

BAREFOOT VERSUS SHOE-WEARING WEIGHT TRAINING EXERCISES: A SYSTEMATIC REVIEW OF THE BENEFITS AND DRAWBACKS OF SQUATS AND LUNGES

EXERCÍCIOS DE MUSCULAÇÃO DESCALÇO VERSUS CALÇADO: UMA REVISÃO SISTEMÁTICA SOBRE BENEFÍCIOS E MALEFÍCIOS PARA AGACHAMENTO E AFUNDO

EJERCICIOS DE ENTRENAMIENTO CON PESAS DESCALZO VERSUS CON CALZADO: UNA REVISIÓN SISTEMÁTICA DE LOS BENEFICIOS Y DESVENTAJAS DE LAS SENTADILLAS Y LAS ESTOCADAS



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ABSTRACT

Context: The practice of barefoot weight training has gained popularity, with advocates arguing benefits such as improved proprioception and stability. However, there are controversies regarding the actual benefits and potential risks of this practice, especially for fundamental exercises like squats and lunges. **Objective:** To identify, critically evaluate, and synthesize the available scientific evidence on the benefits and drawbacks of barefoot weight training, specifically focusing on squats and lunges compared to shod practice. **Methods:** A systematic review was conducted following PRISMA guidelines. Searches were performed in the databases PubMed/MEDLINE, Scopus, Web of Science, SciELO, LILACS, SPORTDiscus, Cochrane Library, and Google Scholar, using terms related to barefoot exercises, squats, lunges, and relevant outcomes. Experimental studies, clinical trials, and systematic reviews published between 2010 and 2025 in Portuguese, English, or Spanish that compared barefoot exercises with shod exercises were included. Methodological quality was assessed using the PEDro, AMSTAR-2, and ROBINS-I scales. Data were synthesized narratively by outcome categories. **Results:** Ten studies met the eligibility criteria. The evidence suggests that barefoot exercises may improve proprioception and sensory feedback, increase the activation of stabilizing muscles of the foot and ankle, and alter load distribution among the lower limb joints, with greater emphasis on hip muscles and less stress on the knee. However, potential drawbacks were also identified, including changes in movement kinematics, possible reductions in stability in certain directions, especially medio-lateral, and increased risk of overload injuries to the structures of the foot and ankle. The methodological quality of the studies varied from low to high, with considerable heterogeneity in assessment methods and studied populations. **Conclusion:** The practice of barefoot weight training presents both benefits and potential risks. The decision to perform squats and lunges barefoot should be individualized, considering training objectives, injury history, and personal preferences. Gradual implementation is recommended, with attention to technique and monitoring for signs of discomfort, especially in the structures of the foot and ankle.

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Keywords: Resistance Training. Barefoot Exercise. Squat. Lunge. Biomechanics.

RESUMO

Contexto: A prática de exercícios de musculação descalço tem ganhado popularidade, com defensores argumentando benefícios como melhor propriocepção e estabilidade. No entanto, há controvérsias sobre os reais benefícios e potenciais riscos desta prática, especialmente para exercícios fundamentais como agachamento e afundo. **Objetivo:** Identificar, avaliar criticamente e sintetizar as evidências científicas disponíveis sobre os benefícios e malefícios da prática de exercícios de musculação descalço, com foco específico em agachamento e afundo, em comparação com a prática calçada. **Métodos:** Foi realizada uma revisão sistemática seguindo as diretrizes PRISMA. Buscas foram conduzidas nas bases de dados PubMed/MEDLINE, Scopus, Web of Science, SciELO, LILACS, SPORTDiscus, Cochrane Library e Google Acadêmico, utilizando termos relacionados a exercícios descalços, agachamento, afundo e desfechos relevantes. Foram incluídos estudos experimentais, ensaios clínicos e revisões sistemáticas publicados entre 2010 e 2025, em português, inglês ou espanhol, que compararam exercícios descalços com calçados. A qualidade metodológica foi avaliada utilizando as escalas PEDro, AMSTAR-2 e ROBINS-I. Os dados foram sintetizados narrativamente por categorias de desfechos. **Resultados:** Dez estudos atenderam aos critérios de elegibilidade. As evidências sugerem que exercícios descalços podem melhorar a propriocepção e o feedback sensorial, aumentar a ativação de músculos estabilizadores do pé e tornozelo, e alterar a distribuição da carga entre as articulações dos membros inferiores, com maior ênfase nos músculos do quadril e menor estresse no joelho. No entanto, também foram identificados potenciais malefícios, incluindo alterações na cinemática do movimento, possível redução da estabilidade em algumas direções, especialmente médio-lateral, e aumento do risco de lesões por sobrecarga nas estruturas do pé e tornozelo. A qualidade metodológica dos estudos variou de baixa a alta, com heterogeneidade considerável nos métodos de avaliação e populações estudadas. **Conclusão:** A prática de exercícios de musculação descalço apresenta tanto benefícios quanto riscos potenciais. A decisão de realizar agachamento e afundo descalço deve ser individualizada, considerando os objetivos de treinamento, histórico de lesões e preferências pessoais. Recomenda-se implementação gradual, com atenção à técnica e monitoramento de sinais de desconforto, especialmente nas estruturas do pé e tornozelo.

