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Original article

Differences in the load-velocity relationship between untrained men and women during the back squat exercise

Diferenças na relação carga-velocidade entre homens e mulheres destreinados durante o back squat

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ABSTRACT

Objectives: The purposes of this investigation were: 1) to compare the load-velocity relationship estimated by the two-point method between untrained men and women during the parallel back squat exercise (BS) and 2) to compare the load-velocity profile found in our study with the load-velocity profiles reported in the scientific literature for trained individuals. Beyond, we aimed to compare the measured 1RM velocity with predicted 1RM velocity by the two-point method in the BS exercise in untrained individuals. **Methods:** Seventy-six untrained individuals (38 men (22.7 ± 4.4 years; 174.9 ± 6.8 cm; 76.1 ± 14.9 kg) and 38 women (24.7 ± 4.3 years; 159.1 ± 6.0 cm; 64.7 ± 13.3 kg) performed a one-repetition maximum test and a progressive two-load test with 20% 1RM and 70% 1RM to estimate their load-velocity relationships. **Results:** The main results revealed that 1) mean propulsive velocity and mean velocity attained at each relative load were different between men and women ($p < 0.05$). However, the measured 1RM velocity was not significantly different between them. Untrained men provided a steeper load-velocity relationship than women. We found that 2) untrained individuals of our study showed a different load-velocity profile than trained individuals from scientific literature studies. Furthermore, 3) the measured 1RM velocity was lower than the predicted 1RM velocity ($p < 0.05$). **Conclusion:** These results suggest that the load-velocity relationship is dependent on sex and training background, and the two-point method using 20% and 70% 1RM might not be reliable to estimate the load-velocity relationship in the BS exercise for untrained men and women.

Keywords: exercise; velocity measurement; muscle strength.

RESUMO

Objetivos: Os objetivos deste estudo foram: 1) comparar a relação carga-velocidade estimada pelo método de dois pontos entre homens e mulheres destreinados durante o exercício agachamento paralelo (BS) e 2) comparar o perfil carga-velocidade encontrado em nosso estudo com os perfis de carga-velocidade relatados na literatura científica para indivíduos treinados. Além disso, comparar a velocidade de 1RM medida com a velocidade de 1RM predita pelo método de dois pontos no exercício BS em indivíduos destreinados. **Métodos:** Setenta e seis indivíduos destreinados (38 homens (22,7 ± 4,4 anos; 174,9 ± 6,8 cm; 76,1 ± 14,9 kg) e 38 mulheres (24,7 ± 4,3 anos; 159,1 ± 6,0 cm; 64,7 ± 13,3 kg) realizaram um teste de uma repetição máxima e um teste progressivo de duas cargas com 20% e 70% 1RM para estimar suas relações carga-velocidade. **Resultados:** Os principais resultados revelaram que 1) a velocidade média propulsiva e a velocidade média atingida em cada carga relativa foram diferentes entre homens e mulheres ($p < 0,05$). No entanto, a velocidade de 1RM medida não foi significativamente diferente entre eles. Homens destreinados forneceram uma relação carga-velocidade mais acentuada do que as mulheres. Descobrimos que 2) os indivíduos destreinados de nosso estudo apresentaram um perfil carga-velocidade diferente dos indivíduos treinados dos estudos da literatura científica. Além disso, 3) a velocidade de 1RM medida foi menor do que a velocidade de 1RM predita ($p < 0,05$). **Conclusão:** Esses resultados sugerem que a relação carga-velocidade é dependente do sexo e nível de treinamento, e que o método de dois pontos usando 20% e 70% 1RM não seria confiável para estimar a relação carga-velocidade no exercício agachamento paralelo em homens e mulheres destreinados.

Palavras-chave: exercício; mensuração da velocidade; força muscular.

