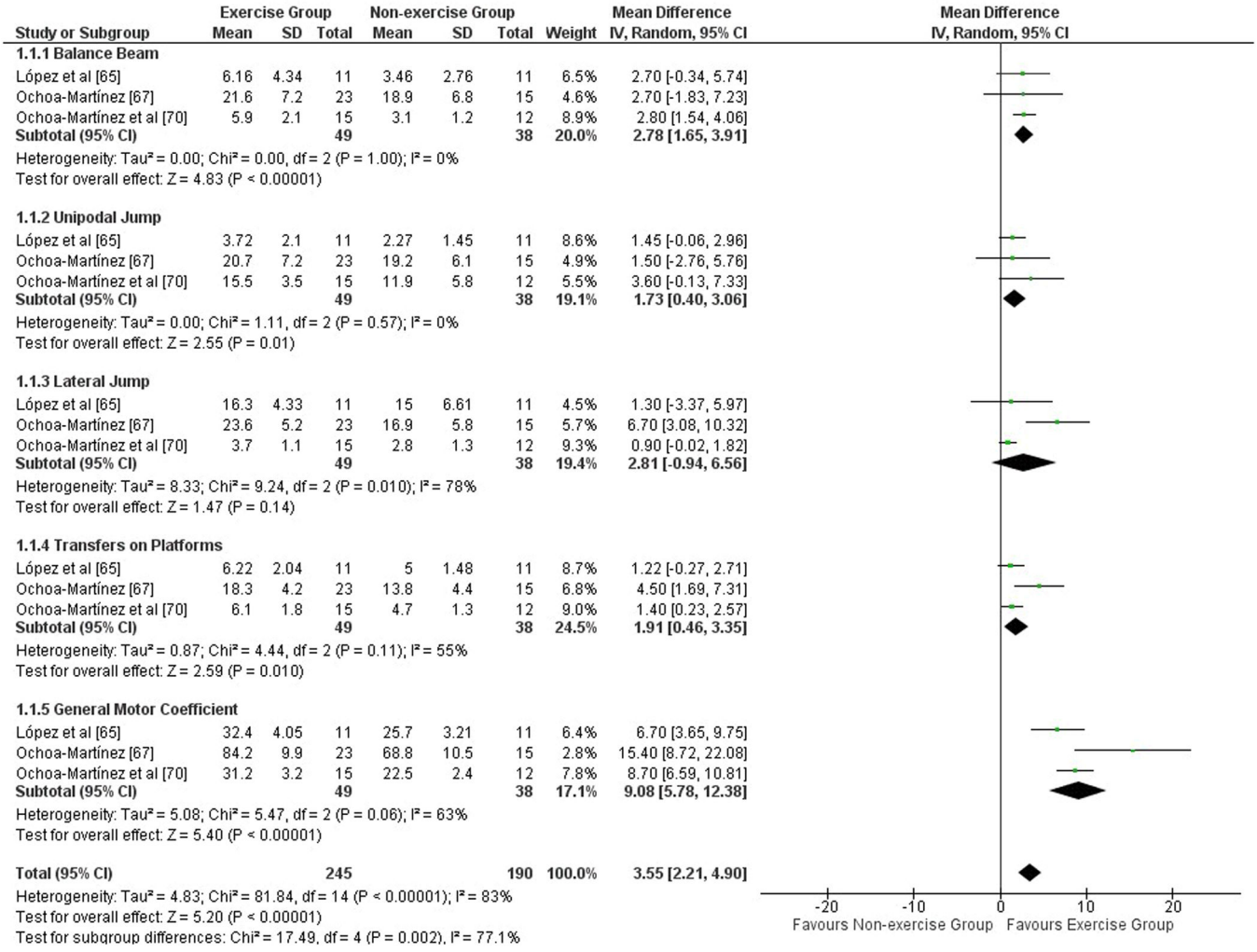

Fig. 3. Comparison between the use of exercise interventions versus not performing exercises to improve motor performance on (Balance beam, lateral jump, unipodal jump, transfers on platforms and motor coefficient) of children and adolescentes with sensorioneural hearing loss of both sexes, on Körperkoordinationstest für Kinder (KTK) test.

