Methods for assessing vertical jump in resistance-trained men: a systematic review

Métodos para evaluar el salto vertical en hombres entrenados en resistencia: una revisión sistemática

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Abstract

Objective: this review aimed to investigate the methods used for vertical jump assessment in men with resistance training experience.
Methodology: this review followed the PRISMA guidelines and was registered in PROSPERO (CRD42024598675). A search was conducted in Scopus, Web of Science, PubMed (via MEDLINE), SportDiscus, and ScienceDirect databases. Cross-sectional studies conducted on men with resistance training experience who were assessed using vertical jump tests were included.
Results: during the initial screening, 5011 articles were found. Of these, 3003 were detected as duplicates and excluded, along with 1978 articles analyzed in the title and abstract screening phase, and 18 articles in the full-text screening phase. Thus, 12 articles were considered for final analysis. Five studies were rated as "high quality" and seven as "moderate quality".
Conclusions: the countermovement jump (CMJ) emerged as the sole type of vertical jump used to assess performance in the selected studies. Indirect assessment tools such as contact mats and infrared timing systems were the most utilized due to their economic and operational advantages. The CMJ was applied at different time points post-training stimulus. The number of attempts, intervals between them, and the final score varied across the studies.

Keywords

Assessment; countermovement jump; resistance training; vertical jump.

Resumen

Objetivo: esta revisión tuvo como objetivo investigar los métodos utilizados para la evaluación del salto vertical en hombres con experiencia en entrenamiento de resistencia.
Metodología: esta revisión siguió las directrices PRISMA y fue registrada en PROSPERO (CRD42024598675). Se realizó una búsqueda en las bases de datos Scopus, Web of Science, PubMed (vía MEDLINE), SportDiscus y ScienceDirect. Se incluyeron estudios transversales realizados con hombres con experiencia en entrenamiento de resistencia que fueron evaluados mediante pruebas de salto vertical.
Resultados durante la etapa inicial de selección, se identificaron 5011 artículos. De estos, 3003 fueron detectados como duplicados y excluidos, junto con 1978 artículos eliminados durante la fase de evaluación por título y resumen, y 18 artículos durante la fase de revisión del texto completo. Así, se consideraron 12 artículos para el análisis final. Cinco estudios fueron clasificados como de "alta calidad" y siete como de "calidad moderada".
Conclusiones: el salto con contramovimiento (CMJ, por sus siglas en inglés) emergió como el único tipo de salto vertical utilizado para evaluar el rendimiento en los estudios seleccionados. Las herramientas de evaluación indirecta, como las alfombrillas de contacto y los sistemas de cronometraje por infrarrojos, fueron las más utilizadas debido a sus ventajas económicas y operativas. El CMJ fue aplicado en distintos momentos posteriores al estímulo del entrenamiento. El número de intentos, los intervalos entre ellos y la puntuación final variaron entre los estudios.

Palabras clave

Evaluación; salto con contramovimiento; entrenamiento de resistencia; salto vertical.

Introduction

Resistance training (RT) is a training model used both to improve physical fitness characteristics related to an individual's health (Silva et al., 2024) and to enhance sports performance in amateur and professional competitive scenarios (Øvretveit & Tøien, 2018). Resistance training has been shown to influence vertical jump performance through neuromuscular and morphological adaptations, such as increased maximal strength, improved motor unit recruitment, and enhanced efficiency of the stretch-shortening cycle (SSC). These mechanisms contribute to greater lower-limb power output, which is essential for jumping (Pardos-Mainer et al., 2021). According to the desired objective, training variables must be manipulated to tailor the training program to the required stimuli (Grgic et al., 2018; Silva et al., 2023).

In addition to how RT can be prescribed, it is also possible to evaluate how this training can be assessed before and after a specific time window to understand the chronic effects of its implementation and monitored throughout training sessions to comprehend the acute effects that might influence subsequent sessions. This allows for observing how the physiological system of an individual subjected to training responds to the proposed stimulus (ACSM, 2018; Helms et al., 2020).

In competitive contexts, training monitoring (TM) is a common practice due to the importance of the athlete's current state for the execution of upcoming training sessions or competitions (Redman et al., 2021; Scott et al., 2016) Continuous recording and periodic analysis of psychophysiological parameters such as the rating of perceived exertion (RPE), biochemical markers like cortisol or testosterone, physical performance measures related to force and power production capacity (e.g., execution speed, repetitions in reserve, or vertical jump), and cardiorespiratory status (e.g., heart rate) are utilized. However, outside the competitive environment, some of these parameters seem challenging to apply due to logistical or cost-related constraints (Helms et al., 2020).

Certain tools are more practical for monitoring the individual's condition after a training session, especially in a recreational environment. One option is the use of rating of perceived exertion (RPE) scales (Zourdos et al., 2016; Gomes et al., 2022), which primarily rely on the process of application and the individual's prior preparation to interpret and respond more accurately to their psychophysical condition according to the imposed session intensity. Another practical option is the evaluation of a physical performance parameter, such as the vertical jump (Zhu et al., 2022), to compare results before and after a training session or with a measurement taken at full rest from the same individual (Watkins et al., 2017). Well-known instruments for conducting this type of assessment include force platforms, video analysis applications, timing systems, and wearable devices (Moir, 2008). This approach allows for understanding the acute influence of training on the practitioner, particularly regarding the effect of fatigue on lower-limb power production capacity. Understanding how detrimental a training session may have been for the individual facilitates the planning of subsequent training sessions, especially in terms of manipulating variables such as the necessary recovery interval, as well as the volume and intensity to be prescribed. In this context, the vertical jump can serve as a tool to help assess the readiness state of these individuals within the framework of training monitoring (Watkins et al., 2017).

