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SYSTEMATIC REVIEW AND META-ANALYSIS

EFFECTIVENESS OF WHOLE BODY VIBRATION ON QUADRICEPS STRENGTH AND VERTICAL JUMP IN HEALTHY ATHLETES: a systematic review and meta-analysis

Eficácia da vibração de corpo inteiro na força do quadríceps e salto vertical em atletas saudáveis: uma revisão sistemática e meta-análise

Eficacia de la vibración de todo el cuerpo sobre la fuerza del cuádriceps y el salto vertical en atletas saludables: una revisión sistemática y metanálisis

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ABSTRACT

Introduction: whole body vibration (WBV) is currently a training method increasingly used as an adjunct in sports to improve strength performance in various sports. Being a muscle training widely used for demanding sports practices of athletes who are physically well prepared for better performances. In addition, the literature shows that physical training with aerobic and resistance exercises promotes an improvement in the regenerative capacity of the athlete. However, the literature does not present systematic review studies on the effect of WBV on muscle strength in athletes. **Objective**: This review and meta-analysis aimed to evaluate the effectiveness of WBV on muscle strength and vertical jump in healthy athletes. **Method**: A systematic review of randomized clinical trials which had used WBV compared to usual exercises in athletes of different modalities and having the assessment of muscle strength and vertical jump as outcomes. This study was conducted using PubMed/Medline, SciELO, LILACS, CINAHL and PEDro databases, without language or year restrictions. The search terms used were: 'athletes', 'muscle strength', 'resistance training', 'muscle contraction', 'strength', 'clinical trial' and 'whole body vibration'. Risk of bias (RoB 2.0) and evidence quality (GRADE) were evaluated. **Results:** Three clinical trials participated in the review, which presented a varied risk of bias and low quality of evidence. The WBV program for athletes increased muscle strength; however, no effects were verified for the vertical jump height. **Conclusion**: The studies evaluated in this review show that training with WBV was effective in increasing muscle strength in athletes, especially when associated with other conventional training; however, no changes were observed for the vertical jump height. The studies showed a variable risk of bias and low evidence quality.

Keywords: Physical training; Musculoskeletal repercussions; Professional athletes; Exercise.

RESUMO

Introdução: a vibração de corpo inteiro (WBV) é atualmente um método de treinamento muito utilizado como coadjuvante em vários esportes para melhorar o desempenho da força. Este é um treinamento muscular para práticas esportivas exigentes de atletas que estejam bem preparados fisicamente para melhor desempenho. Além disso, a literatura mostra que o treinamento físico com exercícios aeróbicos e resistidos promove melhora na capacidade regenerativa do atleta. No entanto, há necessidade de verificar os efeitos da VCI na força muscular e do salto vertical em atletas. **Objetivo:** esta revisão e meta-análise teve como objetivo avaliar a eficácia da vibração de corpo inteiro (WBV) na força muscular e no salto vertical em atletas saudáveis. **Método:** revisão sistemática de ensaios clínicos randomizados que utilizaram a VCI comparada a exercícios usuais em atletas de diferentes modalidades e tendo como desfechos a avaliação da força muscular e do salto vertical. Foram utilizadas as bases de dados PubMed/Medline, SciELO, LILACS, CINAHL e PEDro, sem restrições de idioma ou ano. Os termos de busca utilizados foram: 'atletas', 'força muscular', 'treinamento de resistência', 'contração muscular', 'força', 'ensaio clínico' e 'vibração de corpo inteiro'. Risco de viés (RoB 2.0) e qualidade da evidência (GRADE) foram avaliados. **Resultados:** três ensaios clínicos participaram da revisão, apresentaram risco variado de viés e baixa qualidade de evidência. O programa WBV para atletas aumentou a força muscular; entretanto, não foram verificados efeitos para a altura do salto vertical. **Conclusão:** os estudos avaliados nesta revisão mostram que o treinamento com VCI foi eficaz no aumento da força muscular em atletas, principalmente quando associado a outros treinamentos convencionais; no entanto, não foram observadas alterações para a altura do salto vertical. Os estudos mostraram risco variável de viés e baixa qualidade de evidência.

Palavras-chave: Treinamento físico; Repercussões musculoesqueléticas; Atletas profissionais; Exercício.