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Introduction

The one-repetition maximum (1RM) value is the primary reference for prescribing training loads in resistance training [1]. The classical way to assess it is through the trial and error method, directly measuring the 1RM load [2]. As this method has essential drawbacks [3], researchers tried to determine the 1RM load through indirect methods [4-6]. However, indirect methods pursue relevant limitations as well [3]. The movement velocity measuring during resistance exercises gained popularity in the field of strength and conditioning to avoid these methods' limitations as almost perfect relationships were found between the magnitude of the load and the bar velocity in many resistance exercises [7-11]. In this regard, generalized regression equations have been proposed to determine relative load (%1RM) and the 1RM load [8,12].

The generalized group equations also have some critical limitations [13]. It assumes that the load-velocity relationship is exercise-specific, i.e., each exercise has its 1RM velocity (V1RM). In this way, the velocity of each % 1RM is treated as been equal for all individuals. Recent studies have observed that the load-velocity relationship is individual, suggesting using an individualized load-velocity relationship for a more accurate 1RM prediction [14,15]. Furthermore, there is also a possibility that the training level of the individuals influences the load-velocity relationship once it is well known that untrained individuals pursue different nervous system integration and insufficient ability of the nervous system to activate the muscles appropriately [16]. As the movement velocity is a consequence of the muscle force applied, and the muscle force applied is a consequence of muscle activation and coordination, different muscle activation patterns could lead to different velocities outputs. Besides that, the higher rate of strength gain of untrained individuals could influence the velocities outputs as those individuals still can achieve a much better neuromuscular performance [17]. It would be interesting to evaluate untrained and trained individuals' load-velocity profiles to test this hypothesis.

Another limitation of the generalized group equations is that the load-velocity profile is sex-specific [14]. Recently, Torrejón *et al.* [18] found that the load-velocity profile differs more between men and women than between individuals with different strength levels in the bench press exercise. Balsalobre-Fernández *et al.* [7] showed that women develop velocities with each %1RM lower than men in the military press exercise. Based on our knowledge, only one scientific study [4] verified the load-velocity relationship in untrained men and women in a lower-body exercise, the back half-squat. However, recent solid evidence [19] suggested that the use of the half-squat exercise is inconvenient. This study indicated limited performance improvements, pain and discomfort increments after half-squat training and the use of parallel or full squat exercise was recommended. Thus, it will be pertinent to provide a detailed description of the load-velocity relationship in untrained men and women in an effective squat exercise.

Furthermore, the two-load method has emerged as an alternative method to the traditional load-velocity testing with multiple loads. The multiple-load method consists of the velocity measurement against several external loads (usually 4-9 loads) at varying progressive intensities. In this way, it can be prone to fatigue, time-consuming, and impractical on a daily basis and for large groups [13,20]. In this regard, assuming that the load-velocity relationship is generally stable and linear in resistance exercises, the two-load method only analyses two loads [13]. Recent research [21] found that the two-load method is optimal because of the higher validity and similar reliability observed than the multiple-load method [13]. Although the two-point method is reliable for determining the load-velocity relationship and predicting the 1RM, it has been analyzed after applying the multiple-load method. In this regard, this method should be analyzed separately from the multiple-load method because the fatigue accumulated through several loads could affect the velocity output [13].

Therefore, our purposes were 1) to estimate and compare the load-velocity relationship between untrained men and women and 2) to compare the load-velocity relationship found in our study with those found in the scientific literature for trained individuals in the parallel back squat exercise (BS) to know if the training level influences the load-velocity relationship. Besides that, we aimed 3) to assess if the measured V1RM is similar to the predicted V1RM from the load-velocity relationship estimated by the two-point method in the BS exercise in untrained individuals.

Methods

Experimental design

A cross-sectional study was designed to meet the objectives described above. The participants reported to the laboratory on three occasions, separated by at least 48-72 hours. This study's independent variable was the %1RM, and the dependent variable was the velocity attained at each %1RM. During the first session, height and body mass were measured, and familiarization with BS was performed. During the second session, the individual 1RM for the BS was established. In the third session, we estimated the load-velocity relationship through the two-load method. To control the influence of external factors possibly affecting exercise performance, all the sessions were controlled by the same two investigators, certified strength and conditioning specialist (CSCS), and were conducted in the physiology laboratory in the Physical Education Department at the Federal University of Sergipe, under similar environmental conditions (~23° C; ~60% humidity).

