Anthropometric measurements usage to control the exercise intensity during the performance of suspension rowing and back squats

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ABSTRACT

Objective: To verify the reproducibility and sensitivity of the procedure of load prescription from percentages of high and body mass in the suspension rowing (SR) and back squat (BS).

Method: Ten athletes (age: 24.5 ± 3.7 years, weight: 77.8 ± 15.3 kg, height: 172.5 ± 5.1 cm) engaged in resistance training programs were evaluated. BS and RS exercises were performed during four different days, in different intensities. Loads equal to 25% and 50% of body mass were used in the BS. RS exercises were performed with the feet directly under the anchor point and 1/3 of athlete’s height away from the anchor point. The highest number of repetitions executed were measured.

Results: No differences were found between test and re-test, with high intraclass correlation coefficient values (ICC > 0.79). The average number of repetitions differ significantly among the exercises performed according to intensity proposed (RS: p < 0.001, BS: p = 0.03).

Conclusion: The distance of the feet in relation to the zero point seems to be an easy and effective parameter for quantification of loads during RS training. Similarly occurs with the use of the body mass percentage for prescription of BS exercise.

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Uso de parámetros antropométricos para controlar la intensidad del ejercicio en el remo en suspensión y sentadillas

RESUMEN

Objetivo: Verificar la reproducibilidad y la sensibilidad del protocolo de prescripción de cargas a partir de porcentajes de la altura y de la masa corporal en los ejercicios de remo en suspensión (RS) y sentadillas (BS).

Método: Se evaluaron 10 sujetos (edad: 24.5 ± 3.7 años, peso: 77.8 ± 15.3 kg, altura: 172.5 ± 5.1 cm) que participaban en programas de entrenamiento de resistencia. Se llevaron a cabo ejercicios de RS y BS durante 4 días diferentes, a distintas intensidades. Para BS se utilizaron cargas equivalentes al 25 y al 50% de la masa corporal. Los ejercicios RS se realizaron con los pies directamente debajo del punto de anclaje y a 1/3 de la altura del sujeto respecto a este mismo punto. Se midió el número máximo de repeticiones realizadas.

Resultados: No se encontraron diferencias entre test y retest, con valores altos del coeficiente de correlación intraclase (ICC > 0.79). El promedio de repeticiones difiere de modo significativo, entre los ejercicios realizados, de acuerdo con la intensidad propuesta (p < 0.001 y p = 0.03, para RS y BS, respectivamente).

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Uso de parâmetros antropométricos para controle da intensidade nos exercícios de remada em suspensão e agachamento

**Resumo**

Objetivo: Verificar a reprodutibilidade e a sensibilidade do protocolo de prescrição de cargas, a partir de percentagens da altura e da massa corporal nos exercícios de remada em suspensão (RS) e agachamento (BS).

**Método:** Foram avaliados 10 sujeitos (idade: 24.5 ± 3.7 anos; massa corporal: 77.8 ± 15.3 kg; estatura: 172.5 ± 5.1 cm) que participavam em programas de treinamento resistido. Foram aplicados os exercícios RS e BS durante 4 dias diferentes, com intensidades distintas. Para BS, foram utilizadas cargas equivalentes a 25 e 50% da massa corporal. Para o exercício de RS foram utilizados os pés diretamente abaixo do ponto de encaixe e a 1/3 da estatura do sujeito em relação a este mesmo ponto. Foi medido o número máximo de repetições realizadas.

**Resultados:** Não foram encontradas diferenças entre teste e reteste, com valores altos de coeficiente de correlação intraclass (ICC > 0.79). A média de repetições diferiu de modo significante entre os exercícios realizados, de acordo com a intensidade proposta (p < 0.001 e p = 0.03, para RS e BS, respectivamente).

**Conclusão:** A distância dos pés em relação ao ponto 0 parece ser um parâmetro fácil e eficaz para a quantificação das cargas durante o treinamento de remada em suspensão. Do mesmo modo, o uso da percentagem da massa corporal para prescrição de agachamentos.

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the resolution 196/96 of the National Health Council and was approved by the local ethical committee (approval number 037/2011).