RESUMEN

Introducción: La vibración de cuerpo entero (WBV) es actualmente un método de entrenamiento ampliamente utilizado como complemento en varios deportes para mejorar el rendimiento de la fuerza. Se trata de un entrenamiento muscular para prácticas deportivas exigentes por parte de deportistas físicamente bien preparados para un mejor rendimiento. Además, la literatura muestra que el entrenamiento físico con ejercicios aeróbicos y de resistencia promueve una mejora en la capacidad regenerativa del deportista cuando. Sin embargo, la literatura no presenta estudios de revisión sistemática sobre el efecto de WBV en la fuerza muscular en atletas. **Objetivo:** evaluar la efectividad de la WBV sobre la fuerza muscular y el salto vertical en atletas sanos. **Método:** revisión sistemática de ensayos clínicos aleatorizados que utilizaron WBV en comparación con los ejercicios habituales en atletas de diferentes modalidades y teniendo como resultados la evaluación de la fuerza muscular y el salto vertical. Este estudio se realizó en las bases de datos PubMed/Medline, SciELO, LILACS, CINAHL y PEDro, sin restricciones de idioma ni año. Los términos de búsqueda utilizados fueron: 'atletas', 'fuerza muscular', 'entrenamiento de resistencia', 'contracción muscular', 'fuerza', 'ensayo clínico' y 'vibración de cuerpo entero'. Se evaluó el riesgo de sesgo (RoB 2.0) y la calidad de la evidencia (GRADE). **Resultados:** tres ensayos clínicos participaron en la revisión, con riesgo variable de sesgo y baja calidad de la evidencia. El programa WBV para atletas aumentó la fuerza muscular; sin embargo, no se verificaron efectos para la altura del salto vertical. **Conclusión:** los estudios evaluados en esta revisión muestran que el entrenamiento con WBV fue efectivo para aumentar la fuerza muscular en los atletas, especialmente cuando se asocia con otro entrenamiento convencional; sin embargo, no se observaron cambios en la altura del salto vertical. Los estudios mostraron riesgo variable de sesgo y evidencia de baja calidad.

Palabra Clave: Entrenamiento físico; repercusiones musculoesqueléticas; atletas profesionales; ejercicio.

INTRODUTION

Vibration is a fast and oscillatory movement[1] which can be used for therapeutic purposes. It began in the Soviet Union to improve muscle strength in astronauts.[2] Subsequent to this milestone, other equipment was developed which promotes whole-body vibration (WBV)[2,3] and the physical principles of this vibration are based on providing muscle stimulation through mechanical oscillations, which in turn provide periodic changes in force, acceleration and displacement in time that causes a reactive force in the human body.[4] WBV is currently a training method increasingly used as an adjunct in sports to improve strength performance in various sports.[5-10]

Sports practices require athletes to be well physically prepared for better performances, with muscle training being widely used. When the order of exercises and the frequency are performed correctly, they promote injury prevention and prolong the career of athletes, in addition to reducing financial expenses in clubs with doctors and physical therapists.[11]

The literature shows that physical training with aerobic and resistance exercises promotes an improvement in the athlete's regenerative capacity, meaning that the athletes recover faster when they have a good previous physical preparation.[12] In addition, plyometric exercises induce adaptations in terms of biomechanical variables related to jumping and physical fitness in female volleyball players[13] and increase the change of direction speed, strength and aerobic resistance in soccer players.[14]

However, the literature presents few studies on the effect of WBV on muscle strength in athletes. In this sense, this systematic review aims to identify the effectiveness of WBV on improving muscle strength and jumping in professionals from various sports modalities.

METHOD

This review followed the PRISMA[15] rules and recommendations for elaborating a systematic review registered with PROSPERO and the protocol of this systematic review was registered under the number: CRD4202128617.

Three independent reviewers (ECSCM, BLMC and TGO) carried out the search for articles and the Boolean operators "OR" and "AND" were used to cross the descriptors to define the search strategy in the period from 07/12/2021 to 01/30/2022. The search was performed in the PubMed/Medline, Scientific Electronic Library Online (SciELO), Latin American and Caribbean Health Sciences Literature (LILACS), Cumulative Index to Nurse and Allied Health Literature (CINAHL) and Physiotherapy Evidence Database (PEDro) databases. The following MeSH and DeCS descriptors were used: athletes; muscle strength; resistance training; muscle contraction; strength; clinical trial and whole body vibration.

Articles without language restriction or publication date were analyzed. The data were exposed, verifying disparity in the material, discrepancy in the inclusion/exclusion and duplications. A fourth researcher was elected to resolve disputes in the search, data extraction and quality score (PEMM).