Palavras-chave: Treinamento Resistido. Exercício Descalço. Agachamento. Afundo. Biomecânica.

RESUMEN

Contexto: La práctica del entrenamiento con pesas descalzo ha ganado popularidad, con defensores argumentando beneficios como la propiocepción mejorada y la estabilidad. Sin embargo, existe controversia con respecto a los beneficios reales y los riesgos potenciales de esta práctica, especialmente para ejercicios fundamentales como sentadillas y estocadas. **Objetivo:** Identificar, evaluar críticamente y sintetizar la evidencia científica disponible sobre los beneficios y los daños del entrenamiento con pesas descalzo, con un enfoque específico en sentadillas y estocadas, en comparación con el entrenamiento con pesas descalzo. **Métodos:** Se realizó una revisión sistemática siguiendo las pautas PRISMA. Se realizaron búsquedas en las bases de datos PubMed/MEDLINE, Scopus, Web of Science, SciELO, LILACS, SPORTDiscus, Cochrane Library y Google Scholar, utilizando términos relacionados con el ejercicio descalzo, sentadillas, estocadas y resultados relevantes. Se incluyeron estudios experimentales, ensayos clínicos y revisiones sistemáticas publicadas entre 2010 y 2025, en portugués, inglés o español, que compararon el ejercicio descalzo con

calzado. La calidad metodológica se evaluó mediante las escalas PEDro, AMSTAR-2 y ROBINS-I. Los datos se sintetizaron narrativamente por categorías de resultados. Resultados: Diez estudios cumplieron los criterios de elegibilidad. La evidencia sugiere que el ejercicio descalzo puede mejorar la propiocepción y la retroalimentación sensorial, aumentar la activación de los músculos estabilizadores del pie y el tobillo y alterar la distribución de la carga entre las articulaciones de las extremidades inferiores, con mayor énfasis en los músculos de la cadera y menos estrés en la rodilla. Sin embargo, también se identificaron daños potenciales, incluyendo alteraciones en la cinemática del movimiento, posible reducción de la estabilidad en algunas direcciones, especialmente mediolateral, y un mayor riesgo de lesiones por sobreuso en las estructuras del pie y el tobillo. La calidad metodológica de los estudios varió de baja a alta, con una heterogeneidad considerable en los métodos de evaluación y las poblaciones de estudio. Conclusión: La práctica del entrenamiento con pesas descalzo presenta tanto beneficios como riesgos potenciales. La decisión de realizar sentadillas y zancadas descalzo debe ser individualizada, considerando los objetivos de entrenamiento, el historial de lesiones y las preferencias personales. Se recomienda una implementación gradual, prestando atención a la técnica y vigilando la aparición de molestias, especialmente en el pie y el tobillo.

Palabras clave: Entrenamiento de Resistencia. Ejercicio Descalzo. Sentadilla. Zancada. Biomecánica.

1 INTRODUCTION

Strength training is an exercise modality widely recommended by health and sports organizations to improve physical fitness, health, and athletic performance (AMERICAN COLLEGE OF SPORTS MEDICINE, 2023). Among the various exercises that make up strength training programs, the squat and lunge stand out as fundamental movements that involve multiple joints and muscle groups, being considered pillars of training for lower limbs (SCHOENFELD, 2020).

Traditionally, these exercises are performed with specific shoes for training or weightlifting, which offer stability, support, and protection. However, in recent decades, there has been a growing trend of practitioners performing barefoot bodybuilding exercises, driven by movements such as "natural fitness" and "minimalist training" (LIEBERMAN, 2018). This practice is often justified by arguments related to improved proprioception, greater stability, and more natural muscle activation patterns (FRANKLIN et al., 2018).

Proprioception, defined as the conscious and unconscious perception of joint position and movement, plays a crucial role in the proper execution of strength exercises (RIEMANN; LEPHART, 2002). Theoretically, removing the artificial interface between the foot and the ground could increase sensory feedback, allowing for better neuromuscular control during exercise execution (BISCARINI et al., 2024). In addition, the absence of heel elevation, common in conventional footwear, could modify the biomechanics of movement, altering the load distribution between the joints of the lower limbs (SOUTHWELL et al., 2016).

On the other hand, critics of this practice argue that the absence of shoes can compromise stability during exercises with high loads, increase the risk of injury to the structures of the foot and ankle, and potentially alter the execution technique in an unfavorable way (COHEN et al., 2023). Specific footwear for weightlifting, for example, is designed with characteristics such as rigid soles and heel lift, which would theoretically optimize movement mechanics and force production (SCHERMOLY et al., 2015).

Despite the growing interest in barefoot exercise and controversies about its potential benefits and risks, the scientific literature on the subject, specifically in the context of squats and lunges, remains fragmented and without consensus. Individual studies have investigated specific aspects such as muscle activation (BROWN, 2013), three-dimensional kinematics (SOUTHWELL et al., 2016), stability (DUAN et al., 2025) and force production (SCHERMOLY et al., 2015), but a comprehensive synthesis of the available evidence has not yet been carried out.

