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original article

Comparison of the perceived subjective exertion and total load lifted response in resistance exercises performed on stable and unstable platforms

Comparação da resposta da percepção subjetiva do esforço e da carga total levantada nos exercícios resistidos em plataforma estável e instável

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Abstract – This study aimed to compare the perceived subjective exertion (PSE) and total load lifted in resistance exercises performed on stable platforms (SP) and unstable platforms (UP). Participants were 20 men (24.6 ± 3.4 years, 179 ± 0.1 cm, 80.6 ± 9.1 kg and 11.8 ± 3.4% fat). Each subject performed a 15 maximum repetition test in half squat exercises (soil and balance discs), pronated barbell row (soil and bosu) and biceps curl (soil and balance discs) in both conditions. PSE was measured using the OMNI-RES scale and the load lifted value (kg). To verify the normality of data, the Shapiro-Wilk test was used. Possible differences related to loads and PSE on the platforms were performed by the paired t test. Significance level of p <0.05 was adopted. No significant differences between PSE values on SP and UP were respectively observed in the half squat (8.2 and 8.5 / p = 0.8), pronated barbell row (8.4 and 8.4 / p = 0.7) and biceps curl (8.6 and 8.7 / p = 1.0). Higher load values on SP and UP were respectively found in half squat (83.9kg and 70.3kg / p <0.001) and pronated barbell row exercises (53.2kg and 48.6kg / p = 0.01) on SP. However, biceps curl showed dissimilar behavior (48.2kg and 47.4kg / p = 0.5). It was concluded that UP does not promote differences in PSE responses even working with smaller load or similar load.

Key words: Instability; Perceived exertion; Resistance strength.

Resumo – *Objetivou-se comparar a percepção subjetiva do esforço (PSE) e a carga total levantada nos exercícios resistidos em plataformas estáveis (PE) e plataformas instáveis (PI). Participaram do estudo 20 homens (24,6 ± 3,4 anos, 179 ± 0,1 cm, 80,6 ± 9,1 Kg e 11,8 ± 3,4 % de gordura). Cada voluntário realizou um teste de 15 repetições máximas nos exercícios meio agachamento (solo e discos de equilíbrio), remada curvada pronada (solo e bosu) e rosca bíceps (solo e discos de equilíbrio) em ambas as condições. Foram medidas a PSE através da escala de OMNI-RES e o valor da carga levantada (kg). Para verificar a normalidade dos dados, utilizou-se o teste Shapiro-Wilk. As possíveis diferenças relacionadas às cargas e à PSE nas plataformas foram realizadas pelo teste t pareado. Adotou-se um nível de significância de p<0,05. Não foram encontradas diferenças significativas entre os valores da PSE em PE e PI respectivamente, no meio agachamento (8,2 e 8,5 / p=0,8), remada curvada pronada (8,4 e 8,4 / p=0,7) e rosca bíceps (8,6 e 8,7 / p=1,0). Foram encontrados maiores valores de carga em PE e PI respectivamente, nos exercícios de meio agachamento (83,9kg e 70,3kg / p<0,001) e remada curvada pronada (53,2kg e 48,6kg / p=0,01) na PE. Em contrapartida, para a rosca bíceps não ocorreu o mesmo (48,2kg e 47,4kg / p=0,5). É possível concluir que as PI não promovem diferenças nas respostas da PSE mesmo sendo trabalhadas com uma menor carga ou com uma carga semelhante.*

Palavras-chave: *Esforço percebido; Instabilidade; Força de resistência.*

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INTRODUCTION

Artifacts that can cause instability have been commonly added to resistance training protocols (RT) aiming to improve muscular balance and joint stability[1]. RT on UP is widely used in rehabilitation and neuromuscular fitness. UP is used to produce body oscillations and trigger a rapid motor response, improving muscle reactivity and neuromuscular recruitment pattern[2,3]. Thus, training on UP promotes disorders in the sensory system, causing involuntary dynamic motor reactive responses to generate neuromuscular control in a given joint[3].