To assess vertical jump performance, different tests with distinct characteristics can be used. Among these, the countermovement jump (CMJ) evaluates an individual's ballistic force production capacity through a rapid eccentric–concentric movement (Mema, Lleshi & Kushta, 2025). Other protocols, such as the squat jump (SJ) and the drop jump (DJ), are also used to assess different force qualities, like minimizing the stretch-shortening cycle contribution or assessing the reactive strength index. These different protocols are applied across various populations and contexts, serving as functional assessment strategies in health and performance domains (Santos et al., 2022).

A systematic review (Petrigna et al., 2019) highlighted the use of vertical jump tests as an assessment tool for adolescents in the context of public health. Another systematic review (Dutaillis et al., 2024) examined the use of the vertical jump to evaluate improvements in individuals following anterior cruciate ligament reconstruction. While the use of the vertical jump as an assessment tool is increasingly being applied in different populations and contexts beyond the sports setting (Lourenço et al., 2023; Cabarkapa et al., 2024), an existing gap is that previous reviews have not addressed the use of these tests in individuals within the specific context of recreational resistance training. Therefore, considering this practice, it becomes necessary to analyze the use of vertical jump tests for assessing and monitoring fatigue and power production capacity in this context. Furthermore, given the diversity of existing instruments and protocols, understanding the literature within a specific context such as the one mentioned provides clarity for its practical application. Accordingly, the objective of this review was to investigate vertical jump assessment methods in men with resistance training experience. To this end, the study focused on addressing the following questions: "What types of vertical jump are being used?", "What instruments are being used to perform these assessments?", "How are the assessment protocols being applied?" and "What data are being considered for final analysis?"

Method

Study design

This systematic review was conducted following the guidelines established by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021) and was registered under the number CRD42024598675 in the International Prospective Register of Systematic Reviews (PROSPERO).

Eligibility criteria

For the selection of studies to be analyzed, the eligibility criteria were based on the PECOS acronym (Morgan et al., 2018), where the participants (P) were men engaged in traditional resistance training (22.67 ± 3.21 years), the exposure (E) was the assessment of vertical jump performance, without the use of a comparator (C), the outcome (O) was the instrument and method used for conducting this assessment, and the study design (S) consisted of cross-sectional studies. For the purpose of this review, “recreationally trained” was defined as individuals participating in resistance training voluntarily, without engaging in formal, structured sports competitions. All studies conducted with women, those that used any type of training other than traditional resistance training, those that did not use any form of vertical jump as a assessment method, and those involving professional or amateur athletes engaged in any type of competitive activity were excluded. Additionally, conference abstracts, other reviews, preprints, and clinical trials were excluded.

Search strategy

A search was conducted in May 2025 across the Scopus, Web of Science, PubMed (via MEDLINE), SportDiscus, and ScienceDirect databases without applying filters. The search phrase used was: (("vertical jump"[Title/Abstract] OR "countermovement jump"[Title/Abstract] OR "squat jump"[Title/Abstract] OR "abalakov"[Title/Abstract] OR "drop jump"[Title/Abstract])) AND (("resistance training"[Title/Abstract] OR "strength training"[Title/Abstract] OR "power training"[Title/Abstract] OR "traditional training"[Title/Abstract])). The retrieved articles were uploaded to the Rayyan website (Ouzzani et al., 2016). Two independent reviewers, with the assistance of a third independent reviewer to resolve any disagreements, screened and excluded duplicate studies. Subsequently, the articles were analyzed by their titles and abstracts, followed by full-text reviews according to the selected eligibility criteria.

Methodological quality and risk of bias assessment

The Joanna Briggs Institute Critical Appraisal Checklist for Analytical Cross-Sectional Studies was used by two independent reviewers to assess the methodological quality of the included articles. It consists of eight questions, each to be answered with “yes,” “no,” “unclear,” or “not applicable,” in addition to an overall evaluation with options of “included,” “excluded,” or “seek more information.” The checklist covers the following questions: Q1) Were the inclusion criteria clearly defined?; Q2) Were the study subjects and setting described in detail?; Q3) Was the exposure measured in a valid and reliable manner?; Q4) Were objective and standardized criteria used to measure the condition?; Q5) Were confounding factors identified?; Q6) Were strategies to deal with confounding factors stated?; Q7) Were the outcomes measured in a valid and reliable manner?; Q8) Was appropriate statistical analysis used? (Moola et al., 2024). Its result was determined by the number of “yes” responses for each study, defined as follows: studies with up to 3 “yes” responses were considered of “low quality”; with 5 to 6 responses, “moderate quality”; and with 7 or more, “high quality” (Canto, 2021). A third reviewer was available to resolve potential disagreements.

Data extraction

The data extracted for subsequent analysis included: authors, year of publication, country where the study was conducted, sample size, sample characteristics, and resistance training experience. Additionally, data regarding training volume and intensity, assessment procedures, type of jump used for assessment, instrument used, and collected variables were also extracted. The entire procedure was conducted by two independent reviewers, with any discrepancies resolved by a third independent reviewer.

Results

According to the defined eligibility criteria, 5011 articles were identified in the initial screening. Of these, 3003 were detected as duplicates and excluded from the process, along with 1978 articles analyzed during the title and abstract screening phase and 18 articles excluded during the full-text review phase. Consequently, 12 articles were included in the final analysis (Figure 1).