Participants

Seventy-six (38 men and 38 women) untrained individuals volunteered to participate in this research study. Men (22.7 ± 4.4 years; 174.9 ± 6.8 cm; 76.1 ± 14.9 kg) and women (24.7 ± 4.3 years; 159.1 ± 6.0 cm; 64.7 ± 13.3 kg). All of them had a minimum of one year of resistance training experience with the BS, but they were untrained for at least three months at the moment of the study. All participants were free from musculoskeletal pain, neuromuscular disorders, or any form of joint or bone disease that could compromise the test performance. None of the participants took drugs, medications, or other substances to alter their physical performance during the tests. Participants were informed of the study procedures, risks, and benefits. They read and signed a written informed consent form before initiating the study. The study procedures were approved by the Federal University of Sergipe Institutional Review Board (CAAE: 23629619.4.0000.5546).

Familiarization with the BS exercise

After a standardized dynamic warm-up (the warm-up was the same for all the sessions), which each participant performed 5 min of joint mobility, followed by two sets of 15 and 10 repetitions (interspaced with 2 min rest) with external loads of 10 and 20 kg for women, 20 and 30 kg for men respectively of the BS. The participants were familiarized with the proper technique of the BS. The movement started from an upright position (point A), with hips and knees fully extended. The bar was grasped with a pronated grip and rested across the back on the trapezius's upper part. The stance was approximately shoulder-width apart, parallel feet flat on the floor or externally rotated to a maximum of 15°. From this position, participants descended in a controlled motion until the inguinal crease reached (point B) the same horizontal plane as the superior border of the patella [10,22]. After a momentary pause (~1.5 s), they ascended back to the upright position while keeping an upright straight trunk posture [23].

1RM strength testing

In the second session, after the dynamic warm-up described above, the 1RM BS load was measured according to the protocol established by Pareja-Blanco *et al.* [24]. The BS technique performed was the same as described above. Once the subjects reached point B of the BS, the bar's distance to the ground was measured to establish the BS's depth. The bar displacement was measured with the linear position transducer cited behind to ensure that the subjects performed a similar depth at each BS repetition. A limit of 10% bar displacement loss was established since the loads were increased, and if this criterion was not attended, a new trial was made after a 5 min rest.

Two-load method

In the third session, the individual load-velocity relationship was estimated using a progressive two-load test. Before the commencement of the load-velocity test, participants performed the same standardized warm-up mentioned above. After warming up, the BS exercise bar velocity in the Smith machine was measured against two loads, 20% and 70% 1RM measured in the second session. The BS's eccentric phase was executed at a controlled mean bar velocity (~0.50-0.70 m.s-1) to ensure standardization and security during the lift. Participants were instructed to move as fast as possible during the concentric phase. Strong verbal encouragement was provided to the individuals to reach maximal intended velocity. One set against each load was performed, and five to three repetitions were executed. The set was stopped when the bar velocity decreased in two consecutive reps. If the same bar displacement was not replicated or the controlled bar velocity during the eccentric phase was not achieved, a new set was made after 3 minutes rest [25]. The fastest repetition of the BS at each load was considered for the analysis.

Measurement equipment and data analysis

Height (cm) and body mass (kg) were measured using a stadiometer (*Sanny, ES2030, São Paulo, Brazil*), with an accuracy of 0.1 cm and an anthropometric scale (*Líder®, P150C, São Paulo, Brazil*) with a maximum capacity of 150 kg respectively. These variables were measured according to procedures described elsewhere [26]. A Smith Machine (*Technogym, Gambetola-Italy*) was used for all the BS performed. Velocity data was measured with a linear position transducer (LPT) with a frequency of 1,000 Hz (*Chronojump ®, Boscosystem, Barcelona-Spain*). The bar displacement and velocity were automatically calculated by the custom software v.1.9.0. The validity and reliability of this device have been previously reported [27,28].