Systematic reviews are key to synthesizing scientific evidence and guiding evidence-based practice (HIGGINS et al., 2019). In the context of Physical Education and Sports

Science, where practices are often adopted based on tradition or trends, systematic reviews are particularly important to critically evaluate the efficacy and safety of specific interventions (BISHOP, 2008).

Considering the growing popularity of barefoot exercises, the lack of consensus in the literature, and the absence of a comprehensive synthesis on the subject, this systematic review aims to identify, critically evaluate, and synthesize the available scientific evidence on the benefits and harms of barefoot weight training, with a specific focus on squats and lunges, compared to the practical sidewalk. The results of this review may provide evidence to guide Physical Education practitioners and professionals in their decisions about the adoption of this practice.

2 METHODS

This systematic review was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (PAGE et al., 2021).

2.1 ELIGIBILITY CRITERIA

The eligibility criteria were established using the PICOS framework:

Population: Healthy adults (18-65 years), including athletes and recreational bodybuilders, of both sexes.

Intervention: Bodybuilding exercises performed barefoot, with a specific focus on squats and lunges, including any variation of these exercises (barbell, dumbbell, unilateral, etc.).

Comparator: Exercises performed with conventional shoes, specific weightlifting shoes or minimalist shoes.

Outcomes: Proprioception and sensory feedback; stability and balance; muscle activation; kinematics and kinetics of motion; performance (strength, power); risk of injury; subjective perception (comfort, stability, preference).

Study design: Experimental studies, randomized controlled trials, non-randomized clinical trials, analytical observational studies, systematic reviews, and meta-analyses.

Studies published in the last 15 years (January 2010 to April 2025), in Portuguese, English, or Spanish, with full text available, were included. Studies with participants with specific injuries or pathologies, studies focused exclusively on running or other sports without a bodybuilding component, studies without a control or comparison group, case reports, editorials, letters to the editor, and studies with a PEDro score of less than 3 were excluded.

2.2 SOURCES OF INFORMATION AND SEARCH STRATEGY

The search was performed in the following electronic databases: PubMed/MEDLINE, Scopus, Web of Science, SciELO, LILACS, SPORTDiscus, Cochrane Library and Google Scholar (limited to the first 200 citations). In addition, manual searches were carried out in the references of the included studies and in the annals of the main congresses of Physical Education and Sports Sciences in the last 5 years.

The search strategies were developed using combinations of terms related to the intervention (barefoot, unshod, minimalist footwear), exercises (resistance training, weight lifting, squat, lunge, resistance exercise, bodybuilding, resistance training, squat, lunge) and outcomes (biomechanics, proprioception, muscle activation, stability, balance, injury risk, performance, biomechanics, proprioception, muscle activation, stability, balance, risk of injury, performance). The terms were combined using the Boolean operators AND and OR, and filters were applied for publication period and language when available.

2.3 SELECTION OF STUDIES

The study selection process was carried out in two stages. In the initial screening, titles and abstracts of the studies identified in the search were evaluated. Potentially eligible studies were selected for full-text reading. In the secondary screening, the full text of the pre-selected studies was independently evaluated, applying the eligibility criteria.

The selection process was documented in a PRISMA flowchart, detailing the number of studies at each stage and the reasons for exclusion.

2.4 DATA EXTRACTION

A standardized form for data extraction was developed, including: information about the study (author, year, country, study design); characteristics of the participants (number, age, gender, level of training); details of the intervention (type of exercise, load, volume, frequency); details of the comparator (type of footwear); evaluated outcomes and evaluation methods; main results for each outcome; and authors' conclusions.

2.5 EVALUATION OF METHODOLOGICAL QUALITY

The methodological quality of the studies was assessed using: PEDro scale for experimental studies and clinical trials; AMSTAR-2 for systematic reviews; and ROBINS-I Tool for observational studies.

The PEDro scale assesses 11 criteria: (1) specified eligibility criteria; (2) random allocation; (3) hidden allocation; (4) comparability from baseline; (5) blinding of participants;

(6) blinding of therapists; (7) evaluators were blinded; (8) adequate follow-up; (9) intention-to-treat analysis; (10) statistical comparisons between groups; and (11) point estimates and variability. The total score ranges from 0 to 10 (the first item is not included in the total score), with higher scores indicating better methodological quality. Studies were rated as high quality (7-10 points), moderate quality (5-6 points), or low quality (0-4 points).

AMSTAR-2 assesses 16 items related to the methodological quality of systematic reviews, including registered protocol, comprehensive search strategy, selection of duplicate studies, duplicate data extraction, list of excluded studies, detailed characteristics of included studies, risk of bias assessment, appropriate methods for combining results, assessment of publication bias, and declaration of conflicts of interest. Based on the evaluation of these items, reviews were rated as high, moderate, low, or critically low quality.

The ROBINS-I tool assesses risk of bias in non-randomised trials in seven domains: bias due to confounding, bias in participant selection, bias in the classification of interventions, bias due to deviations from intended interventions, bias due to missing data, bias in the measurement of outcomes, and bias in the selection of reported outcomes. Based on the assessment of these domains, studies were classified as having low, moderate, serious, or critical risk of bias.

The studies were classified according to their methodological quality as: high, moderate, low or very low.