Figure 1. Flowchart of the article selection process.

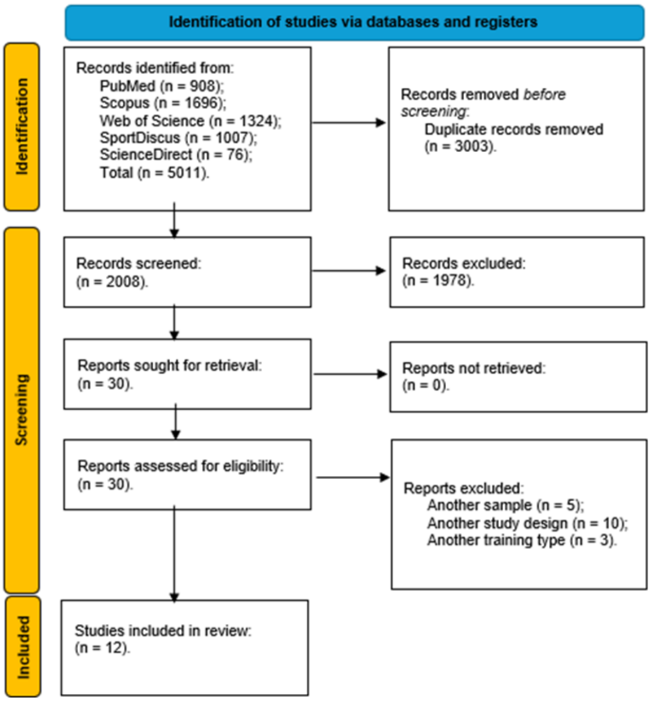

Table 1 provides information regarding the sample characterization. Of the 12 selected articles, four (33%) were conducted in Brazil, six (50%) in Spain, one (8%) in Portugal, and one (8%) in the United States. The total number of men assessed using the vertical jump was 201, all with at least one year of resistance training experience (except for Varela-Olalla et al. (2020), which does not specify the duration of experience but indicates the recreational status of the participants). Among the range of publication years for the included articles, the earliest study was conducted in 2014, while the most recent was published in 2024.

Table 1. Sample characterization and jump results.

Author	Country	Characterization	RT Experience	Pre Results	Post Results
Andrade et al., 2022	Portugal	13 men; Age: 23.3 ± 1.5 years; TBM: 80.5 ± 8.7 kg; Height: 1,75 ± 0.03 m; BMI: 26 ± 2.7 kg/m^2; 1RM: 87.9 ± 16.4 kg.	1.4 ± 1.4 years	Full squat (cm): Pre: 31.1 ± 3.7;	Full squat (cm): Post: 29.2 ± 3.8.