For these objectives to be achieved, implements as Swiss balls, Dyna disc, BOSU and balance cone[4-7] are used in different exercises. Considering that in many everyday activities, as well as in sports, no muscle operates in isolation[6], the importance of using instability in some period of training becomes increasingly evident due to both preventive[5] and rehabilitative[8-10] benefits.

For the monitoring and control of intensity during resistance exercise, perceived subjective exertion (PSE) has great support from the scientific community, specially due to its close relationship with key physiological stress markers during exercise such as electromyographic activity and blood lactate[11,13].

Marshall and Murphy[14] found higher PSE in push-up and double leg hold exercises, both on the Swiss ball compared to stable surfaces. In this sense and taking into account that changes in the surfaces of exercises are susceptible to changes in motor pattern by increasing the participation of stabilizing muscles and core during the performance of movements[5,7,15], we believe that they might be able to change the nature of physiological responses, thus affecting perceived exertion.

Another peculiarity of exercises performed on unstable surfaces is related to a probable loss of ability to generate force compared to stable surfaces, which is elucidated in several experiments[7,8,16]. Paradoxically, Goodman et al.[17] reported no differences between surfaces, showing that these changes appear to be dependent on the type of exercise used, the muscles involved in these movements and the devices used to generate instability.

Thus, based on the above, further studies should be carried out to investigate the application of unstable bases in RT in order to verify the existence of probable differences in PSE responses and on the load values in different exercises and platforms. Thus, the aim of this study was to compare the perceived subjective exertion and total load lifted in resistance training in stable and unstable platforms. The initial hypothesis of the study is that instability could lead to lower load lifted values; however, it could lead to higher PES response due to the increased degree of difficulty in performing the exercise.

METHODOLOGICAL PROCEDURES

Sample

The study included 20 male subjects (24.6 ± 3.4 years, 179 ± 0.1 cm, 80.6 ± 9.1 kg, 11.8 ± 3.4% fat) with previous experience in resistance training

(6.2 ± 4.6 years). The sample was selected in a non-probabilistic manner, in which volunteers that met the inclusion and exclusion criteria were selected. Subjects who met the following criteria were included in the study: (a) males aged 19-30 years, (b) not having suffered any kind of musculoskeletal injury in the upper or lower limbs in the last six months, (c) negatively responding to all items in the Physical Activity Readiness Questionnaire / PAR-Q[18], (d) be familiar for more than twelve months with RT (regular physical activity> three times a week). The following individuals sample were excluded who: (a) those making use of medications, alcohol and / or tobacco, (b) those reporting musculoskeletal disease and / or injury, (c) those with previous experience in RT on unstable platforms. The research project was approved by protocol No. 204 521/2013 of the Ethics Committee of Research with Human Beings of the Federal University of Juiz de Fora. All subjects signed the Informed Consent Form according to Resolution 196/96 of the National Health Council.

Experimental design

In the 1st session, subjects were informed about the study purposes and procedures to which they would be submitted. They were instructed not to perform physical activities 48 hours before the day of tests on the platforms and to feed at least 2 hours before the test and hydrate. Subjects signed the Informed Consent Form and then completed two questionnaires whose application aimed to evaluate the inclusion or exclusion of individuals in the sample: the PAR-Q; and an anamnesis. After the measurement of anthropometric variables, individuals underwent a series of familiarization on UPs, performing 2-3 sets of 15 repetitions at approximately 60% of maximum perceived effort to be guided on motor coordination and movement pace. Also, they were clarified on the PSE definition through the OMNI-RES scale[19]. In the 2nd, 3rd, 4th and 5th sessions, subjects underwent strength 15MR tests and retests with an interval of 48 hours between days on both platforms randomly.