Eligibility criteria

Randomized clinical trials that performed WBV compared to other training methods for athletes aged between 18 and 50 years were included for this study, and those athletes who had some type of comorbidity or who had not been trained for more than one year were excluded.

Study type

Studies from controlled and randomized or quasi-randomized clinical trials were included for this review.

Primary outcome

Quadriceps muscle strength assessed by isometric force platform or bilateral lower limb dynamometry.

Secondary outcome

Vertical jump height measured by countermovement jump duration.

Study selection

Studies were reviewed by three independent reviewers and analyzed by title, and then from pre-selection it was verified whether muscle strength and vertical jump outcomes were assessed by dynamometry/isometric platform and countermovement jump duration, respectively. Once these criteria were met, a complete reading of potentially eligible studies was performed to confirm their inclusion. Studies were included where the volunteers received the WBV overall and without restrictions regarding frequency (Hertz), amplitude (millimeters) and dose (duration time). Studies which performed exercise or conventional training for the control group were included. After the initial review, a fourth reviewer (PEMM) resolved disagreements between the three reviewers.

Data extraction and management

A form was developed for data extraction by the reviewers that was filled out independently by the researchers, including information on title, author, year, number of participants, eligibility criteria, group characteristics, exclusions, intervention and outcome measures. The data were summarized in tables and compared, the data were entered into Review Manager 5.4.1 and verified for the accuracy of the studies.

Risk of bias

The rating scale used to qualify the studies was based on the Revised Cochrane risk-of-bias tool for randomized trials (RoB 2.0), with the judgment of high risk, low risk or uncertain risk of bias based on the methodological description of the studies. The 5 domains evaluated were biases in the randomization process, intended intervention, missing data, outcome measurement, and outcome reporting.

For judging the domains, a high risk was considered for not citing the process; uncertain risk for citation without clarification; and low risk for citation with description of the operation mode.