Costa et al., 2021a	Brazil	18 men; Age: 21.5 ± 2.4 years; TBM: 77.8 ± 7.1 kg; Height: 1.8 ± 0.0 m; BMI: 23.8 ± 1.7 kg/m².	At least 2 years	Drop set (cm): Pre: 31.1 ± 3.0; Desc. pyramid (cm): Pre: 31.1 ± 3.4; Traditional (cm): Pre: 31.2 ± 3.5.	Drop set (cm): Post: 29.0 ± 3.2; Desc. pyramid (cm): Post: 30.4 ± 3.0; Traditional (cm): Post: 30.9 ± 3.4.
Costa et al., 2021b	Brazil	11 men; Age: 23.8 ± 2.3 years; TBM: 78.3 ± 6.9 kg; Height: 1.73 ± 0.05 m; BMI: 25.9 ± 1.8 kg/m²; 10RM: 98.4 ± 13.4 kg.	1 to 5 years	Failure (cm): Pre: 35.2 ± 7.0; Non-failure (cm): Pre: 35.2 ± 6.6.	Failure (cm): Post: 33.7 ± 5.5; 30min: 34.9 ± 6.8; Non-failure (cm): Post: 36.3 ± 6.4; 30min: 34.5 ± 6.1.
Cuevas-Aburto et al., 2022	Spain	31 men; Age: 21.3 ± 2.3 years; TBM: 78.4 ± 12.9 kg; Height: 1.76 ± 0.07 m; 10RM: 78.5 ± 12.7 kg.	At least 1 year	Traditional (cm): Pre: 34.49 ± 0.79; Cluster Set (cm): Pre: 34.70 ± 1.09; Rest Redist. (cm): Pre: 34.63 ± 1.2.	Traditional (cm): Post: 32.41 ± 1.09; Cluster Set (cm): Post: 32.10 ± 1.01; Rest Redist. (cm): Post: 31.82 ± 0.97.
Fonseca et al., 2020	Brazil	22 men; Age: 21.4 ± 2.3 years; TBM: 78.1 ± 6.7 kg; 12RM: 85.27 ± 19.29 kg.	1 to 5 years	Failure (cm): Pre: 30.0 ± 4.1; Non-failure (cm): Pre: 30.1 ± 3.6.	Failure (cm): Post: 27.4 ± 3.8; 10min: 28.1 ± 3.8; 20min: 28.9 ± 4.2; 30min: 29.1 ± 3.9; Non-failure (cm): Post: 28.5 ± 3.6; 10min: 29.1 ± 3.6; 20min: 29.8 ± 3.8; 30min: 30.1 ± 3.7.
Garnacho-Castaño et al., 2015	Spain	13 men; Age: 21.23 ± 1.83 years; TBM: 81.21 ± 8.98 kg; Height: 1.80 ± 0.05 m; BMI: 24.87 ± 1.99 kg/m².	2.69 ± 1.25 years	Constant (cm): Pre: 34.6 ± 4.06.	Constant (cm): Post: 32.3 ± 3.74.
Girman et al., 2014	EUA	11 men; Age: 22.9 ± 2.6 years; TBM: 78.5 ± 1.6 kg; Height: 1.76 ± 0.10 m; %G: 12.9 ± 3.1 %.	6.4 ± 1.5 years	Traditional (cm): Pre: 62.13 ± 2.35; Cluster Set (cm): Pre: 63.80 ± 2.15.	Traditional (cm): Mid: 57.71 ± 2.78; Post: 54.99 ± 2.69; 15min: 57.58 ± 1.99; 30min: 59.03 ± 2.06; Cluster Set (cm): Mid: 63.73 ± 2.33; Post: 60.33 ± 2.21; 15min: 59.31 ± 2.35; 30min: 59.16 ± 2.26.
Gomes et al., 2015	Brazil	14 men; Age: 24 ± 4 years; TBM: 81 ± 11 kg; Height: 176 ± 6 m; 1RM: 107 ± 30 kg.	At least 3 years	Elastic band (ms): Pre: 292.08 ± 77.08; No elastic band (ms): Pre: 292.08 ± 77.08.	Elastic band (ms): Post: 272.61 ± 35.70; No elastic band (ms): Post: 297.76 ± 41.38.
Pareja-Blanco et al., 2019	Spain	17 men; Age: 23.6 ± 3.6 years; TBM: 76.2 ± 10.9 kg; Height: 1.80 ± 0.10 m; 1RM: 111.4 ± 25.2 kg.	2.8 ± 1.1 years	60-20 (cm/%): Pre: 42.0 ± 6.2; 60-40 (cm/%): Pre: 42.7 ± 6.1; 80-20 (cm/%): Pre: 43.1 ± 3.8; 80-40 (cm/%): Pre: 43.3 ± 3.9.	60-20 (cm/%): Post: 75.4 ± 1.9; 60-40 (cm/%): Post: 67.3 ± 2.6; 80-20 (cm/%): Post: 78.4 ± 1.8; 80-40 (cm/%): Post: 76.7 ± 1.4.
Piqueras-Sanchiz et al., 2022	Spain	16 men; Age: 23.4 ± 4.4 years; TBM: 73.9 ± 9.1 kg; Height: 1.75 ± 0.05 m; 1RM: 105.8 ± 12.1 kg.	2 to 6 years	3 sets of 8 reps (cm): Pre: 37.3 ± 4.6; 6 sets of 4 reps (cm): Pre: 37.5 ± 3.6.	3 sets of 8 reps (cm): Post: 27.0 ± 3.8; 6 sets of 4 reps (cm): Post: 29.6 ± 3.4.
Sánchez-Valdepeñas et al., 2024	Spain	20 men; Age: 24.5 ± 4.8 years; TBM: 76.3 ± 8.6 kg; Height: 1.79 ± 0.07 m; 1RM/TBM: 1.49 ± 0.26.	At least 1 year	BFR0 (cm): Pre: 39.3 ± 6.8; BFR10 (cm): Pre: 39.2 ± 6.7;	BFR0 (cm): Post: 35.6 ± 7.0; BFR10 (cm): Post: 35.0 ± 5.9;

				BFR20 (cm): Pre: 39.3 ± 6.4; BFR40 (cm): Pre: 39.0 ± 6.7.	BFR20 (cm): Post: 33.5 ± 5.4; BFR40 (cm): Post: 28.7 ± 5.6.
Varela-Olalla et al., 2020	Spain	15 men; Age: 23 ± 2.4 years; TBM: 73.1 ± 8.2 kg; Height: 1.75 ± 0.06 m; 1RM: 99.7 ± 13.1 kg; 1RM /MPV: 0.3 ± 0.1.	Recreational	Traditional (cm): Pre: 35.4 ± 4.4; Cluster set (cm): Pre: 34.4 ± 4.7.	Traditional (cm): Post: 32.6 ± 3.3; Cluster set (cm): Post: 33.4 ± 4.5.

Legend: TBM= total body mass; BMI= body mass index; %G= body fat percentage; 1RM= one-repetition maximum; 1RM/TBM= one-repetition maximum normalized by the individual's total body mass; cm= centimeters; pre= before exercise; post= after exercise; mid= mid exercise; BFR= blood flow re-striction; reps= repetitions; cm/% = pre in centimeters, post as percentage; min= minutes; desc.= de-scendent; redist.= redistribution.

Table 2 presents the data regarding the conditions analyzed in each included study, as well as the volume and intensity prescribed for each training session. Among the exercises analyzed, one study utilized knee extension (8%), seven studies used squats (58%), three studies employed half-squats (25%), and one study used the 45° leg press (8%). In terms of analysis approaches, resistance training was prescribed in different ways: by absolute load values based on a maximum repetition test (1RM, 10RM, 12RM, 15RM), by percentage ranges based on the maximum load of one repetition (10%-90%), and by velocity imposed against the load.

Table 2. Characteristics of resistance training.