**Experimental procedures**

The deep back squat exercises were performed with a bar of 220 cm (Olympic-type; PHYSICUS®, Brazil), with loads equal to 25% (BS25%) and 50% (BS50%) of body mass. Regarding to suspension rowing, it was used a TRX Suspension Trainer (TRX®). The anchor point was fixed at 230 cm of height and the strap length was 130 cm. A zero point was defined as the position of the feet directly under the anchor point (RSP0). The 1/3 point (RSP1/3) was defined as the position in which the feet were placed 1/3 of the athlete’s height away from the anchor point (Fig. 1). In the upward phase, the elbows should move toward sides and remain close to body until reached a parallel position to the body. Quality control in the execution of the movement followed previous guidelines for the RS® and BS.9

In the first session, the subjects answered an anamnesis and their weight and height were measured. After a general warm-up of 5 min on cycle ergometer, the subjects executed the highest number repetitions in the following conditions randomly determined: (i) BS test session with load equivalent to 25% of body mass (BS-T25%) and RS with the feet in the zero position (RSP0) or (ii) BS test session with load equivalent to 50% body mass (BS50%) and RS with the feet placed in the position corresponding to 1/3 of the height of the individual in relation to the zero point (RSP1/3). On the second day, the complementary protocol was executed. For days 3 and 4 the re-test sessions were performed, in which the procedures of days 1 and 2 were repeated. The sessions were separated an interval of 48 h between them.

**Statistical analysis**

The normality of the data was checked and subsequently confirmed with the Shapiro–Wilk test. Student’s t test was used to compare between test and re-test, and between intensities. To determine test–retest reliability, intra-class correlation coefficients (ICC’s) were calculated. The level of significance was fixed at \( p \leq 0.05 \). The standard error of measurement (SEM), the minimal detectable change (MDC) and their respective confidence intervals at 90% were calculated. The correlations were analyzed by Pearson’s coefficient.

**Table 1**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean (SD)</th>
<th>( t ) test ( (p) )</th>
<th>ICC (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test RSP0 (reps)</td>
<td>31.9 (8.4)</td>
<td>1.30 (0.79)</td>
<td></td>
</tr>
<tr>
<td>Re-test RSP0 (reps)</td>
<td>35.0 (9.1)</td>
<td>(0.21) (0.01)</td>
<td></td>
</tr>
<tr>
<td>Test RSP1/3 (reps)</td>
<td>94.5 (42.5)</td>
<td>0.70 (0.90)</td>
<td></td>
</tr>
<tr>
<td>Re-test RSP1/3 (reps)</td>
<td>100.7 (42.0)</td>
<td>(0.46) (0.001)</td>
<td></td>
</tr>
<tr>
<td>Test BS25% (reps)</td>
<td>111.6 (85.2)</td>
<td>0.06 (0.91)</td>
<td></td>
</tr>
<tr>
<td>Re-test BS25% (reps)</td>
<td>110.6 (87.7)</td>
<td>(0.94) (0.001)</td>
<td></td>
</tr>
<tr>
<td>Test BS50% (reps)</td>
<td>51.9 (35.5)</td>
<td>0.02 (0.96)</td>
<td></td>
</tr>
<tr>
<td>Re-test BS50% (reps)</td>
<td>52.0 (29.1)</td>
<td>(0.98) (&lt;0.001)</td>
<td></td>
</tr>
</tbody>
</table>

* No statistically significant difference between test and re-test; RSP0: test at zero point for suspension rowing exercise; RSP1/3: 1/3 of the distance away from zero point for rowing suspension exercise; BS25%: load equivalent to 25% of the body mass for back squat; BS50%: load equivalent to 50% of the body mass for back squat; reps: number of repetitions.

**Results**

Loads used for BS25% and BS50% were 19.4 ± 3.8 kg and 38.9 ± 7.6 kg, respectively. Table 1 shows the descriptive measures and ICC values between test and retest. Additionally, SEM and MDC values are presented in Table 2, indicating higher intra-individual variation with higher intensities.

**Table 2**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Score</th>
<th>LL90%</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEM</td>
<td>RSP0</td>
<td>3.85</td>
<td>24.36</td>
</tr>
<tr>
<td></td>
<td>RSP1/3</td>
<td>13.45</td>
<td>72.31</td>
</tr>
<tr>
<td></td>
<td>BS25%</td>
<td>20.63</td>
<td>77.56</td>
</tr>
<tr>
<td></td>
<td>BS50%</td>
<td>7.94</td>
<td>38.80</td>
</tr>
<tr>
<td>MDC</td>
<td>RSP0</td>
<td>5.44</td>
<td>22.92</td>
</tr>
<tr>
<td></td>
<td>RSP1/3</td>
<td>19.02</td>
<td>63.11</td>
</tr>
<tr>
<td></td>
<td>BS25%</td>
<td>29.18</td>
<td>63.46</td>
</tr>
<tr>
<td></td>
<td>BS50%</td>
<td>11.23</td>
<td>33.38</td>
</tr>
</tbody>
</table>

LL, lower limit; UL, upper limit; SD, standard deviation. RSP0: test at zero point for suspension rowing exercise; RSP1/3: 1/3 of the distance away from zero point for rowing suspension exercise; BS25%: load equivalent to 25% of the body mass for back squat; BS50%: load equivalent to 50% of the body mass for back squat.
height and weight to calculate loads. The main findings are: (i) test and re-test have not shown difference in any of the situations; (ii) different intensities from the same exercises presented significant differences; (iii) relevant correlations were identified and, as expected, (iv) greater number of repetitions was executed with smaller loads, which is in accordance with the principle of the inverse relationship between volume and intensity.