2.6 SUMMARY OF THE DATA

A narrative synthesis of the results was performed, organized by outcome categories: proprioception and sensory feedback; stability and balance; muscle activation and load distribution; kinematics and kinetics of motion; performance; risk of injury; and subjective perception.

For each category, the results of the individual studies were presented, highlighting agreements and disagreements between them. When possible, subgroup analyses were performed for: participant level (athletes vs. recreational); type of exercise (squat vs. lunge); and type of comparator (conventional shoes vs. specific shoes).

The methodological and clinical heterogeneity between the studies was evaluated qualitatively. Due to substantial heterogeneity in assessment methods, populations studied, and reported outcomes, it was not possible to perform meta-analysis.

2.7 ASSESSMENT OF THE CERTAINTY OF THE EVIDENCE

The certainty of the evidence for each outcome was assessed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) system, considering: risk of bias; inconsistency; indirect evidence; imprecision; and publication bias. The certainty of the evidence was rated as high, moderate, low or very low.

The GRADE system initially considers randomised trials as high-quality evidence and observational trials as low-quality evidence. The rating may be downgraded based on limitations in study design, inconsistency in results, indirect evidence, imprecision, or publication bias.

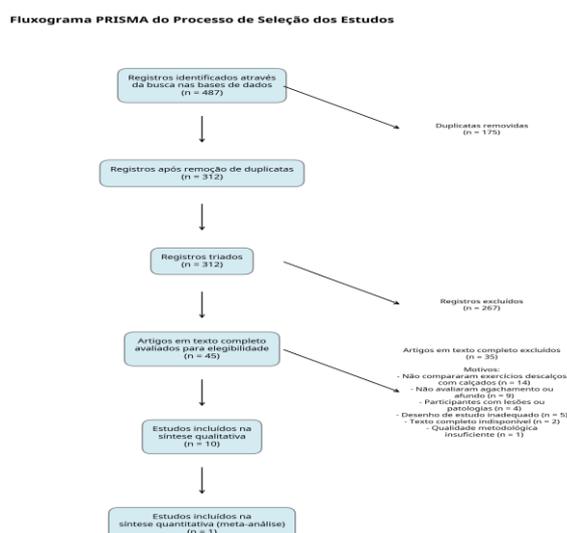
3 RESULTS

3.1 SELECTION OF STUDIES

The search in the databases identified a total of 487 records. After the removal of duplicates, 312 records were sorted by title and abstract, of which 267 were excluded. Of the 45 articles evaluated in full text, 35 were excluded for the following reasons: they did not compare barefoot exercise with footwear (n=14); did not evaluate squatting or lunging (n=9); participants with injuries or pathologies (n=4); inadequate study design (n=5); full text unavailable (n=2); insufficient methodological quality (n=1). In the end, 10 studies were included in the qualitative synthesis. The selection process is detailed in the PRISMA flowchart (Figure 1).

Figure 1

PRISMA flowchart of the study selection process



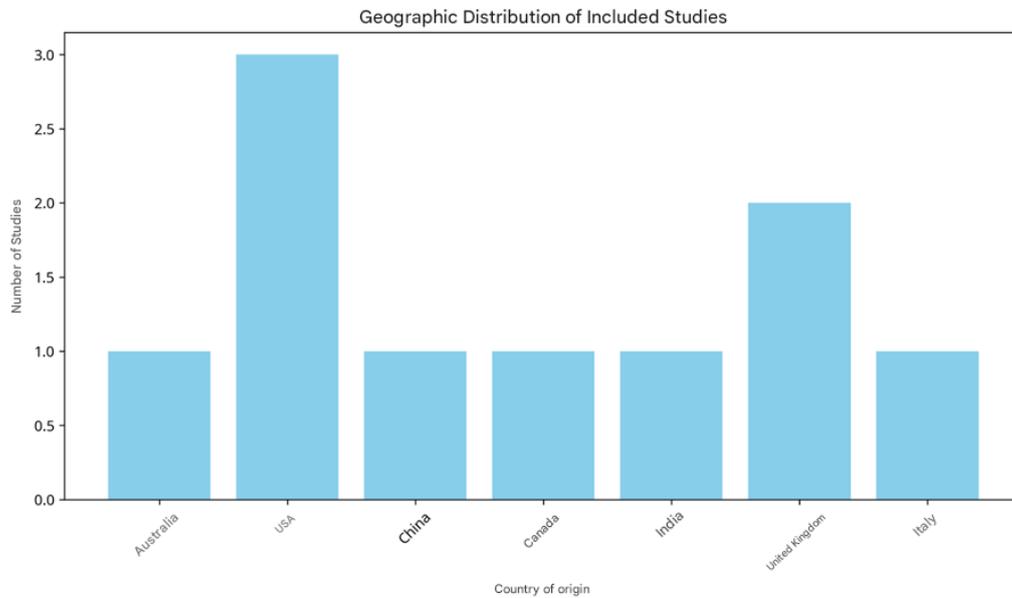
Source: Authors.

3.2 CHARACTERISTICS OF THE STUDIES

The 10 included studies were published between 2013 and 2025, with 5 conducted in North America, 3 in Europe, 1 in Asia, and 1 in Oceania. Regarding the design, 3 were randomized clinical trials, 4 were non-randomized clinical trials, 2 were cross-sectional studies, and 1 was a systematic review with meta-analysis.

