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Sex differences in rating of perceived exertion in different body-weight resistance exercises

For correspondence:
rod.ferrari84@gmail.com

Vinícius Mallmann Schneider[1,2] , Renato Maynart[1,4], Leandro de Oliveira Carpes[1,2], Jocelito B. Martins[4] , Rodrigo Ferrari[1,2,3]

[1]Sports and Exercise Training Study Group, Hospital de Clínicas de Porto Alegre, RS, Brazil

[2]Postgraduate Program in Cardiology, School of Medicine, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

[3]School of Physical Education, Physiotherapy and Dance, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil

[4]Faculdade Sogipa de Educação Fisica, Porto Alegre, RS, Brazil

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ABSTRACT

Aims: This study analyzed and compared the the rating perceived exertion (RPE) of upper and lower body weight resistance exercises (BWR) performed by men and women. Methods: Forty-eight participants (24 men and 24 women) attended two experimental sessions: an introduction to the BWR and RPE scale and an assessment session to determine the RPE of each exercise. Four dynamic BWR (Lower-limb: Squat and Lunge; Upper-limb: Knee Push-Up and Push-Up) and two isometric BWR (Core: Front and Side Plank) were evaluated. Each exercise's RPE was

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Authors X @*xtwitter* and Y @*ytwitter* can be reached on Twitter.

evaluated using a Borg CR10 scale. Results: Push-up exercises have the highest RPE value (4 men, 10 women) and squat exercise the lowest RPE value (1 men, 2 women). Comparing the RPE's between men and women, there was a significant difference in the upper-limb exercises (Men: 4; Women: 10; P <0.001). There was no difference in lower-limb (Men: 3; Women: 3; P= 0.991) and core exercises (Men: 3; Women: 3; P= 0.856). Women demonstrated a higher RPE's than men for the upper-limb exercises, but did not show for higher RPE's in lower-limb and core BWR. Conclusion: The study provides new evidence for the use of RPE in BWR interventions and suggests that exercise professionals should consider that RPE during BWR is influenced by exercise, sex, and training status.

INTRODUCTION

Physical activity recommendations could be more prominent, particularly among older populations and women (Garcia-Hermoso et al., 2023). The negative effects of the COVID-19 pandemic caused by SARS-Co infectious diseases have further reduced compliance with these recommendations (Park and others, 2022). Exercise and outdoor physical activity are chosen to maintain fitness and reduce the inactivity of the COVID-19 pandemic caused by social isolation (Kaur et al., 2020; Abdelbasset, 2020). Body weight resistance exercises (BWRs) are becoming increasingly popular alternatives to resistance training because they are easy to do in different places, such as sports facilities, public places, and even homes (Harrison, 2010). BWR can improve skeletal muscle mass, strength, function, and other health outcomes when properly prescribed (Martins et al., 2018).

The intensity prescription during resistance training is essential since the best improvements in maximum strength, power, and local muscular endurance can be achieved when different percentages of maximum strength (i.e., one repetitions maximum test - 1RM) are used for each objective (Suchomel et al., 2021). However, determining the relative intensity of different BWR exercises and, in turn, an individualized BWR prescription is still a challenge. Rating of perceived exertion scales (RPE) can be used to define the exercise intensity of BWR, providing an easily accessible way to prescribe and monitor the resistance training (Lea et al., 2022; Chen et al., 2002). Due to the minimal time to test, and the capacity to evaluate individuals of different sexes, ages, and physical fitness levels (Bjarnason-Wehrens et al., 2004; Buckley and Borg, 2011), RPE can be a valid tool to monitor the exercise intensity during BWR.

Sex differences may influence the RPE after different BWR. Women seem to produce lower peak torque but have a higher fatigue tolerance when compared to men of similar training

status (Gentil et al., 2017; Laurent et al., 2010). Women also demonstrated a more significant strength loss after eccentric exercise but a faster muscle recovery than men (Sayers and Clarkson, 2001). Still, women experienced greater muscle perfusion, less peripheral fatigue, and a longer time to task failure than men during the low-force fatiguing contraction (Laurent et al., 2010). To our knowledge, no studies have compared the RPE of BWR in men and women. Therefore, the purpose of the present study was to evaluate the RPE of different BWR and to compare the RPE of men and women.