Collection of total load lifted for 15MR

Strength tests were applied in the following order: half free squat, pronated row and elbow flexion. The procedures were: a) warm up with 15 repetitions at 40-60% maximum perceived load for 15 MR; b) after one minute of rest, subjects performed five repetitions at 60-80% maximum perceived load for 15 MR; c) after one minute of rest, the load test took place, in which each individual performed a maximum of three attempts for each exercise with a five minute interval between attempts; d) when the participant could no longer perform the movement correctly, the test was stopped, being recorded as maximum total load lifted (MTLL) for 15 repetitions that obtained in the last full execution of the concentric muscular failure[20]. As in the performance of exercises in general, data collection used a motion amplitude limiter to determine the initial and final positions of each exercise. Intervals between attempts in each exercise during the 15MR test were determined between three and five minutes. After obtaining the load for the first exercise, a 10 minute interval was adopted before going on to the next exercise.

In order to reduce the margin of error in the MTLL test for 15 MR, the following strategies were adopted: a) familiarization before test, informing the participant about the data collection procedures; b) instructions on the execution techniques and speed (EMT-888 Tuner® metronome, with one second in the concentric phase and 2 seconds in the eccentric phase or 40 bpm = 20 repetitions per minute) of exercises; c) use of verbal encouragement; d) use of weights previously calibrated in precision scale. The retest application aimed to assess the load reliability. The greatest weight obtained on both days (test and retest) with difference lower than 5% was considered.

Collection of perceived subjective exertion

To assess perceived subjective exertion, individuals had to select a number in the OMNI-RES scale that represented the effort of the exercised muscles (peripheral fatigue) immediately after MTLL strength test for 15MR, since its anchoring was not performed. The PSE used in the search results was that obtained for the 15 MR test with the highest load lifted value.

Description of exercises

- Half Squat (free bar)

The volunteer is in the standing position facing the bar support of the "Righetto Fitness Equipment®, squat cage, São Paulo, Brazil" apparatus with bar resting on the shoulders, feet parallel spaced at the same distance from the shoulders and hands fixed on the bar. Lower limbs were flexed simultaneously up to reaching an angle of 90° between thigh and floor, (amplitude limiter) and returning to the starting position in a controlled manner. This exercise on UP was performed on two balance discs "Pretorian®, Balance Cushion, São Paulo, Brazil" one under each foot as identified in the figure below.

Figure 1: Exercises performed. A = Half squat exercise (free bar); B = Pronated barbell row exercise (free bar); C = Elbow flexion exercise (biceps curl)

The volunteer grabbed the bar with spacing equal to the shoulder width and with backs of the hands facing up, lean the torso forward at an angle of

45° with the floor. The volunteer pulled the bar vertically until it touches the bottom of the chest, keeping the vertebral spine straight and knees slightly bent. The volunteer returned the bar to the starting position up to complete elbow extension. This exercise on UP was held at "Bosu®, Sport Balance Trainer - 55cm, San Diego, USA" being inflated up to 25 cm of height to carry out all tests according to manufacturer identified in the figure below.

With feet facing the "Righetto Fitness Equipment®, Cross Over, São Paulo, Brazil" apparatus and maintaining the lateral spacing of shoulder width, the volunteer was positioned, having the elbow joint, both segments, near the side of the body and hands in supination to grab the bar, performing full elbow flexion movement, with subsequent return in a controlled manner to the initial position. This exercise on UP was performed on two balance discs from Pretorian®, Balance Cushion, São Paulo, Brazil identified in the figure below.

Statistical analysis

Based on a pilot study carried out by our group (n = 4) and on available literature, calculation was performed to determine the appropriate sample size. To achieve 80% statistical power, it was calculated that a sample of 20 subjects would be required to detect a difference of 5 kg in the half squat MTLL among groups (Granmo 5.2, IMIM, Barcelona, Spain). Data were submitted to descriptive analysis using mean and standard deviation. To verify normal distribution of all variables, the Shapiro-Wilk test was used. Possible differences related to loads and PSE on the different platforms were assessed using the paired t test. For data analysis, the SPSS software (version 17.0) was used. The level of significance was set at $p < 0.05$.