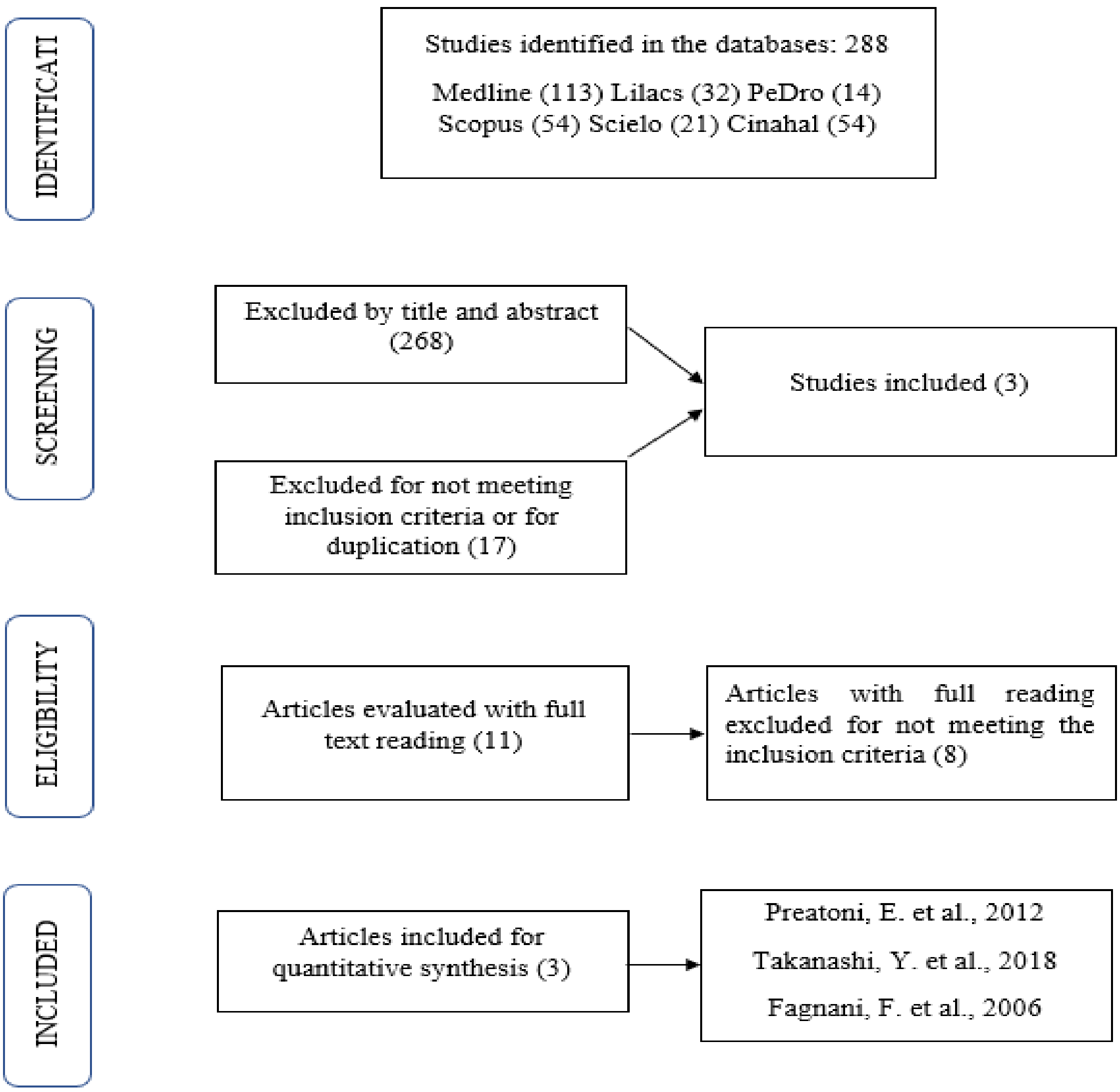
Evidence certainty assessment

The assessment of the certainty of the evidence was performed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system, with five factors being evaluated which can decrease the quality of evidence, such as the risk of bias, inconsistency, indirect evidence, imprecision and publication bias, ranking as high, moderate, low, and very low.[16]

RESULTS

A total of 268 of the 288 titles searched and analyzed in the databases were excluded for not meeting the inclusion criteria. Of the remaining 11, another eight were excluded due to duplicity, or because they performed a different outcome measure, or because they included training with athletes with musculoskeletal diseases. After reading the articles, three were considered eligible for this review, as recommended by PRISMA. All of the included articles performed the intervention with the WBV, while the control group performed other types of exercises. This process is described in figure 1.

Figure 1 - Search and selection of studies for systematic review according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).



Characteristics of the studies

The studies that participated in the review[17,18,19] did not describe the randomization method and were developed with athletes from different modalities (soccer, softball, athletic pitchers, volleyball, basketball, athletics and gymnastics). All used[17,18,19] WBV in the intervention group compared to conventional training previously performed with regular exercises among athletes, which were not detailed in the studies. None of the studies described blinding of participants or raters. The population involved was female[17,19] and one study were male[18], and the sample ranged from 14 to 26 participants. The characteristics of the studies are expressed in table 1.

Table 1 - Description of the studies.

Study	Methods Design	Sport Modallity	Sample	Intervention	Evaluated Outcomes	Outcome Evaluation
Preatoni et al.	Clinical Trial (Pre and post intevention)	Football and softball	Participants: 18 athletes, womens, Average age: 23.8 +- 4.9,	Dose: 6 x of 6 repetitions; Duration: 8 weeks; Frequency: 2x per week;	Strength; Muscle Power; vertical jump;	Muscle strength; Isometric force platform; Vertical jump; Countermovement jump duration;
			Group VCI + load: n=6 Group VCI: n=6 Group control: n=6 (conventional training)	Frequency of equipment: 25-45Hz and Amplitude: 2.6-4.4mm		Optical acquisition system: optojump
Takanashi Y et al.	Clinical Trial Randomized (Pre and post intervention)	Athletic pitchers	Participants: 14 pitchers; Male; Age: 19-22 years	Dose: 16-24 min; Duration: 8 weeks: Frequency:	Strength, Vertical jumping skill, Balance	Muscle strength. Dynamometry, Bilateral lower limbs; Vertical jump; Jump time
			Group VCI: n=7 and Group Control: n= 7	Frequency of equipment: 30-50Hz and Amplitude: 2.5mm		(DKH multi-jump tester)
Fagnani et. al	Randomized clinical trial (pre and pos intervention)	Volleyball, Basketball, Athletics and Gymnastics	Participants: 26; Womens; Age: 21-27 years old	Dose: 15-45s Duration: 8 weeks of 3x week	Concentric quadriceps Extension; Flexibility test; Vertical jump	Muscle strength; Dynamometry; Bilateral lower limbs; Vertical jump; Countermovement jump
			Group VCI: n= 13 Group control: n= 13 (Training prior to the research).	Frequency of equipment: 35Hz and amplitude: 4mm		(Capacitive platform + digital timer)

Intervention

The duration of the interventions was eight weeks, and the WBV protocol applied ranged from 2 to 3 times a week, with amplitude ranging from 2.5 to 4.4 mm and frequency between 25 to 50Hz. No difficulties in performing the training or adverse effects were reported in the analyzed studies, despite the record of two withdrawals without reporting their causes.