METHOD

Study Design

This cross-sectional, quantitative, and descriptive study assessed the RPE after different BWR in men and women. The study was conducted from December 2020 to November 2021. This project was submitted and approved by the Research Ethics Council of the Hospital Mãe de Deus/Associação Educadora São Carlos, Brazil (number 36115720.1.0000.5328). The study protocol was conducted according to the principles of the Declaration of Helsinki. This manuscript was written following the recommendations in the STROBE document (Vandenbroucke et al., 2007).

2.2 Participants

Forty-eight participants (24 men and 24 women) between the ages of 20 and 69 years took part in this study and were selected in a non-random (convenience) manner. Individuals who presented with pulmonary disease, heart disease, renal failure, or joint, bone, or muscle injuries in the three months before this study were excluded. The participants were classified according to the level of regular physical activity: the ones who engaged in physical exercises up to one time per week (physically inactive) and the ones who were physically active at least two times per week (physically active).

Participants were first contacted through phone calls, text messages, or social networks. All study procedures were explained, and the informed consent form was signed upon agreement. Due to the COVID-19 pandemic caused by Sars-Cov-2, the researchers performed the entire study remotely, including evaluations of RPE and the questionnaires. The procedures were conducted through online forms using the Google platform and video calls using Google Meet, Zoom, or Whatsapp media. The participants had their copy of the informed consent form made available for completion through the online form. The researcher clarified any doubt about

procedures via online descriptions or video calls before the beginning of the experimental sessions.

2.3 Experimental procedures

Initially, an anamnesis was performed to identify possible musculoskeletal injuries, cardiovascular diseases or any other exclusion criteria, and a physical activity readiness questionnaire (Par-Q+) was conducted (Schwartz et al., 2021). Each participant attended two sessions, with a minimum interval of 48 hours between them: a familiarization with the BWR and RPE scale, and an assessment session to determine the RPE of each exercise. Participants were instructed not to perform any physical exercise 24 hours before the experimental sessions, to maintain sleep patterns, and not to consume caffeine or other stimulant substances 12 hours before the session.

The familiarization session introduced the use of the RPE scale and the BWR to minimize potential bias related to the use of RPE scales or the correct technique of BWR. A previous demonstration of the proposed movements and eventual feedback on the proper executions were made available. The following BWR were performed: Squat, Knee Push-Up, Plank, Lunge, Push-Up, and Forearm Side Plank (Figure 1). The CR-10 Borg scale was presented to the participants, and they were instructed to rate the effort of the movements (0: rest; 1: very very easy; 2: easy; 3: moderate; 4: somewhat hard; 5: hard; 7: very hard; 10: Maximal) to obtain anchoring and adjustment of their perceived exertion (Foster et al., 2001). The RPE requested was local, explicitly targeting the joint and muscles involved in each exercise and not the overall fatigue.

In the second session, the RPE during the BWR was evaluated as follows: two repetitions of Squat and Knee Push-Up were performed as a warm-up, with a one-minute interval between them. After that, up to 5 repetitions of each of the four dynamic exercises (Squat, Knee Push-Up, Lunge, and Push-Up) were performed. For the isometric exercises (Front Plank and Forearm Side Plank), the participants sustained the positions requested for 10 seconds. A two-minute interval was adopted between the exercises. Visual feedback for the isometric exercises and some accessories, such as a chair (regular, without wheels) for the squat exercise, was used to delimit the range of motion of dynamic exercises. The participants were instructed to perform the exercises at a volitional speed, always in front of the camera, as familiarized in the first session. The RPE was collected immediately after each exercise and was used to define the BWR intensities. The exercises were performed following the same order (Squat, Knee Push-Up, Lunge, Push-Up, Front Plank and Forearm Side plank) to minimize residual fatigue from the previous movement.