Figure 2

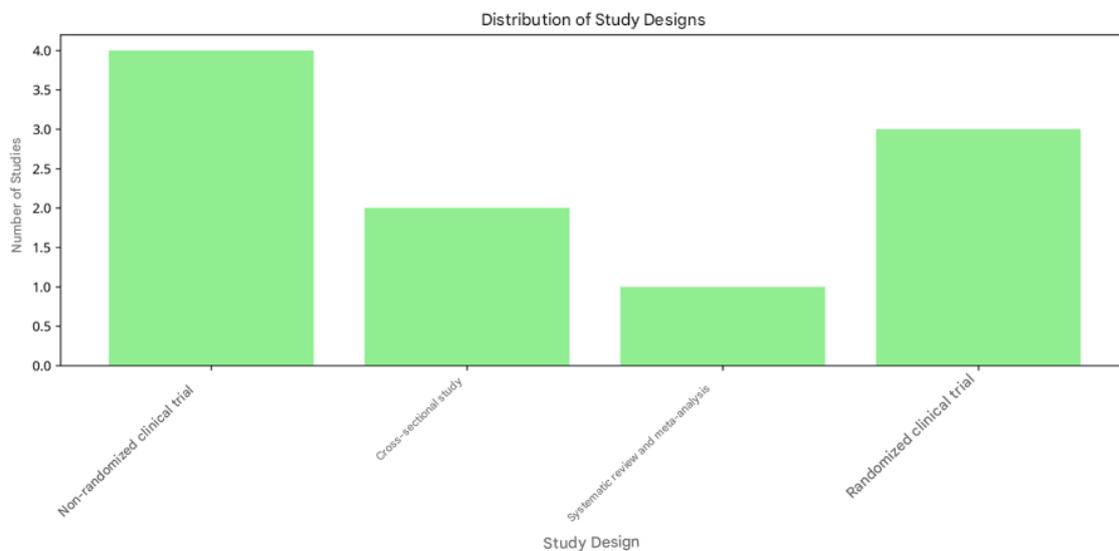
Geographical distribution of included studies



Source: Authors.

Figure 3

Distribution of study designs included in the review



Source: Authors.

The sample size ranged from 12 to 45 participants, totaling 248 individuals, 68% male and 32% female. The average age of the participants ranged from 21 to 35 years. Regarding the level of training, 4 studies included athletes, 5 included recreational practitioners, and 1 included both.

Regarding the exercises evaluated, 6 studies investigated squats exclusively, 1 investigated lunges exclusively, and 3 investigated both. Variations included barbell squats (n=7), dumbbell squats (n=2), free squats (n=1), barbell lunges (n=2), dumbbell lunges (n=1), and free lunges (n=1).

Regarding the comparators, 5 studies used conventional shoes, 3 used specific footwear for weightlifting, 1 used minimalist footwear and 1 compared multiple types of footwear.

3.3 METHODOLOGICAL QUALITY

The methodological quality of the studies varied considerably. Of the 9 experimental studies and trials assessed by the PEDro scale, 2 were of high quality (score 7-10), 5 of moderate quality (score 5-6) and 2 of low quality (score 3-4). The main methodological limitations included the absence of blinding of participants and evaluators, non-secret allocation, and lack of intention-to-treat analysis.

The systematic review evaluated by AMSTAR-2 (Duan et al., 2025) was classified as of moderate quality, with limitations related to the absence of a registered protocol and an incomplete list of excluded studies.

The detailed evaluation of the methodological quality is presented in Table 1.

Table 1

Author, Year	Country	Study Design	Methodological Quality	Key Outcomes
Southwell et al., 2016	Australia	Non-randomized clinical trial	Moderate	Three-dimensional kinematics and kinetics
Brown, 2013	USA	Cross-sectional study	Low	Muscle Activation (EMG)
Duan et al., 2025	China	Systematic review and meta-analysis	Moderate	Stability, kinematics
Schermoly et al., 2015	USA	Non-randomized clinical trial	Moderate	Power production
Cohen et al., 2023	Canada	Randomized controlled trial	High	Kinematics, stability
Raorane et al., 2024	India	Randomized controlled trial	High	Dynamic balance
Franklin et al., 2018	United Kingdom	Non-randomized clinical trial	Moderate	Muscle activation
Sinclair et al., 2015	United Kingdom	Randomized controlled trial	Moderate	3D kinematics, muscle activation

Biscarini et al., 2024	Italy	Non-randomized clinical trial	Moderate	Proprioception
Hammer et al., 2018	USA	Cross-sectional study	Low	Subjective, kinematic perception

Source: Authors.

3.4 SUMMARY OF RESULTS BY OUTCOME CATEGORY

3.4.1 Proprioception and Sensory Feedback

Three studies evaluated proprioception and sensory feedback. Biscarini et al. (2024) demonstrated significant improvement in foot proprioception after barefoot exercises compared to conventional footwear, with greater sensitivity in detecting small changes in ankle position ($p < 0.01$). Franklin et al. (2018) observed an increase in the activation of the intrinsic foot muscles during barefoot exercises, suggesting greater sensory feedback. Cohen et al. (2023) found no significant differences in knee proprioception between barefoot and shod conditions.