Risk of bias

All clinical trials included in this review compare the use of WBV to conventional training, however the training of the control groups was not described. Although the studies were described as randomized clinical trials, they did not present the randomization method or the allocation sequence.

Participants were comparable at baseline and were aware that they were participating in clinical trials. Blinding of participants or raters in both trials was not reported.

The method of measuring the results was adequate in two of the studies,[17,19] because there was a comparison between before and after training, but the jump measurement was not detailed in one of them, only reporting the results considering the significance.[18] The risk of bias in the studies can be seen in figure 2.

Figure 2 - Risk of bias from randomized controlled trials for muscle strength and vertical jump outcomes. Methodological evaluation of articles according to the Cochrane Collaboration Reviewer's Handbook, ROB2.0

	Randomisation process	Timing of identification or recruitment of participants	Deviations from the intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall
Preatoni et al. 2012	-	!	+	+	-	+	-
Takanashi et al. 2018	!	!	-	+	-	-	-
Fagnani et al. 2006	!	!	+	+	-	+	-

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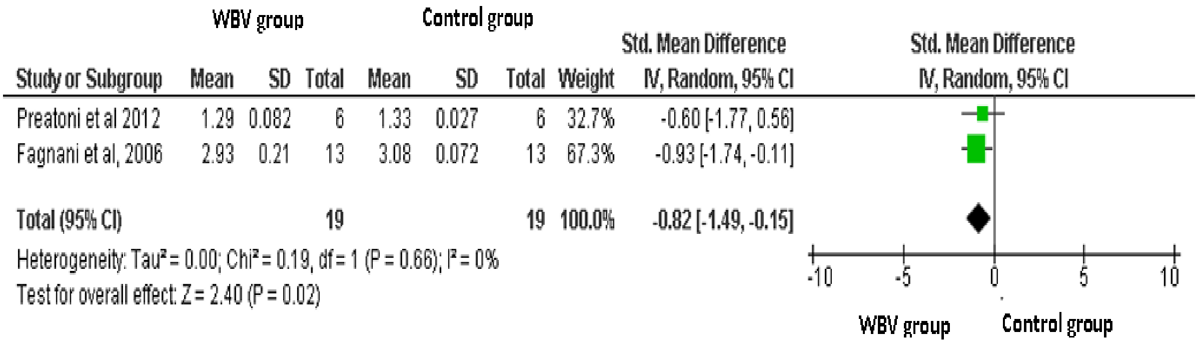
Evaluated outcomes

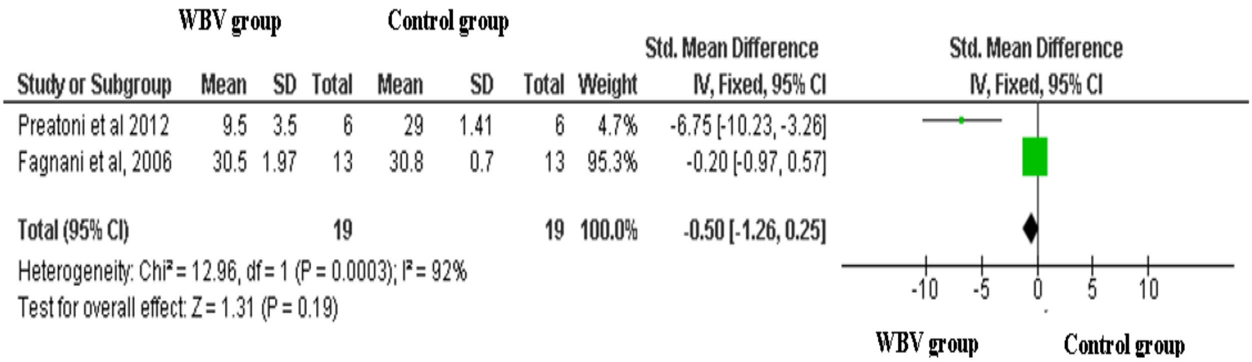
Only two studies[17,19] were considered for the meta-analysis, which involved the assessment of muscle strength and vertical jump. Interventions in the trials were performed using the WBV, with muscle strength and jump height being evaluated in all studies, where muscle strength was assessed by an isometric strength platform[17] and bilateral dynamometry of the lower limbs.[18,19] An increase was observed in muscle strength for the groups that performed WBV when compared to athletes who performed conventional training,[17,19] as can be seen in Figure 3.