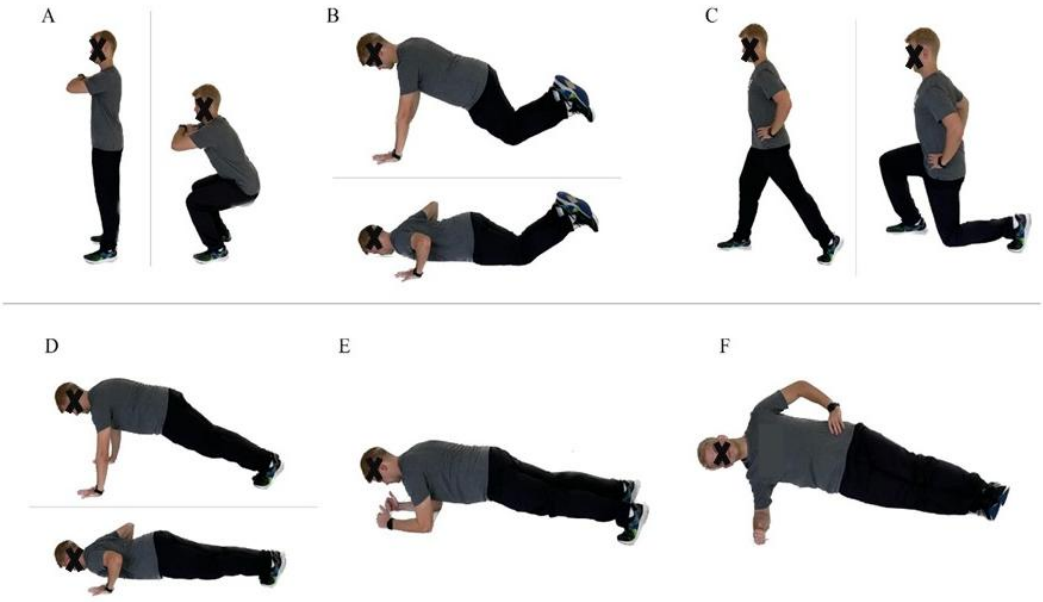

Figure 1. Body-weight resistance exercises assessed during the study a) Squat; b) Bent-Knee Push-up; c) Lunge; d) Push-Up; e) Plank; f) Forearm Side Plank.

2.4 Statistical analysis

Descriptive statistics were used to analyze the data collected using the Shapiro-Wilk and Levene tests for data normality and homogeneity of variances, respectively. The results were expressed as mean and standard deviation for parametric and median data and interquartile interval for non-parametric data. Considering the analyses comparing men and women, the independent T-test was used for age and anthropometric measurements. The chi-square test was utilized for the dichotomous variables (cardiometabolic risk factors and levels of physical activity). The Mann-Whitney test was used for the RPE analyses, considering that this variable presented nonparametric data. The significance index adopted in this study was $P < 0.05$. All statistical tests were performed in the SPSS 22.0 software.

Results

Initially, 57 participants were accessed according to the eligibility criteria; nine were excluded due to lack of time to perform the study sessions. In total, 48 participants (Men: 24; Women: 24) completed the two experimental sessions. During the intervention, there were no

dropouts or injuries of any nature, musculoskeletal discomfort, or malaise. The general characteristics of the participants are presented in table 1. Overall, men were taller and had greater body mass than women (P < 0.001). Nevertheless, no sex-related differences were found when co

Table 1. Characteristics of the participants

	Men (n=24)	Women (n=24)	*P* value
Age, years (SD)	37 (13)	40 (11)	0.421
Anthropometric measurements (SD)			
Body mass, kg	83 (13)	69 (12)	<0.001*
Height, cm	177 (17)	163 (14)	<0.001*
BMI, kg/m²	27 (4)	26 (3)	0.250
Cardiometabolic risk factor, n (%)			
Smoking	1 (4)	3 (13)	0.296
Hypertension	1 (4)	5 (21)	0.081
Overweight	12 (50)	15 (63)	0.383
Hyperglycemia	0 (0)	3 (13)	0.074
Use of medication	6 (25)	9 (38)	0.350
Physical Activity Levels, n (%)			
Physically Inactive	9 (38)	8 (33)	0.763
Physically Active	15 (62)	16 (67)	0.763

Values are median (standard deviation); BMI = body mass index; *$P < 0.05$.