Mean velocity (MV) and mean propulsive velocity (MPV) for each exercise's repetition were obtained. The MV is the average velocity of the whole concentric phase of the BS. The MPV is the average velocity of the BS's propulsive phase. The propulsive phase is the portion of the concentric phase that occurs until the braking phase. When the measured acceleration [a] is greater than the acceleration due to gravity, i.e., $a \geq - 9.81$ m.s-2 [13,25].

Statistical analyses

Descriptive data are presented as mean, standard deviation, and 95% confidence intervals (CI). The *Kolmogorov-Smirnov* test confirmed the normal distribution of the data. Linear regression analyses were used to describe the load-velocity relationships to estimate the relative load from the bar velocity. An independent t-test was used to compare the velocities against 20-100% 1RM between untrained men and women. One sample t-test was used to compare anthropometric measures, relative and absolute strength, MPVs, and MVs of our study with, on our knowledge, all the studies of the scientific literature that verified the load-velocity relationship for the parallel BS exercise with trained individuals. We calculated paired t-test to determine the goodness of the two-point method to estimate the V1RM, comparing the velocity of the directly measured 1RM with the estimated V1RM. Cohen's d effect size (ES) was measured to determine the magnitude of the mean differences. The interpretation of the ES was as follows: trivial (< 0.20), small (0.20-0.59), moderate (0.60-1.19), large (1.2-2.0) and very large (> 2.0) effect [29]. The level of significance was established at $p < 0.05$. Statistical analyses were performed using Graphpad Prism 8.0.2 (*GraphPad Software Inc., La Jolla, CA, USA*).

Results

1RM Back Squat

The measured 1RM value of the BS for men and women was 100 ± 22 kg (i.e., 1.34 ± 0.28 per kg of body mass) and 63 ± 16 kg (i.e., 0.98 ± 0.29 per kg of body mass), respectively. Untrained men lifted a higher 1RM load than untrained women ($p < 0.05$).

Comparison of load-velocity relationships between untrained men and women

Table I shows that estimated MPV and MV attained at each relative load (20-100%, with 10% increments) were different between men and women ($p < 0.05$). Untrained men achieved higher velocity values at each % 1RM, providing a steeper load--velocity relationship than untrained women. However, the measured V1RM was not significantly different between them (Table I).

One sample t-test showed quite similar ($p > 0.05$) anthropometric measures, absolute and relative strength of our sample compared with the trained male of Martínez-Cava *et al.* study [10] (Table II). When compared with the NCAA Division I baseball athletes of Spitz *et al.* study [30], there was statistical differences between untrained men of our study and the athletes of their study (Table II). The athletes were younger, taller, bigger, and stronger than our sample. We found that our study's untrained individuals showed a different load-velocity profile than trained individuals of Martínez-Cava *et al.* [10] and Spitz *et al.* [30] studies (Table III). Untrained men of this study achieved higher velocities than trained men of the Martínez-Cava *et al.* study[10] . Spitz *et al.* [30] analyzed only four relative loads. Our study's untrained men attained lower velocities with 30%, 50%, and 70% 1RM loads compared with their study. However, the velocity of 90% 1RM was similar between us and their study.

V1RM prediction through the two-point method

Table I shows that the measured V1RM was significantly different from predicted 1RM MPV for men (ES = 2.83) and women (ES = 2.54), and for predicted 1RM MV for men (ES = 4.12) and women (ES = 2.90). The measured 1RM velocities were smaller than the predicted 1RM velocities for both sexes.