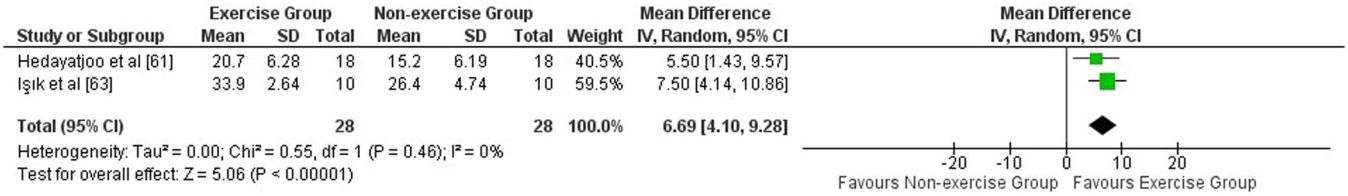

Fig. 4. Comparison between the use of exercise interventions versus not performing exercises to improve balance of children and adolescents with sensorioneural hearing loss of both sexes, represented by performance on balance subtest of the Bruininks-Oseretsky test of Motor Proficiency.

would be an impossible control measure to carry out.

Another important limitation of a trial, identified in this review, was the inclusion of children with cochlear implants in the same sample as those who did not undergo surgery. This is a bias, as children with SNHL undergoing cochlear implant surgery have shown a high frequency of vestibular dysfunction.[83–88] Therefore, including children with and without cochlear implants in the same sample may have underestimated the size of the intervention effect, due to the motor and manual dexterity problems that these children present, already well documented in the literature.[88–93]

Furthermore, children using cochlear implants have better hearing conditions than those not undergoing surgery[94–98] and this can be an advantage for these children, as several investigations have observed that hearing appears to improve spatial orientation, and postural stability,[99–101] including children with SNHL, whether through individual sound amplification devices or cochlear implants.[102–105] This suggests that auditory input is not neutral in the motor skills of children with SNHL undergoing cochlear implant surgery.[106] Therefore, the inclusion of children with and without cochlear implants in the same sample is a confounding bias.

Strengths and weaknesses of the RCTs analyzed

The analyzed trials have strengths and weaknesses, which need to be mentioned and discussed. No trial analyzed mentioned performing the calculation to estimate the sample size of their studies, this is a weakness

of RCTs, as it compromises the external validity of the study, when its results cannot be generalized. Therefore, we suggest that future RCTs on the topic estimate their sample size through sample calculation.

Another weakness of the RCTs analyzed was not having assessed the vestibular function of the sample. Children with SNHL (with and without cochlear implants) have vestibular dysfunction,[107–112] and those with SNHL and associated vestibular dysfunction have worse neuromotor performance (including manual dexterity), compared to hearing children,[109–111] and also children with SNHL and normal vestibular function.[109–111] When children's vestibular function is not assessed, it is not known for sure which children this intervention was effective for, since children with SNHL present divergent motor performance according to their vestibular function.

Therefore, we suggest that future RCTs on the topic evaluate the function of the children's vestibular system, and present their results, for children with normal vestibular function and with vestibular dysfunction. These data are important to guide clinical practice and the rehabilitation of motor coordination and manual dexterity of children with SNHL with and without vestibular dysfunction.