Table 2 shows the results of RPE after the BWR. Women presented higher RPE than men when performing upper-limb exercises (Push-up with and without knee support; P < 0.001 / P = 0.021). However, after the lower-limb and core exercises, no significant differences were found between men and women (P > 0.05).

Table 2. Overall rating of perceived exertion of different body-weight resistance exercises.

Exercises	RPE Men (n=24)	RPE Women (n=24)	*P* value
Push-up	4 (3 - 6) (Moderate)	10 (5 - 10) (Extremely strong)	<0.01*
Knee Push-up	2 (1 - 3) (Weak)	3 (2 - 5) (Moderate)	0.02*
Squat	1 (1 - 2) (Very weak)	2 (1 - 2) (Weak)	0.430
Lunge Right	3 (2 - 4) (Moderate)	3 (2 - 3) (Moderate)	0.991
Lunge Left	3 (2 - 4) (Moderate)	3 (2 - 3) (Moderate)	0.692
Plank	3 (2 - 4) (Moderate)	3 (2 - 5) (Moderate)	0.856
Forearm Side Right Plank	4 (3 - 5) (Moderate)	4 (3 - 5) (Moderate)	0.562
Forearm Side Left Plank	4 (3 - 6) (Moderate)	4 (3 - 7) (Moderate)	0.445

Values are in median (interquartile range); RPE: Rating of perceived exertion; *Difference between men and women (P < 0.05).

Table 3 shows the RPE comparisons between physically active and inactive participants of both sexes. There was no difference between physically active versus inactive men for the upper limb, lower limb, and core exercises. In women, differences were found after the Left Forearm Side Plank (P < 0.01) and the Right Forearm Side Plank (P = 0.052) exercises. In physically active participants, comparison between sexes demonstrated differences in RPE of upper-limb exercises (Push-Up: P < 0.01; and Knee Push-Up: P = 0.02). In physically inactive participants, the only difference between men and women was found after the Push-Up exercise (P < 0.01).

Table 3. Rating of perceived exertion of different body-weight resistance exercises in physically active and inactive men and women.

Exercises	Active RPE	Inactive RPE	*P* value	*P* sex value	
				Active	Inactive
Push-up					
Men	4 (2 - 6) (Moderate)	5 (3 - 6) (Strong)	0.318	**<0.01#**	**<0.01#**
Women	7 (5 - 10) (Very strong)	10 (10 - 10) (Extremely strong)	0.192		
Bent-Knee Push-up					
Men	2 (1 - 3) (Weak)	2 (2 - 3) (Weak)	0.482	**0.02#**	0.541
Women	3 (3 - 4) (Moderate)	4 (2 - 6) (Moderate)	0.928		
Free Squat					
Men	1 (1 - 2) (Very weak)	2 (1 - 2) (Weak)	0.155	0.188	0.743
Women	2 (1 - 2) (Weak)	2 (1 - 3) (Weak)	1.000		

Lunge Right					
Men	2 (2 - 4) (Weak)	3 (2 - 3) (Moderate)	0.558	0.922	1.000
Women	2 (2 - 3) (Weak)	3 (2 - 4) (Moderate)	0.350		
Lunge Left					
Men	2 (1 - 4) (Weak)	3 (2 - 4) (Moderate)	0.290	0.545	0.888
Women	2 (2 - 3) (Weak)	3 (2 - 4) (Moderate)	0.350		
Plank					
Men	3 (2 - 5) (Moderate)	3 (3 - 4) (Moderate)	0.953	0.953	0.743
Women	3 (3 - 3) (Moderate)	3 (2 - 7) (Moderate)	0.697		
Right Forearm Side Plank					
Men	4 (3 - 5) (Moderate)	4 (3 - 5) (Moderate)	0.411	0.922	0.277
Women	3 (3 - 5) (Moderate)	5 (4 - 9) (Strong)	0.052		
Left Forearm Side Plank					
Men	4 (3 - 5) (Moderate)	5 (3 - 6) (Strong)	0.379	0.984	0.930
Women	3 (3 - 5) (Moderate)	7 (5 - 10) (Very strong)	<0.01*		

Values are in median (interquartile range); RPE: Rating of perceived exertion; *Difference between active women *vs.* inactive women ($P < 0.05$); #Difference between active men *vs.* active women or inactive men *vs*. inactive women ($P < 0.05$).