Table I - Mean propulsive velocity (MPV) and mean velocity (MV) attained with 20-100% 1RM in the parallel back squat exercise estimated through the two-load method for the untrained men and women

Relative Load (%1RM)	MPV ($m.s^{-1}$)				MV ($m.s^{-1}$)			
	Men	Women	p	ES	Men	Women	p	ES
20%	1.12 ± 0.13 (1.08-1.16)	0.78 ± 0.10 (0.74-0.81)	0.000	2.91	0.98 ± 0.10 (0.95-1.01)	0.73 ± 0.07 (0.71-0.75)	0.000	2.93
30%	1.03 ± 0.12 (0.99-1.07)	0.72 ± 0.09 (0.70-0.75)	0.000	2.97	0.91 ± 0.09 (0.88-0.94)	0.69 ± 0.06 (0.67-0.71)	0.000	3.00
40%	0.95 ± 0.11 (0.91-0.98)	0.67 ± 0.08 (0.65-0.70)	0.000	2.96	0.85 ± 0.08 (0.82-0.87)	0.64 ± 0.06 (0.63-0.66)	0.000	2.98
50%	0.86 ± 0.10 (0.83-0.89)	0.62 ± 0.07 (0.60-0.64)	0.000	2.83	0.78 ± 0.07 (0.76-0.80)	0.60 ± 0.06 (0.58-0.62)	0.000	2.80
60%	0.77 ± 0.09 (0.74-0.80)	0.57 ± 0.07 (0.55-0.59)	0.000	2.51	0.72 ± 0.07 (0.70-0.74)	0.56 ± 0.06 (0.54-0.58)	0.000	2.45
70%	0.68 ± 0.09 (0.66-0.71)	0.52 ± 0.07 (0.50-0.54)	0.000	2.03	0.65 ± 0.07 (0.63-0.67)	0.52 ± 0.07 (0.49-0.54)	0.000	1.99
80%	0.60 ± 0.10 (0.57-0.63)	0.47 ± 0.08 (0.44-0.49)	0.000	1.48	0.59 ± 0.07 (0.57-0.61)	0.47 ± 0.08 (0.45-0.50)	0.000	1.52
90%	0.51 ± 0.10 (0.48-0.54)	0.41 ± 0.09 (0.38-0.44)	0.000	0.97	0.52 ± 0.08 (0.50-0.55)	0.43 ± 0.09 (0.40-0.46)	0.000	1.10
100%	0.42 ± 0.12 (0.39-0.46)	0.36 ± 0.11 (0.33-0.40)	0.020	0.54	0.46 ± 0.09 (0.43-0.49)	0.39 ± 0.11 (0.35-0.42)	0.002	0.75
V1RM	0.16 ± 0.05 (0.14-0.18)	0.15 ± 0.04 (0.13-0.16)	0.177	0.19	0.16 ± 0.05 (0.14-0.18)	0.15 ± 0.04 (0.13-0.16)	0.177	0.19

Values are mean ± SD (95% confidence interval); p = p-value; ES = Cohen's d effect size; V1RM = measured 1RM velocity

Table II – Anthropometric and muscular strength measures comparison between untrained men of our study and trained men of Martínez-Cava *et al.* [10] and male NCAA Division I baseball position players of Spitz *et al.* [30] studies

Variables	Our study	Martínez-Cava *et al.*	ES	Spitz *et al.*	ES.
Age (years)	22.7 ± 4.4	23.0 ± 4.4	0.07	19.4 ± 1.0*	1.03
Height (cm)	174.9 ± 6.8	174.0 ± 7.4	0.02	182.4 ± 6.5*	1.13
Body mass (kg)	76.1 ± 14.9	76.0 ± 12.8	0.01	87.2 ± 7.4*	0.94
1RM load (kg)	100 ± 21.9	94.3 ± 15.0	0.30	148 ± 20.5*	2.26
1RM/body mass ratio	1.34 ± 0.28	1.27 ± 0.25	0.26	1.7 ± 0.2*	5.89

Values are mean ± SD; * = significantly different from our study ($p < 0.001$); ES = Cohen's d effect size