Author	Training	Intensity	Volume and intervals
Andrade et al., 2022	Smith Squat; 2 conditions: Squat vs. Bench Press.	80% of 1RM.	3x 8 reps, 3min RI.
Costa et al., 2021a	Leg press 45º; 3 conditions: Drop set vs. descending pyramid vs. traditional.	Drop set: 12RM and 15RM; Descending pyramid: 10RM, 12RM e 15RM respectively; Traditional: 12RM.	Drop set: 2x 10 + 5 reps, 6min RI; Descending pyramid: 3x 10 + 10 + 10 reps, 3min RI; Traditional: 3x 10 reps, 3min RI.
Costa et al., 2021b	Leg extension; 2 conditions: Failure x no failure.	10RM.	Failure: 3x to failure, 3min RI; No failure: 6x 5 reps, 80s RI.
Cuevas-Aburto et al., 2022	Squat; 3 conditions: Traditional x cluster set x redistributed rest.	10RM.	Traditional: 3x 6 reps, 3min RI; Cluster 3x6 reps, 30s RI every 2 reps, 3min RI between sets; Redistributed rest: 9x 2 reps, 45s RI.
Fonseca et al., 2020	Squat; 2 conditions: Failure x no failure.	12RM.	Failure: 4x 12 reps. No failure: 8x 6 reps. 3min RI.
Garnacho-Castaño et al., 2015	Half squat; 3 conditions: 1RM vs. Incremental vs. Constant.	1RM: 188.78 ± 35.64; Incremental: (10% - 40%) 22.8 ± 3.54; Constant: (Lactate Threshold from Incremental) 43.72 ± 11.87.	1RM: 3-5 attempts, 2-4min RI; Incremental: 1x 30 reps each %; Constant: 21x 15 reps.
Girman et al., 2014	Squat; 2 conditions: Traditional x cluster set	Tradicional: 50%-70% of 1RM; Cluster: 55%-70% of 1RM.	Traditional: 4x 6 reps, 2 min RI; Cluster set: 5x 4-10 reps, 15s RI every 2 repetições, 2 min RI between sets.
Gomes et al., 2015	Half squat; 2 conditions: EB x no EB	90% of 1RM.	1x 3 reps; 3min RI between conditions.
Pareja-Blanco et al., 2019	Squat; 4 conditions: 60-20 x 60-40 x 80-20 x 80-40	60% - 80% of 1RM	3x number of repetitions until reaching the corresponding velocity loss (20% or 40%). 4min RI.
Piqueras-Sanchiz et al., 2022	Squat; 2 conditions: 3 sets of 8 reps x 6 sets of 4 reps	75% of 1RM	a: 3x 8 reps, 5 min RI; b: 6x 4 reps, 2 min RI; Total volume of both conditions: 24 reps; Total RI: 10 min.
Sánchez-Valdepeñas et al., 2024	Squat; 4 conditions: 50% of BFR, until: 0% x 10% x 20% x 40% VL.	60% of 1RM	3x number of repetitions until reaching the corresponding velocity loss (0%, 10%, 20% or 40%); 2min RI.
Varela-Olalla et al., 2020	Smith half squat; 2 conditions: Traditional x cluster set	Load corresponding to 0.5 m/s.	Traditional: 1x until a 20% reduction in the maximum velocity achieved in the set.

	Cluster: 1x until reaching the number of repetitions found on the traditional day, with a 15s inter-repetition RI between each repetition.

Legend: RI= rest interval; RM= maximum repetition; reps= repetitions; s= seconds; min = minutes; m/s= meters per second; BFR= blood flow restriction; EB= elastic band; VL= velocity loss.

Table 3 presents the extracted data related to the assessments conducted in the analyzed studies. All studies used the countermovement jump (CMJ) as the movement for evaluating vertical jump performance. Four studies (33%) used a contact mat, four (33%) used an infrared timing system, two (17%) used a force platform, and two (17%) used an image analysis application. The number of attempts per protocol varied across studies, with 7 out of 12 (58%) utilizing 3 attempts. The recovery interval between attempts was also heterogeneous: 1 study (8%) used 3 seconds, while 5 studies (42%) used 30 seconds of rest. All assessments were conducted before and after the conditions proposed in each study. The post-stimulus assessment timings showed variability. The most frequent time point was “immediately post”, used in 5 of the 12 studies (42%). Other studies assessed at varied time points (e.g., 15s, 1min, 2min, 3min), while four studies (33%) conducted later measurements, ranging from 10 to 30 minutes post-stimulus. Regarding the analyzed variables, 11 studies (92%) used jump height calculated from flight time, one study (8%) used jump time, one study (8%) used impulse, one study (8%) used mean power, and one study (8%) used peak power.

Table 3. Characteristics of vertical jump assessments.