Figure 3 - Forest plot of muscle strength outcome studies.



The studies used an optical acquisition system,[17] multijump tester[18] or a capacitive platform with a digital timer,[19] to assess the countermovement jump height, and there was also no increase in the jump of those groups of athletes who performed WBV when compared with conventional training, according to Figure 4.

Figure 4 - Forest plot of vertical jump outcome studies.



The quality of evidence was very low in terms of risk of bias, inconsistency and imprecision, as shown in Table 2.

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Table 2 - Quality of evidence assessment using the GRADE system.

Quality assessment							**No of participants**		**Effect**		**Quality Importance**
No of studies	Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Muscle strength	Vertical Jump	Relative (95% CI)	Absolute (95% CI)	
Muscle Strenght											
2	Randomized Trials	Serious[1]	No Serious	No Serious	No Serious	none	19	19	-	OR (-1,49 to -0,15)	Very low Important
Vertical Jump											
2	Randomized controlled trials	Serious[1]	Very Serious[2]	No Serious	Serious[3]	none	19	19	-	OR (1,26 to 0,25)	Very low Important

Legend: [1] Limitation of randomization process and allocation blinding; [2] Heterogeneity (I^2 92%); [3] Wide Confidence interval

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DISCUSSION

This systematic review aimed to verify the effectiveness of WBV on muscle strength and vertical jump when added to the training of athletes. The results showed improvement in muscle strength in those who underwent WBV training, however, no changes were observed for the jump height.

The studies involved had low methodological quality, in addition to the small number of clinical trials developed that met the eligibility criteria for this review, as only three studies[17–19] were included and two of these were included in the meta-analysis.[17,19] These studies had low methodological quality with a high risk of bias for both outcomes, in addition to presenting inconsistency, serious imprecision for the vertical jump, and also lack of sample size calculation and allocation secrecy. All studies involved in this review used the synchronous vibrating platform with similar dose, duration, frequency and amplitude parameters during the intervention.

Athletes who used WBV training showed an increase in muscle strength, similar to what was found in elite male track and field athletes[20] and in patients with chronic kidney disease.[21] A reduction in mass and hypoplasia of muscle fibers is expected[22] regarding chronic diseases with repercussions on the musculoskeletal system, as well as in aging, where there is a reduction in muscle strength.[23] WBV has been shown to be an alternative means of performing exercise by increasing muscle strength in older adults[24] under these conditions and in chronic conditions such as postmenopausal women[22] and patients with chronic obstructive pulmonary disease.[25] WBV promotes repeated vibratory tonic stimulation, which stimulates contraction, promotes changes in its structure and improves its muscle response and increases strength.[26,27]

Athletes who were evaluated by vertical jump in the studies that participated in this review did not present an increase in jump height at the end of WBV training. A study carried out with professional athletes in which WBV was associated with the performance of isometric and dynamic exercises [10] and another carried out with basketball players[28] also showed no increase in jump height. However, a study carried out with handball or water polo players showed a gain of 11.9% in the average jump height after WBV training.[29] Another study developed with soccer players also showed an increase in the vertical jump height at the end of a WBV program; however, this protocol was associated with a warm-up exercise on a horizontal stationary bicycle before training.[30]

A possible explanation for the lack of results for the vertical jump test found in this review seems to be related to the non-excitation of the stretch reflex [24] during its performance. Although this test involves contracting and stretching the muscles involved in the jump, it is characterized by a large angular displacement and low stretching speed, which is insufficient to excite the gamma spindle motor stretch, which would increase the contraction of these muscles by increasing the recruitment of motor units.[29]

Although this review was performed with only three articles, it was possible to perform the meta-analysis for the considered outcomes, although the low quality of the articles limits recommending WBV training for vertical jump height in athletes. In this sense, it is necessary to carry out new studies of randomized and controlled clinical trials with a better methodological design to demonstrate the effectiveness of WBV in athletes.

CONCLUSION

The studies evaluated in this review show that WBV training was effective in increasing muscle strength in athletes, especially when associated with other conventional training; however, no changes were observed for the vertical jump height. As a suggestion, future studies using WBV as part of the training program for athletes need to pay attention to methodological issues involving clinical trials in order to ensure better quality of scientific evidence and indication of its use in sports practice.

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