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Table III - Diferenças da velocidade média propulsiva (MPV) e da velocidade média (MV) no exercício agachamento paralelo com a barra nas costas em homens treinados e destreinados deste estudo e dos estudos de Martínez-Cava *et al.* [10] e Spitz *et al.* [30]

Loads	MPV ($m{,}s^{-1}$)			MV ($m{,}s^{-1}$)		
	Our study	Martínez-Cava *et al.*,	ES,	Our study	Spitz *et al.*,	ES,
30%	1.03 ± 0.12 (0.99-1.07)	-	-	0.91 ± 0.09 (0.88-0.94)	1.19 ± 0.03 (1.13-1.25)*	4.17
40%	0.95 ± 0.11 (0.91-0.98)	0.88 ± 0.07 (0.86-0.90)*	0.75	-	-	-
50%	0.86 ± 0.10 (0.83-0.89)	0.78 ± 0.06 (0.76-0.80)*	0.97	0.78 ± 0.07 (0.76-0.80)	0.99 ± 0.02 (0.94-1.04)*	4.08
60%	0.77 ± 0.09 (0.74-0.80)	0.69 ± 0.05 (0.67-0.70)*	1.10	-	-	-
70%	0.68 ± 0.09 (0.66-0.71)	0.59 ± 0.05 (0.58-0.61)*	1.24	0.65 ± 0.07 (0.63-0.67)	0.75 ± 0.02 (0.71-0.79)*	1.94
80%	0.60 ± 0.10 (0.57-0.63)	0.50 ± 0.04 (0.51-0.53)*	1.31	-	-	-
90%	0.51 ± 0.10 (0.48-0.54)	0.40 ± 0.04 (0.39-0.41)*	1.44	0.52 ± 0.08 (0.50-0.55)	0.51 ± 0.04 (0.43-0.59)	0.16
100%	0.42 ± 0.12 (0.39-0.46)	0.30 ± 0.04 (0.28-0.31)*	1.34	-	-	-
Measured 1RM	0.16 ± 0.05 (0.14-0.18)	0.30 ± 0.04 (0.28-0.31)*	3.09	-	-	-

Values are mean ± SD (95% confidence interval); * = significantly different from our study ($p < 0.001$); ES = Cohen's d effect size

Discussion

This study's main findings were the different load-velocity relationships and the similar measured V1RM found between untrained men and women, besides the different load-velocity relationships between untrained men of our study and trained men in previous studies. This finding suggests that the load-velocity relationship is sex- and training level-dependent. Higher velocities with the same %1RM were found for men compared with women during the BS. Untrained and trained individuals showed different load-velocity profiles. As the measured V1RM was different from the estimated V1RM through the two-point method with 20% and 70%1RM, this result might suggest that the two-point load method applied separately does not predict the V1RM accurately for the BS. These results provide novel information for strength and conditioning professionals that use the velocity-based resistance training approach.

Assessing the first aim of this study, we observed that men attained higher velocities than women with a large and very large difference until 80%1RM. However, when getting closer to the 1RM load, the differences were small and moderate. When we look at the measured velocities, men attained higher velocities than women at submaximal loads (20 and 70%1RM), but at the maximal load (1RM), the velocities attained between sexes were similar. Previous studies [7,14] also have found this pattern in upper-body pushing resistance exercises like the bench press and military press. In contrast, Torrejón *et al.* [18] verified different measured V1RM between trained men and women. However, it was observed in all studies cited above a steeper load-velocity relationship for men when compared with women. This study verified the same finding with the BS exercise (Table I). Therefore, this suggests that the load-velocity relationship is also sex-specific, even for the BS.

Interestingly, the previous studies cited above assessed the load-velocity relationship in trained men and women through the multiple-load method. Knowing that the distance between the loads is more important than the number of loads to determine the load-velocity relationship accurately [20]. This study used the two-load method, and a similar pattern was observed in the load-velocity relationship of untrained men and women for a lower-body resistance exercise. To our knowledge, this is the first study that used the two-load method separately. With this method, the goodness of fit cannot be verified, as only two points are used. However, this still provides valid information due to the many studies showing the load-velocity relationship is linear.