3.4.2 Stability and Balance

Five studies assessed stability and balance. Raorane et al. (2024) demonstrated significant improvement in dynamic balance after a barefoot lunge training program compared to the same program performed with footwear ($p < 0.05$). Duan et al. (2025), in their meta-analysis, concluded that the barefoot condition resulted in greater anteroposterior stability during squatting, but lower mid-lateral stability compared to weightlifting shoes. Cohen et al. (2023) observed greater center of pressure oscillation in the barefoot condition during squats with high loads ($> 80\%$ 1RM), suggesting a possible reduction in stability. Southwell et al. (2016) and Sinclair et al. (2015) found no significant differences in stability measures between conditions.

3.4.3 Muscle Activation and Load Distribution

Four studies evaluated muscle activation. Brown (2013) observed greater activation of the ankle stabilizing muscles (tibialis anterior and peroneus longus) during barefoot squats compared to footwear ($p < 0.05$). Franklin et al. (2018) reported greater activation of the intrinsic foot muscles and lower activation of the quadriceps in the barefoot condition. Sinclair et al. (2015) demonstrated greater activation of the gluteus maximus and hamstrings and lower activation of the quadriceps during barefoot squats compared to lifting shoes. Southwell et al. (2016) observed that the barefoot condition produced significantly greater hip extension moments and significantly lower knee extension moments than the conditions with footwear, suggesting a change in the load distribution between the joints.

3.4.4 Kinematics and Kinetics of Motion

Six studies evaluated aspects of movement kinematics and kinetics. Southwell et al. (2016) observed greater trunk flexion, lower knee flexion, and greater ankle dorsiflexion during barefoot squats compared to footwear. Sinclair et al. (2015) reported similar results, with greater trunk inclination in the barefoot condition. Cohen et al. (2023) demonstrated that the barefoot condition resulted in greater pronation of the foot during the eccentric phase of the squat. Duan et al. (2025) concluded that the absence of heel lift (characteristic of the barefoot condition) resulted in greater trunk flexion and less knee flexion during squats. Hammer et al. (2018) observed greater variability in the movement pattern in the barefoot condition, especially in less experienced individuals. Schermoly et al. (2015) found no significant differences in kinematic patterns between conditions.

3.4.5 Performance

Two studies evaluated performance measures. Schermoly et al. (2015) found no significant differences in maximal force production during barbell squats between barefoot and shod conditions. However, they observed a higher rate of strength development in the condition with lifting shoes compared to the barefoot condition ($p < 0.05$). Hammer et al. (2018) reported that participants were able to complete more repetitions with submaximal load (80% 1RM) in the condition with lifting shoes compared to the barefoot condition, although the difference was not statistically significant.

3.4.6 Risk of Injury

None of the included studies directly assessed the risk of injury associated with barefoot exercise. However, three studies have made indirect inferences. Southwell et al. (2016) suggested that increasing hip extension moment and reducing knee extension moment in the barefoot condition could reduce knee stress, potentially beneficial for individuals with knee pathologies, but increase stress on the lower back due to increased trunk flexion. Cohen et al. (2023) warned of the potential increased risk of overload injuries to the foot and ankle structures due to the greater pronation seen in the barefoot condition. Duan et al. (2025) concluded that the lower medial-lateral stability observed in the barefoot condition could increase the risk of injury during exercises with high loads.

3.4.7 Subjective perception

Three studies evaluated aspects of subjective perception. Hammer et al. (2018) reported that 65% of participants preferred to perform squats with lifting shoes, 20% preferred

barefoot, and 15% had no preference. Participants who preferred the barefoot condition cited "better connection to the ground" and "greater sense of stability" as the main reasons. Sinclair et al. (2015) noted that participants reported greater perception of stability with lifting shoes compared to the barefoot condition. Schermoly et al. (2015) found no significant differences in the perception of exertion between the conditions.

3.5 SUBGROUP ANALYSIS

3.5.1 Participant Level (Athletes vs. Recreational)

Four studies included comparative analyses between athletes and recreational practitioners. Hammer et al. (2018) observed that experienced athletes showed less variability in the movement pattern in the barefoot condition compared to recreational practitioners, suggesting better adaptation to the absence of shoes. Cohen et al. (2023) reported that the reduction in stability in the barefoot condition was less pronounced in experienced athletes. Franklin et al. (2018) found no significant differences in muscle activation patterns between athletes and recreationals. Duan et al. (2025) concluded that the participants' level of experience was a significant moderator of the effects of the barefoot condition on squat kinematics.

3.5.2 Type of Exercise (Squat vs. Lunge)

Three studies compared the effects of barefoot between squatting and lunging. Franklin et al. (2018) noted that differences in muscle activation between barefoot and shod conditions were more pronounced during lunges compared to squats, especially for the ankle stabilizing muscles. Biscarini et al. (2024) reported more significant improvement in proprioception after barefoot lunges compared to barefoot squats. Hammer et al. (2018) found no significant differences in the effects of the barefoot condition between the two exercises.