Regarding methods of assessing vestibular function, De Kegel et al[111] and Gadsbøll et al[112] reported that the asymmetry of the vestibular evoked myogenic potential (VEMP) and the video head impulse test (v-HIT) can be good predictors of vestibular disorders in children with SNHL, in addition to being easy, quick and comfortable tests for children (from 3 years of age).[112] Therefore, such methods can be used to assess children's vestibular function in upcoming RCTs on the topic.[113]

All outcomes above are extremely relevant, as they provide theoretical-scientific information to guide clinical practice and should be investigated by future RCTs on the topic. The RCTs analyzed present strengths, which should be maintained by future RCTs on the topic. One of them is the choice of instruments validated for the pediatric population, such as the KTK test and BOT of Motor Proficiency, which are reliable, valid, and responsive instruments for evaluating motor coordination and manual dexterity of children in this age group.[114–117]

Furthermore, the RCTs analyzed had a very satisfactory duration of interventions, eight trials had a total intervention time of $\geq$10 weeks. This longer period for interventions may be more beneficial for those children who probably need to improve their motor skills later, due to their greater motor difficulty, due to the probable presence of vestibular dysfunction.

These strengths are extremely relevant, as they demonstrate the robustness of the studies, guide clinical practice, and should be maintained in future RCTs on the topic.

Implications for clinical practice

Although the meta-analyses in this review demonstrate that the practice of exercises improved the motor coordination and balance of children with SNHL, these results are evidence of low and very low certainty. According to the GRADE approach,[118] when evidence is of low certainty it is very likely that future research will have an important impact on the confidence of the effect estimate, and will probably change the effect estimate. When findings come from very low-certainty evidence, any estimate of the effect is very uncertain.

Thus, although the RCTs analyzed observed that the proposed exercises improved the motor coordination and manual dexterity of children with SNHL, these results are not consistent and should be interpreted with caution, due to low and very low certainty of evidence. Due to these limitations and biases present in the RCTs analyzed, it is suggested that future RCTs on the topic be proposed, with greater methodological rigor, to encourage and guide clinical practice on the topic, based on high-certainty evidence.

The next RCTs on the topic must present greater methodological rigor in terms of allocation secrecy and blinding of outcome evaluators. Furthermore, future RCTs need to estimate their sample size through sample calculation so that their results are representative and generalizable. The vestibular function of the sample also needs to be evaluated, and the results need to be exposed, to show the effectiveness of interventions for children with SNHL with and without vestibular dysfunction.

Furthermore, it is also important that future RCTs mention the adverse events of interventions so that doctors and physiotherapists can analyze the relationship between the benefits and adverse events of these interventions for clinical decision-making. Future RCTs should also evaluate whether the proposed intervention is effective in improving, in addition to motor coordination and manual dexterity, other areas of the child's life, such as the performance of children with SNHL in school, recreational activities, and sports practices.

Future RCTs could also look at how long it takes to improve these outcomes,[119] and how long these effects last. Adolescents should also be included in future RCTs, as evidence shows that, without interventions, these motor problems affect children with SNHL, and remain into adolescence,[120–123] justifying why adolescents should be included in future RCTs on the topic.

This review observed positive effects of interventions on motor coordination and manual dexterity in RCTs in which exercise programs involved sessions of 30 min or more, performed two or more times a week, and lasting a total of four or more weeks.[61–71] Regarding the exercises used in the interventions, those that had the best effects on the outcomes were those that involved manual precision exercises, to hit a target, for example, those that involved eye-hand coordination exercises, exercises that involved dual tasks, and those performed in challenging positions for body balance, with a reduction in the support base, and displacement of the center of gravity, such as vertical jumps (forward and sideways). This information will provide theoretical-scientific support to guide future RCTs and clinical practice on the topic.

This systematic review had as a limitation, not having searched banks of theses and dissertations.

Conclusion

Exercise interventions were effective in improving motor coordination and manual dexterity of children with SNHL. However, these results are not consistent, as they are based on low or very low-certainty evidence, and should be interpreted with caution. Due to the limitations and biases present in the RCTs analyzed, it is suggested that new RCTs on the topic be proposed, and present greater methodological rigor, to encourage and guide clinical practice on the topic based on high-certainty evidence.

Declaration of competing interest

The authors declare no competing interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.bjpt.2025.101556.

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