RESULTS

No significant differences were found among PSE OMNI-RES values in half squat exercises ($p = 0.8$), barbell row ($p = 0.7$) and biceps curl ($p = 1.0$), comparing stable and unstable platforms, as illustrated in Figure 2.

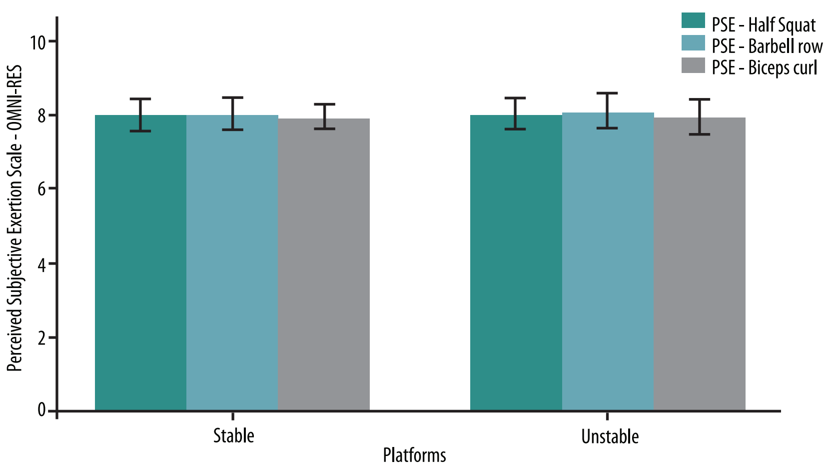

Figure 2 - Graphical representation of mean and confidence interval (95%) of the Perceived Subjective Exertion Scale - OMNI-RES values in half squat, barbell row and biceps curl exercises on stable and unstable platforms.

When comparing the MTLL values (Kg) on stable and unstable platforms, significant differences were found in half squat ($p < 0.001$) and barbell row exercises ($p = 0.0$). In contrast, for the biceps curl exercise, significant differences were found ($p = 0.5$) as shown in Figure 3.

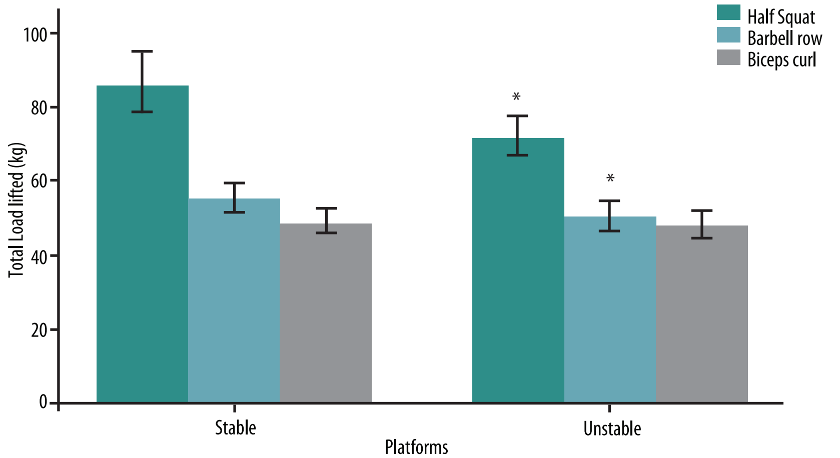

Figure 3 - Graphical representation of the mean and confidence interval (95%) for load values (kg) in half squat, barbell row and biceps curl exercises in stable and unstable platforms. * Significant difference in relation to the stable surface condition ($p \leq 0.05$).

DISCUSSION

The aim of this study was to compare the response of perceived subjective exertion and total load lifted in resistance exercises performed on stable and unstable surfaces. The main findings of this study show that for half squat and barbell row exercises, the use of UP caused lower load raised values compared to SP, confirming the initial hypothesis of this study that movement instability promotes a decrease in strength produced. However, in biceps curl exercise, significant differences were found in MTLL values. Regarding PSE, no significant differences were observed between SP and UP, which results are contradictory to the hypothesis of this study.