Author	Vertical jump	Instrument	Assessment	Outcome variables
Andrade et al., 2022	CMJ	Infrared timing system; (Optojump, Microgate, Bolzano, Italy)	Pre and 3min post; 3 attempts; Best result.	Jump height calculated based on flight time.
Costa et al., 2021a	CMJ	Contact mat; (Cefise, São Paulo, Brazil)	Pre and 30min post; 3 attempts with 30s RI.	Jump height calculated based on flight time.
Costa et al., 2021b	CMJ	Contact mat; (Hidrofit®, Belo Horizonte, MG, Brazil)	Pre, immediately post, 30min post; 3 attempts with 30s RI; Best result.	Jump height calculated based on flight time.
Cuevas-Aburto et al., 2022	CMJ	Image analysis; (MyJump2, iOS)	Pre and immediately post; 4 attempts with 30s RI.	Jump height calculated based on flight time.
Fonseca et al., 2020	CMJ	Contact mat; (Jump System Pro; Cefise, Nova Odessa, Brazil)	Pre, 15s, 10min, 20min, and 30min post; 3 attempts with 30s RI; Best result.	Jump height calculated based on flight time.
Garnacho-Castaño et al., 2015	CMJ	Force platform; (Quattro Jump model 9290AD; Kistler Instruments, Winterthur, Switzerland)	Pre and post constant test; 3 attempts with 30s RI; Average of the results.	Jump Height; Average Power Output; Peak Power Output.
Girman et al., 2014	CMJ	Contact mat; (Just Jump System, Perform Better, Cranston, RI, USA)	After each blood collection; (Pre, mid-exercise, immediately post, 15min post, and 30min post).	Jump height calculated based on flight time.
Gomes et al., 2015	CMJ	Force platform; (EMG System Brasil, São José dos Campos, Brasil)	Pre and 1min post; 3 attempts with 3s RI.	Jump Time; Impulse.
Pareja-Blanco et al., 2019	CMJ	Infrared timing system; (OptojumpNext, Microgate, Bolzano, Italy)	Pre and immediately post; 3 attempts with 20s RI; Average of the results.	Jump height calculated based on flight time.
Piqueras-Sanchiz et al., 2022	CMJ	Infrared timing system; (OptojumpNext, Microgate, Bolzano, Italy)	Pre and immediately post; 2 attempts with 10s RI; Average of the results.	Jump height calculated based on flight time.
Sánchez-Valdepeñas et al., 2024	CMJ	Infrared timing system; (OptojumpNext, Microgate, Bolzano, Italy)	Pre and 2min post; 2 attempts with 10s RI; Average of the results.	Jump height calculated based on flight time.
Varela-Olalla et al., 2020	CMJ	Image analysis; (MyJump2 iOS)	Pre and immediately post.	Jump height calculated based on flight time.

Legend: CMJ= countermovement jump; s= seconds; min= minutes; h= height

Table 4 presents the methodological quality assessment scores for each study, where one study (8%) scored 5, six studies (50%) scored 6, four studies (34%) scored 7, and one study (8%) scored 8. Thus, according to the applied criteria, five studies were classified as "high quality," and seven studies as "moderate quality”. An observation of the protocols suggests that this quality rating does not appear to clearly influence the choice of instrumentation or specific protocol parameters. For instance, the use of 3 jump attempts measured by a contact mat was found in both "high quality" (Fonseca et al., 2020) and "moderate quality" (Costa et al., 2021a) studies. Similarly, the use of 2 jump attempts measured by an infrared timing system was reported in both "high quality" (Sánchez-Valdepeñas et al., 2024) and "moderate quality" (Piqueras-Sanchiz et al., 2022) studies.

Table 4. Critical Appraisal Checklist for Analytical Cross-Sectional Studies.

Studies	1	2	3	4	5	6	7	8	Total	Q
Andrade et al., 2022	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Costa et al., 2021a	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Costa et al., 2021b	Y	Y	Y	Y	U	Y	Y	Y	7	High
Cuevas-Aburto et al., 2022	Y	Y	Y	Y	U	Y	Y	Y	7	High
Fonseca et al., 2020	Y	Y	Y	Y	Y	Y	Y	Y	8	High
Garnacho-Castaño et al., 2015	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Girman et al., 2014	Y	Y	Y	Y	U	Y	Y	Y	7	High
Gomes et al., 2015	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Pareja-Blanco et al., 2019	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Piqueras-Sanchiz et al., 2022	Y	Y	Y	Y	U	N	Y	Y	6	Mod
Sánchez-Valdepeñas et al., 2024	Y	Y	Y	Y	U	Y	Y	Y	7	High
Varela-Olalla et al., 2020	Y	Y	Y	U	U	N	Y	Y	5	Mod

Legend: Y= yes, N= no, U= Unclear, Q= Final classification of methodological quality, High= High quality, Mod= Moderate quality.

Discussion

The objective of this review was to investigate the methods of vertical jump assessment in men with resistance training experience. Among the included studies, it was observed that the countermovement jump (CMJ) was the only type of vertical jump used for assessment before and after the stimuli proposed in each study. The dominance of this jump type may be attributed to its motor characteristics, aiming to utilize the stretch-shortening cycle (SSC) without the assistance of the upper limbs to enhance performance. With the individual starting in an upright position and performing subsequent flexion and extension movements of the hips, knees, and ankles in the shortest time possible, both the elastic mechanical components and the contractile components of the lower limb muscles contribute to better results (Komi & Bosco, 1978).

This reasoning explains why other types of jumps were not observed, such as the squat jump, which aims to mitigate the effects of elastic mechanical components and stretch reflex responses by introducing a pause between the eccentric and concentric phases (Van Hooren & Zolotarjova, 2017), or the Abalakov jump, which uses the upper limbs to enhance performance, rather than relying solely on the lower limbs (Soler-López et al., 2022).

In the SSC, the body rapidly descends with the help of gravitational force during the eccentric phase, reaching maximum downward velocity, increased kinetic energy, and minimal braking time. This requires greater force production for deceleration at the end of this phase and subsequent acceleration for the concentric phase (Hernández-Davó et al., 2021). Various mechanisms influence this process, such as elastic energy accumulation, preload, muscle history dependence, stretch reflexes, and muscle-tendon interactions, which contribute to mechanical work production during subsequent concentric actions (Kurt et al., 2023) and explain performance differences between the jump squat and the CMJ (Van Hooren & Zolotarjova, 2017).