Discussion

The main finding of this study is that the RPE after upper limb BWR is lower in men than in women, but a similar RPE was found for lower limb and core exercises. In addition, we observed sex differences in RPE according to training status only for the upper limb exercises. Taken together, these findings underscore the importance of the principle of individualization in the use of RPE, which requires distinctions between sex, training status, and exercise performed in order to correctly prescribe the relative intensity of RPE.

To our knowledge, this is the first study to evaluate RPE in the push-up exercise in men and women with different levels of training. A previous study suggests that the mean difference in upper limb strength between men and women ranges from 75% to 116%, with men having greater upper body strength than women (Bishop et al., 1987). In previous studies, strength performance and EPR after the bench press, an exercise with similar characteristics to the push-up, did not appear to differ between the sexes (Flanagan et al., 2014). In the present study, our results for RPE after the push-up are different between the sexes, and we speculated that the differences between men and women may be related to the total muscle mass involved in the push-up exercise. Something that consequently has a direct impact on the relative load of the exercise, causing women to perform the push-up exercise close to maximal, while men perform at a submaximal load.

Regarding lower-limb and core BWR, our findings showed no differences in the RPE between men and women following Squat, Lunge, Plank, and Forearm Side Plank exercises. In accordance with our findings, previous studies also suggest minimal or no sex differences for lower limb and core strength/RPE (Eston and Evans, 2009), including the concentric, eccentric, and isometric contractions (Pincivero et al., 2002; Pincivero et al., 2010; Pincivero et al., 2000), and dynamic resistance exercises. It seems that we can assume a similar RPE for lower limb and core exercises when prescribing BWR for gym classes with men and women.

Regarding the influence of training status on RPE after BWR, we observed different RPE after BWR of the upper limbs when comparing women and men with the same training status, with higher RPE in women than in men. Furthermore, training status did not influence RPE values in the same sex. A limited number of studies have compared the difference in RPE between the sexes with different levels of resistance training (Lea et al., 2022). It has been suggested that novice athletes may be less accurate in representing actual training load at low relative training volumes, resulting in lower EPR values than well-trained participants, and that trained individuals may be able to produce higher relative forces at set RPE levels than novices (Lea et al., 2022;

Cavarretta et al., 2022). There are no clear differences in RPE ratings caused by level of training and experience, however, as noted above, it is possible that the females performed the upper limb exercises in this study at higher relative loads than the males, which may also help explain the differences between males and females for the same training condition.

This study has limitations, including the COVID-19 pandemic that imposed social isolation, allowing only online assessment during the study period. Another potential limitation is the insufficient sample size to stratify the analysis by age, as the literature presents age-determinant results regarding RPE (Lea et al., 2022). However, our study has several strengths that are worth highlighting. Despite the limitations imposed by the COVID-19 pandemic and social isolation, we used all available tools. We implemented protocols that contributed to the participants' understanding of the information we sought to convey. Some strengths of the methodology developed in our study include the use of explanatory videos about the CR-10 scale, a previous familiarization session, the careful selection of the order of the exercises, and the standardization of execution during the sessions. These approaches helped us to obtain reliable RPE results.

Conclusion and Practical applications

In summary, women demonstrated a higher RPE than men for the upper-limb exercises but not for lower-limb and core BWR. Furthermore, the participants' training status may influence the RPE of some BWR but not all. Our findings hold practical applicability for exercise professionals. BWR offers an accessible and versatile form of resistance training as it can be performed anywhere and anytime but is limited since the resistance load is restricted to the individual's body weight. Considering that the RPE during BWR is influenced by the exercise, sex, and training status of participants, it is necessary to manipulate other exercise characteristics such as the base of support (e.g., using one versus two legs), the range of motion or the velocity of each repetition to achieve the desired relative intensity during this type of resistance training.

Contributions

Contributed to conception and design: RM, RF
Contributed to acquisition of data: RM
Contributed to analysis and interpretation of data: VMS, LOC
Drafted and/or revised the article: VMS, RF, JBM
Approved the submitted version for publication: VMS, RM, LOC, JBM

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