A significant correlation was found between the squat with different loads, revealing a relationship between the different intensities. A prior study\(^{19}\) with untrained subjects attempted to clarify the relationship between different intensities (40%, 60%, 80% 1RM) and the number of repetitions in bench press and parallel squat. After 16 weeks of training, the subjects performed a re-test and showed an increase in the 1RM load for all exercises, however the number of maximum repetitions did not suffer changes. In another study,\(^{20}\) college students (70 men; 101 women) were tested to determine their 1RM bench press lifting strength before and after 14 weeks of training. No differences were found in the number of repetitions performed at the same intensity, which reinforce the involvement between these two variables.

Related to the training level, a previous study\(^{21}\) determined the number of maximum repetitions that trained and untrained males and females performed at various percentages of 1RM (40%, 60%, 80%) for each of seven specified weight training lifts. A higher number of repetitions were found in trained women in relation to untrained ones. When comparing untrained and trained males, a significant difference was found in the number of repetitions performed at all selected percent 1RM for the arm curl, knee extension, and sit-ups, at 60% in leg curl and at 60% and 80% on lateral pull-down. Another authors\(^{15}\) compared trained and untrained men who performed squat, arm curl and bench press at 60%, 80% and 90%, and only found significant differences in the bench press at 90% 1RM.

In contrast, when it was compared the exercise lateral pull-down from at 45% of the their body weight with the respective percentage of 1RM in women of different ages,\(^{22}\) the results showed that the load prescribed represented 73% of 1RM in the group of young women (20–30), 80% in middle-aged women (30–40) and 96% to 115% in elderly women, what means that increasing age is a limiting factor for performance. In the present study, no differences were found between the number of repetitions performed in the different protocols, maybe due to the homogeneity of the sample. In this sense, it seems that the prescription through anthropometrical parameters needs first to be parameterized according to the target population. For adults who are trained, the RS and BS presented stable values regarding to the reproducibility data. On the other hand, considering the high SEM and MDC values presented, these findings should be interpreted with caution, mainly for lower intensities.

RS has been defined in the literature as one of the activities considered suspended training, and it has been described as an efficient method to improve balance and central muscle recruitment,\(^{24}\) likewise to warm-up before the principal exercise without causing muscle fatigue,\(^{25}\) reducing the risk of injury, increasing joint stability,\(^{5,22}\) and enhancing the sports performance.\(^{4,7,24}\)

In relation to the quantification of the intensity in suspension exercises, in order to prescribe the training program, the information available is limited. The vector resistance principle, in which the angle of the body in relation to the ground determines the difficulty, has been suggested to control the intensity in suspension push-ups, because it showed greater activation of the central muscles than the same exercise performed in the traditional way.\(^{23}\) We have not found any study using the individual height as a parameter to determine the intensity of the suspension exercises, which makes this study pioneer on this proposal. Thus, such findings indicate that this procedure appears to be effective and easy to apply.

**Fig. 2.** Maximum number of repetitions in the suspension rowing and back squat exercises.

**Fig. 3.** Correlations among maximum number of repetitions in the different observations (reps: number of repetitions).

**Discussion**

The present study aimed to identify the reproducibility of performance in the RS and BS exercises, considering the individual's...
for the training process organization, considering the absence of difference between test and re-test for the two intensities proposed \((p > 0.05)\) with ICC of 0.79 \((p = 0.01)\) and 0.90 \((p = 0.001)\) to intensities related to point RSP0 and RSP1/3, respectively. Furthermore, the average number of repetitions also shows to be different between the intensities \((p < 0.001)\). Finally, the correlations between intensities in suspension were moderate \((r = 0.72; p = 0.01)\), which strengthens the hypothesis of reliability from the two situations (RSP0 and RSP1/3).

As limitations of the study, were indicated: (i) the absence of measures of physiological parameters of physical exertion, that would be interesting, but do not limit the answer to the aim of the study; and (ii) angulation in relation to different distances in RS is unknown, instead the use of height alone could be more practical. Additionally, it is suggested that future studies evaluate the physiological effects of these different methods, as well as the relationship of these with other parameters and quantification of loads, such as the subjective perception of effort, for example.

In conclusion, the distance of the feet in relation to the zero point seems to be an easy and effective parameter for quantification of loads during training in suspension, considering high intra class correlation between test and re-test, but statistically different values, depending on proximity of the lower limbs relative to the zero point. Similarly occurs with the use of the percentage of body mass for prescription of barbell back squat exercise.

**Conflicts of interest**

The authors have no conflicts of interest to declare.

**References**