Instruments

Among the tools used to analyze vertical jump performance in the selected studies, contact mats (Costa et al., 2021a; Costa et al., 2021b; Fonseca et al., 2020; Girman et al., 2014) and infrared timing systems (Andrade et al., 2022; Pareja-Blanco et al., 2019; Piqueras-Sanchiz et al., 2022; Sánchez-Valdepeñas et al., 2024) were the most commonly used. The former assesses jumps based on the individual's pressure sensitivity on the mat, while the latter uses infrared beams to detect when a body interrupts the connectivity between two device ends. Both tools estimate jump height using the flight time of the jump and a mathematical equation. Other tools, such as force platforms (Garnacho-Castaño et al., 2015; Gomes et al., 2015), enables a more detailed analysis through the coupled load cells that record the force applied to the ground during movement; or the My Jump 2 application (Cuevas-Aburto et al., 2022; Varela-Olalla et al., 2020), which uses the smartphone camera to estimate jump height through an equation that incorporates the flight phase duration by recording the vertical jump and identifying the take-off and landing moments. Subsequently, the height is calculated using the formula h = t2·1.22625, where h represents the height reached and t is the recorded flight time.

Of all tools, only the force platform is considered a primary assessment instrument for vertical jump performance due to its direct measurement of force during the movement, despite its higher cost. It was observed that vertical jump measurements were based on direct variables like flight time and impulse (Gomes et al., 2015) and calculated variables like jump height, peak power, and mean power (Garnacho-Castaño et al., 2015). The other tools are considered secondary assessment instruments since their results are estimates derived from equations that rely on other variables (e.g., $h = g.t^2.8^{-1}$, where h is jump height, g is gravitational force, and t is flight time). Nevertheless, they present themselves as more economically accessible options. Despite their high reliability (Bogataj et al., 2020; Pueo et al., 2017), these tools may overestimate the jump height (Wade et al., 2020). Postural differences during takeoff and landing also pose a challenge to accurate assessment, as variations in ankle angles can affect flight time and reduce measurement precision. Corrective equations are being developed to minimize these errors and increase the validity of indirect assessment tools (Gonçalves et al., 2024), alongside proposed guidelines for data collection based on jump type and assessment instrument (Eythorsdottir et al., 2024).

Assessment protocols

Protocol variability is a recurring theme in this field. These findings align with the systematic review by Petrigna et al. (2019), which also found significant protocol variability in adolescents. This suggests that the lack of standardization is not unique to RT-trained men but rather a persistent issue across different populations. Similarly, while Dutaillis et al. (2024) focused on ACL reconstruction patients, their review also highlighted challenges in comparing outcomes due to varied methodologies, reinforcing the need for standardized assessment guidelines. All selected studies conducted a vertical jump assessment prior to the proposed stimulus to establish a baseline for comparison, aiming to identify potential differences in jump performance following resistance training.

However, following the proposed stimulus in each study, the timing of vertical jump performance assessments ranged from immediately after (Costa et al., 2021b; Cuevas-Aburto et al., 2022; Girman et al., 2014) to 30 minutes later (Costa et al., 2021a; Fonseca et al., 2020), with some studies conducting up to three (Girman et al., 2014) or four (Fonseca et al., 2020) different assessment moments within this interval. Furthermore, the minimum number of attempts per assessment moment was two jumps (Piqueras-Sanchiz et al., 2022; Sánchez-Valdepeñas et al., 2024) while the maximum was four jumps (Cuevas-Aburto et al., 2022). Most studies used three attempts per assessment moment (Andrade et al., 2022; Costa et al., 2021a; Costa et al., 2021b; Fonseca et al., 2020; Garnacho-Castaño et al., 2015; Gomes et al., 2015; Pareja-Blanco et al., 2019). The minimum rest interval between attempts was 3 seconds (Gomes et al., 2015), and the maximum was 30 seconds (Costa et al., 2021a; Costa et al., 2021b; Cuevas-Aburto et al., 2022; Garnacho-Castaño et al., 2015). Some studies utilized the highest value achieved across attempts (Andrade et al., 2022; Costa et al., 2021b; Fonseca et al., 2020), while others calculated the average of all attempts (Garnacho-Castaño et al., 2015; Pareja-Blanco et al., 2019; Piqueras-Sanchiz et al., 2022). Exceptions were studies that did not report such details. While this variation highlights a lack of full standardization, it is crucial to note that clear majority practices did emerge. For instance, the use of 3 attempts was the most common protocol (58% of studies), and 30 seconds was the most frequent rest interval (42% of studies). This suggests that while a definitive consensus is not yet established, common patterns are forming in the literature.

Training methods

All included studies compared at least two conditions involving lower-limb resistance exercises, enabling the analysis of how different resistance training methods acutely affect vertical jump performance. Vertical jump assessments were predominantly associated with squat variations (e.g., full squat, half-squat, smith machine squat), reaffirming the squat's central role as a foundational lower-limb exercise within resistance training protocols.

However, a wide variety of training strategies were tested, including training to failure or not to failure (Costa et al., 2021b; Fonseca et al., 2020), using intensities prescribed in absolute terms (1RM to 15RM)

(Costa et al., 2021a; Costa et al., 2021b; Cuevas-Aburto et al., 2022; Fonseca et al., 2020; Garnacho-Castaño et al., 2015), relative terms (10%-90% of 1RM) (Andrade et al., 2022; Girman et al., 2014; Gomes et al., 2015; Pareja-Blanco et al., 2019; Piqueras-Sanchiz et al., 2022; Sánchez-Valdepeñas et al., 2024), movement velocity (0.5 m/s) (Varela-Olalla et al., 2020), or lactate threshold (Garnacho-Castaño et al., 2015).