Regarding the second aim of this study, Martínez-Cava *et al.* [10] only verified the MPV, whereas Spitz *et al.* [30] only analyzed MV and peak velocity. In this way, untrained men showed a different load-velocity relationship than trained men. Interestingly, when we compared our results with the Martínez-Cava *et al.* [10] study, the individuals of both studies pursued very similar anthropometric and strength values, with small differences. Furthermore, the MPV of a % 1RM in untrained men was 10%1RM higher than trained men (Table III). Trained men showed a deficit of ~0.10 m.s-1 when compared with their untrained counterparts. However, we observed a higher interindividual variability in this study. These findings can be explained by the neuromuscular differences between untrained and trained individuals. Untrained have a limited ability to recruit motor units, especially fast-twitch motor units maximally. They are unable to activate all available muscle fibers successfully. Research has shown that only 71% of muscle tissue is activated during maximal efforts in this population [31,32]. This result can cause a higher interindividual variability in untrained individuals and the difference between populations analyzed.

Spitz *et al.* [30] analyzed only four %1RM. When we compared the male athletes of their study, we observed moderate, large, and very large differences in the anthropometric and strength values. We found a large and very large difference for the MV attained at 30, 50, and 70%1RM between studies samples. However, a trivial difference of the MV at 90%1RM was found. This result was not found in the Martínez-Cava *et al.* [10] study. However, Spitz *et al.* [30] used only four loads in the multiple-load method, while Martínez-Cava *et al.* [10] used, on average, double loads (8.8 ± 1.7 loads). This result suggests that the number of loads influences the velocity output with the fatigue accumulated through several loads being tested. Future studies should analyze the two-point method separately from multiple loads to further elucidate its accuracy in determining the load-velocity relationship.

Regarding the third aim of this study, we implemented the two-load method to assess if the fatigue accumulated through multiple loads being tested influences the V1RM estimation. To assess if the two-point method could predict the V1RM with accuracy, we compared the measured V1RM with the predicted V1RM. We found a very large difference between these velocities suggesting that the two-load method applied separately with 20% and 70% 1RM does not predict the V1RM accurately. We chose these relative loads, as two distant pairs of loads should be applied to maximize the two-point method's reliability and validity [21]. Beyond, it was observed a higher validity and similar reliability than the multiple-load method [21]. Therefore, the present study's result suggests that the movement velocity output is method-dependent, which might suffer the influence of the accumulated fatigue with multiple-loads tested.

This finding strengthens the need that future studies should analyze the two--point method separately from multiple loads to elucidate its accuracy for load-velocity relationship estimation and 1RM load prediction. Future studies should also investigate the best relative loads used during the two-point load method to estimate the load-velocity relationship with a high degree of accuracy.

Conclusion

In conclusion, untrained men pursue a steeper load-velocity relationship compared to untrained women, and the load-velocity relationship is different between trained and untrained males in the BS. Besides that, the movement velocity output is dependent on the method used to estimate the load-velocity relationship in untrained individuals, as the two-point method with 20% and 70% 1RM applied separated from the multiple-load does not estimate the V1RM accurately in the BS. Thus, the load-velocity relationship is dependent on sex, training background, and method estimation, suggesting that researchers and strength and conditioning professionals should take care when estimating the load-velocity relationship and implementing the velocity-based resistance training approach in untrained men and women using the BS.

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Author contributions
Conception and design of the research: de-Oliveira LA. **Data collection:** de-Oliveira LA. **Data analysis and interpretation:** de-Oliveira LA, Martín-Rivera F, Da-Silva Grigoletto ME. **Statistical analysis:** de-Oliveira LA. **Obtaining financing:** N/A. **Writing of the manuscript:** de-Oliveira LA. **Critical review of the manuscript regarding important intellectual content:** Martín-Rivera F, Da-Silva Grigoletto ME.

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