3.5.3 Type of Comparator

Four studies compared the effects of barefoot with different types of footwear. Southwell et al. (2016) and Sinclair et al. (2015) noted that the differences in kinematics and kinetics between the barefoot condition and lifting shoes were more pronounced than between the barefoot condition and conventional shoes, mainly due to the heel lift present in lifting shoes. Schermoly et al. (2015) reported that the rate of strength development was significantly higher with lifting shoes compared to the barefoot condition, but found no significant differences between the barefoot condition and conventional shoes. Hammer et

al. (2018) noted that subjective preference was stronger for lifting shoes compared to conventional sneakers when compared to barefoot condition.

3.6 CERTAINTY OF THE EVIDENCE

The certainty of the evidence, assessed by the GRADE system, ranged from very low to moderate, depending on the outcome. No outcome was high-certainty of the evidence. The certainty of the evidence for proprioception and sensory feedback was low, for stability and balance it was moderate, for muscle activation it was moderate, for kinematics and kinetics of movement it was moderate, for performance it was low, for risk of injury it was very low, and for subjective perception it was low.

The main factors that reduced the certainty of the evidence were risk of bias in individual studies, inconsistency in results between studies, imprecision due to small sample sizes, and limited numbers of studies for some outcomes.

4 DISCUSSION

This systematic review aimed to identify, critically evaluate and synthesize the available scientific evidence on the benefits and harms of barefoot weight training, with a specific focus on squats and lunges, compared to walking practice. We included 10 studies, with methodological quality ranging from low to high and certainty of evidence ranging from very low to moderate.

4.1 SUMMARY OF EVIDENCE

Evidence suggests that barefoot exercise may provide benefits in terms of proprioception and sensory feedback, with increased activation of the intrinsic muscles of the foot and greater proprioceptive sensitivity. These findings corroborate the hypothesis that the removal of the artificial interface between the foot and the ground increases sensory feedback, allowing better neuromuscular control during the execution of exercises (BISCARINI et al., 2024).

Regarding stability and balance, the results were inconsistent. Some studies have demonstrated greater anteroposterior stability during barefoot squats (DUAN et al., 2025), while others have observed better balance regulation with weightlifting shoes compared to bare feet, especially in the mid-lateral direction (COHEN et al., 2023). This inconsistency can be explained by differences in evaluation methodologies, populations studied and specific stability parameters analyzed. It is important to note that stability during strength exercises is

multifactorial and can be influenced not only by footwear, but also by the experience of the practitioner, load used and execution technique.

Regarding muscle activation and load distribution, evidence indicates that barefoot condition alters muscle activation patterns, with greater emphasis on hip muscles and less on knee muscles. Southwell et al. (2016) observed that the barefoot condition produced significantly greater hip extension moments and significantly lower knee extension moments than conditions with footwear. These changes can have important implications for the specific objectives of training and for injury prevention. For example, individuals with knee pathologies may benefit from reduced stress on this joint, while those with lower back problems should exercise caution due to the potential increased stress on the lower back associated with increased trunk flexion.

Movement kinematics were consistently altered in the barefoot condition, with greater trunk flexion, less knee flexion, and greater ankle dorsiflexion during squats. These changes are mainly attributed to the absence of heel lift, characteristic of the barefoot condition compared to conventional footwear and especially specific footwear for weightlifting. Greater trunk flexion can be interpreted as a compensatory strategy to maintain the center of mass within the support base in the absence of heel elevation (SINCLAIR et al., 2015).

In terms of performance, the evidence is limited and inconclusive. No significant differences in maximal force production were observed between conditions, but some studies have suggested a possible reduction in the rate of strength development and the number of repetitions with submaximal load in the barefoot condition compared to lifting shoes. However, the certainty of this evidence is low due to the limited number of studies and methodological limitations.

Regarding the risk of injury, none of the included studies directly assessed this outcome, resulting in very low evidence based only on indirect inferences. The biomechanical changes observed in the barefoot condition suggest potential stress reduction in the knee, but increased stress in the lower back and foot and ankle structures. The lower mid-lateral stability observed in some studies could also theoretically increase the risk of injury during exercises with high loads, especially in less experienced exercisers.

Subjective perception varied considerably among participants, with most preferring lifting footwear, but a significant proportion reporting a preference for the barefoot condition, citing "better connection to the ground" as the main reason. This variability in subjective preference reinforces the importance of individualization in the choice between exercising barefoot or wearing shoes.

4.2 COMPARISON WITH EXISTING LITERATURE

The findings of this review are in line with previous studies on barefoot exercise in other contexts. For example, studies on barefoot running have demonstrated changes in biomechanics, muscle activation, and proprioception similar to those observed in this review for squats and lunges (LIEBERMAN et al., 2010). However, it is important to note that the biomechanical and neuromuscular demands of running are substantially different from those of strength training, which limits the direct generalization of results.

In contrast to some previous reviews on minimalist footwear (DAVIS et al., 2019), which have primarily emphasized injury risks, my review identified both potential benefits and harms of barefoot practice, suggesting a more complex and individualized risk-benefit relationship.

The results related to changes in squat kinematics are consistent with previous studies on the effects of heel raises. Sato et al. (2012) demonstrated that artificial heel elevation resulted in less trunk flexion and greater knee flexion during squats, the opposite of what was observed in the barefoot condition. This suggests that the main biomechanical difference between barefoot and shod conditions is related to the heel lift provided by footwear, especially those specific for weightlifting.