Various methods, such as cluster sets (Cuevas-Aburto et al., 2022; Girman et al., 2014; Varela-Olalla et al., 2020), drop sets, and descending pyramids (Costa et al., 2021a) were also utilized. Other variations included the application or absence of blood flow restriction (Sánchez-Valdepeñas et al., 2024), the use of elastic bands (Gomes et al., 2015), manipulation of velocity loss thresholds (Pareja-Blanco et al., 2019), protocols with equalized training volume (Piqueras-Sanchiz et al., 2022) and comparisons between different exercises, such as bench press and squat (Andrade et al., 2022).

Practical recommendations

Based on the findings of this review, which identified the Countermovement Jump (CMJ) as the unanimous choice for assessing vertical jump performance in this population, some practical recommendations for implementing a standardized assessment can be proposed. The most frequent protocol observed was the use of 3 attempts, with a rest interval of at least 30 seconds between them; this duration was the most common and likely ensures adequate recovery. For the final analysis, using the best score (highest jump) is a robust practice also observed in several 'high quality' studies. Finally, regarding the timing for assessing acute fatigue, this review found significant heterogeneity. Protocols were split between immediate (within 3 minutes post-exercise) or later (15-30 minutes post-exercise) measurements. This suggests that a single time-point recommendation is not possible; the choice of timing must be based on the practitioner's specific goal (i.e., measuring peak acute fatigue vs. tracking the recovery curve).

Limitations and future research

The present study has limitations, such as analyzing only the use of vertical jump assessments following the stimulus, that is, in an acute manner. This approach does not allow for understanding the use of this exercise as a means of evaluating improvements over the medium and long term, as the included articles did not propose longitudinal interventions. Another limitation concerns the sample used. Although it was selected to ensure the internal validity of using the vertical jump as an assessment tool and its application methods in men with resistance training experience, caution is needed when extrapolating these findings to other populations.

The analysis of the included studies reveals relevant methodological heterogeneity in participant characteristics, especially regarding the amount of resistance training experience. The participants' training backgrounds varied substantially across studies, ranging from individuals with just one year of experience to those with over six years of practice. This variation can directly affect neuromuscular responses to applied stimuli, as less experienced individuals tend to demonstrate lower technical efficiency and greater susceptibility to fatigue, which influences power output in assessments such as the vertical jump (Ide et al., 2014). Nevertheless, the diversity in training experience levels highlights the importance of considering the participant's profile when interpreting the results.

A further limitation concerns the methodological quality of the primary studies. The fact that 7 out of 12 of the included studies were classified as "moderate quality" must be considered. This classification was often due to unclear reporting on the identification and handling of confounding factors. This methodological weakness across the literature restricts the overall strength of the conclusions that can be drawn regarding the most appropriate protocols and reinforces the need for greater rigor in future research.

Furthermore, age variations were observed both within and between the included studies, indicating a degree of heterogeneity in the sample. This variation could potentially influence neuromuscular responses and recovery capacities, representing a factor to consider when interpreting the generalizability of the results. Further studies are recommended to explore the application of the vertical jump as a tool for performance evaluation and state monitoring in different contexts, particularly those focused on health and non-athlete populations.

Conclusions

The countermovement jump (CMJ) emerged as the sole type of vertical jump used to evaluate performance in the selected studies. Indirect assessment tools, such as contact mats and infrared timing systems, were the most frequently employed, likely due to their economic accessibility and ease of application. Despite the widespread use of CMJ, methodological heterogeneity was observed, particularly regarding the recovery interval between attempts and the final data used for analysis. However, while a definitive consensus is not yet established, clear common patterns did emerge. This lack of full standardization can hinder comparability between studies. Based on the most common and robust practices identified in this review, a practical protocol is recommended: use 3 attempts with a rest interval of at least 30 seconds between them and use the best score (highest jump) for the final analysis. The choice of post-stimulus assessment timing (e.g., immediately post vs. 15-30 minutes post) must be defined based on the practitioner's specific goal, whether it is measuring peak acute fatigue or monitoring the recovery curve.

Future research should aim to explore alternative types of vertical jumps, compare various assessment tools, include diverse populations, and propose standardized protocols to enhance the reliability, validity, and practical application of jump-based monitoring strategies in recreational resistance training settings and non-athlete populations, with particular emphasis on health promotion.

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Appendix

Appendix 1. Table of search strings by database used

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Base de dados	Frase de busca	N
PubMed	(("vertical jump"[Title/Abstract] OR "countermovement jump"[Title/Abstract] OR "squat jump"[Title/Abstract] OR "abalakov"[Title/Abstract] OR "drop jump"[Title/Abstract])) AND (("resistance training"[Title/Abstract] OR "strength training"[Title/Abstract] OR "power training"[Title/Abstract] OR "traditional training"[Title/Abstract]))	908
Scopus	TITLE-ABS-KEY("vertical jump" OR "countermovement jump" OR "squat jump" OR "abalakov" OR "drop jump") AND TITLE-ABS-KEY("resistance training" OR "strength training" OR "power training" OR "traditional training")	1696
SportDiscus	(vertical jump OR countermovement jump OR squat jump OR abalakov OR drop jump) AND (resistance training OR strength training OR power training OR traditional training)	1007
Web of Science	TS=("vertical jump" OR "countermovement jump" OR "squat jump" OR "abalakov" OR "drop jump") AND TS=("resistance training" OR "strength training" OR "power training" OR "traditional training")	1324
ScienceDirect	("vertical jump" OR "countermovement jump" OR "squat jump" OR "abalakov" OR "drop jump") AND ("resistance training" OR "strength training" OR "power training" OR "traditional training")	76