The lower load lifted in half squat and barbell row exercises on UP would be related to the effect of instability on force production, since UP can promote greater challenge to the neuromuscular system when compared to SP[2].

Previous studies have found a decrease of the dynamic force production in bench press exercise on UP compared to SP[7,8,16]. Behm et al.[21] also found loss of isometric strength of quadriceps and plantar flexors compared to SP. According to Marinkovic et al.[22], differences in maximal strength of 1MR in bench press (Swiss ball and bench) and half squat exercises (bosu and soil) after eight weeks of training (50% of 1MR) are no longer effective to improve maximum muscle strength of inexperienced individuals, as compared to exercises performed on SP, although 1MR strength increased in both conditions.

The biceps curl exercise did not show significant differences in strength parameters between platforms, which is in agreement with findings of Goodman et al.[17] and Melo et al.[23], but in other resistance exercises. These authors also reported that the nature of these responses can be altered by factors such as type of exercise and muscle groups involved in the performance of these movements. Additionally, it could be inferred that although UP imposes an imbalance situation, which is likely to culminate in smaller MTLL values, this response has become attenuated due to the fact that we used the biceps curl exercise on the cable, which has a crucial role on movement stability[24,25]. Such factors could be determinant for similarities found in the MTLL values.

Corroborating these findings, Panza et al.[26] also found no significant differences in the number of maximum repetitions performed in bench press (Swiss ball and bench), but with the use of the free bar with load at 80% of 1MR and strength test applied only on SP.

Regarding PSE, few studies were found in literature with SP, and among them the study by Marshall and Murphy[27] stand out, which included 14 trained volunteers. They performed bench press exercise at 60% of 1MR on UP (Swiss ball) and on SP (right bench). PSE was checked after each series using the Borg scale and, in conclusion, the authors found perceived exertion significantly greater in exercise performed on UP. In another study, these authors found greater PSE in push-up and double leg hold exercises, both in the Swiss ball, compared to stable surfaces [28]. It is noteworthy that unlike the present study, other resistance exercises were analyzed and the Borg scale for PSE collection was used.

Panza et al.[26] compared PSE in horizontal bench press and Swiss ball in 10 trained men. Only one series at 80% of 1MR up to muscle fatigue was performed and the OMNI-RES scale was used. The results showed no significant differences between them, pointing out a small sample size of the study.

These factors explain, in part, the results found in this study. Although the absolute load in exercises was statistically different, PES was probably similar due to a stress in the mechanoreceptors from the instability promoted by UP, which stood out over other peripheral mechanisms [29]. Moreover, there were no different values in the PSE responses when comparing exercises involving large body muscles (half squat), medium musculature (pronated barbell row) and small muscles (biceps curl).

In this sense, future studies should be conducted for a better understanding of how variables (types of surfaces, types of exercises and load percentage) can be adjusted and combined to obtain better performance and practical applicability.

One limitation of the study was the absence of biochemical markers to more effectively justify the PSE response, although maximum strength tests are closely related to the perceived effort of volunteers. In addition, analysis of the electromyographic activity was not used to verify power production, since only the comparison of MTLL was performed. Other limitations were the lack of values in literature related to the calibration of balance discs, lack of extrapolation of data to other populations (sedentary, women, elderly, etc.) and lack of PSE anchoring.

CONCLUSIONS

No significant differences in PSE response were found in the three resistance exercises when SP and UP were compared. Regarding the total load lifted values, no significant difference was observed for the biceps curl exercise; however, free half squat and pronated barbell row exercises on SP showed significantly higher values compared to UP. Thus, RT on UP with lower total maximum load lifted causes similar PSE response; thus, it would be an auxiliary tool in the load control applicability in resistance training.

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