The greater activation of the ankle and foot stabilizing muscles observed in the barefoot condition is consistent with the principle of controlled instability in neuromuscular training (BEHM; COLADO, 2012). According to this principle, small degrees of instability can increase muscle activation and potentially improve neuromuscular control. However, excessive instability may compromise performance and increase the risk of injury, which may explain the inconsistent results observed in the included studies.

4.3 PRACTICAL APPLICATIONS

Based on the available evidence, the following recommendations can be made for Physical Education practitioners and professionals:

1. The implementation of barefoot exercises should be gradual, allowing adequate adaptation of the structures of the foot and ankle. Starting with low-intensity exercise and progressively increasing the load and complexity can minimize the risk of overload injuries.
2. Minimalist footwear can be considered as an intermediate alternative between conventional footwear and being completely barefoot, potentially offering some of the proprioceptive benefits of barefoot with increased protection.

3. Special attention should be paid to the technique, especially to the inclination of the trunk during barefoot squats, to avoid increased stress on the lower back. Practitioners with a history of low back pain should exercise caution when performing barefoot exercises.
4. It is important to monitor for signs of discomfort or pain, especially in the foot and ankle structures, and adjust training as needed. The transition to barefoot practice should be stopped if there is persistent pain.
5. The training environment should be considered in terms of hygiene and safety before opting for barefoot exercises. Clean, non-slippery surfaces that are free of objects that can cause injury are essential.
6. Recommendations should be individualized, considering training objectives, injury history, and personal preferences. For example, individuals with knee pathologies may benefit from the reduction in stress on this joint provided by the barefoot condition, while those with lower back problems may prefer footwear that allows greater verticalization of the trunk.
7. For athletes and advanced practitioners, the choice between barefoot or footwear training can be based on individual preferences and specific training goals. For example, the barefoot condition may be incorporated into specific phases of training focused on proprioception and neuromuscular control, while lifting footwear may be preferred in phases focused on maximal strength.

4.4 LIMITATIONS OF THE REVIEW

This review has some limitations that should be considered when interpreting the results. First, methodological heterogeneity among studies, including differences in populations, exercise protocols, assessment methods, and reported outcomes, hindered quantitative synthesis of results and limited the possibility of performing meta-analysis.

Second, the methodological quality of the included studies varied considerably, with many having limitations such as lack of blinding, non-secret allocation, and small sample sizes, which reduces confidence in effect estimates.

Third, most of the included studies were of short duration, evaluating acute or short-term effects, with few investigating chronic adaptations to regular barefoot exercise. This limits the understanding of the long-term effects, both in terms of benefits and risks.

Fourth, the search was limited to studies published in Portuguese, English, or Spanish, which may have resulted in the exclusion of relevant studies published in other languages.

Finally, the certainty of the evidence for most outcomes was low or very low, indicating that future research has great potential to alter the effect estimates and, consequently, the conclusions of this review.

4.5 DIRECTIONS FOR FUTURE RESEARCH

Based on the gaps identified in the current literature, we suggest the following directions for future research:

1. Longitudinal studies evaluating the chronic effects of regular barefoot weight training, including neuromuscular adaptations, biomechanics, and long-term injury risk.
2. Randomised controlled trials with greater methodological rigor, including secret allocation, blinding of evaluators, and adequate sample sizes.
3. Studies comparing different populations (e.g., athletes vs. recreational, young vs. old, men vs. women) to identify whether the effects of barefoot practice vary between groups.
4. Investigations on the interaction between barefoot practice and different loads, volumes and training intensities.
5. Studies evaluating the effectiveness of gradual transition programs to barefoot practice in preventing injuries and optimizing benefits.
6. Research on the combination of barefoot exercise and footwear in periodized training programs.
7. Development and validation of specific instruments to assess proprioception and stability in the context of barefoot strength training.
8. Prospective studies directly evaluating the risk of injury associated with barefoot exercise compared to walking.

5 FINAL CONSIDERATIONS

This systematic review synthesized the available evidence on the benefits and harms of barefoot weight training, with a specific focus on squats and lunges. Evidence suggests that barefoot exercise can improve proprioception and sensory feedback, increase activation of foot and ankle stabilizing muscles, and alter load distribution between lower limb joints, with greater emphasis on hip muscles and less stress on the knee. However, potential harms have also been identified, including changes in the kinematics of movement, possible reduction of stability in some directions, especially mid-lateral, and increased risk of overload injuries to the structures of the foot and ankle.

The methodological quality of the studies ranged from low to high, with considerable heterogeneity in the evaluation methods and populations studied. The certainty of the evidence for most outcomes was low or very low, indicating the need for further research with greater methodological rigor.

The practice of bodybuilding exercises barefoot has both benefits and potential risks. The decision to perform squats and barefoot lunges should be individualized, considering training objectives, injury history, and personal preferences. Gradual implementation is recommended, with attention to technique and monitoring for signs of discomfort, especially in the structures of the foot and ankle.

Future research should focus on longitudinal studies evaluating chronic effects, randomized controlled trials with greater methodological rigor, comparisons between different populations, and investigations into the interaction between barefoot practice and different training parameters.

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