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Original article

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.

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

Palabras clave:
Levantamiento de pesas
Entrenamiento de fuerza
Reproducibilidad de resultados

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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Conclusión: La distancia de los pies en relación con el punto cero parece ser un parámetro fácil y eficaz para la cuantificación de las cargas durante el entrenamiento RS. Del mismo modo ocurre con el uso del porcentaje de masa corporal para la prescripción de ejercicio BS.

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

Palavras-chave:
Levantamento de pesos
Treinamento de força
Reprodutibilidade de resultados

R E S U M O

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 intraclasse (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.

Introduction

Functional training can be defined as exercises performed in a multiplanar and multi-joint way that simulates specific movements of daily activities and of sportive modalities.[1] Among the different possibilities of strength training, suspension training is widely applied in several contexts. It is considered as an effective technique to improve neuromuscular activation that precedes the use of heavy loads on traditional exercises[2] and, thus, it can be integrated as a component of general warm-up routine.[3] Additionally, improvements in speed and strength indicators are found from the use of suspension training, suggesting increase on recruitment of muscles of central/stabilizer region[4] and decreased incidence of low back pain.[5]

There are three ways to alter the intensity of the suspension exercise by varying a combination of load and stability: (i) Stability Principle: the size and positioning of the base of support (BOS) relative to the center of gravity (COG) determines the stability of an exercise; (ii) Pendulum Principles: the horizontal positioning of the COG relative to the anchor point determines the load of the exercise and (iii) Vector Resistance Principle: the angle of the body relative to the ground determines the load of the exercise.[6] Hence, the possibility of adjusting the resistance of the exercise simply by modifying the position of the body, is a fast and efficient way to prepare a group of athletes simultaneously, each one with individual appropriate load.[3] Nevertheless, there are no scientifically validated parameters for load prescription in the suspension training.

In suspension training, the rowing is a very popular and relevant exercise to promote high relative overload, associated with the muscle integration of the entire body,[5] and it appears to offer considerable advantages to increase the transfer of gains to the physical demands related to sports as the American football[3] and wrestling combat sports.[7]

In addition, the deep back squat (BS) is another form of closed chain exercise widely used in physical fitness programs.[8] Likewise, it is relevant to strength[9] and functionality gains in daily activities.[10] Different from the suspension training that does not have any scientifically proved procedure for intensity prescription, the prescriptions to back squat involve load percentage from maximum repetition test,[11,12] execution time (effort/rest),[13] rate of perceived exertion (RPE),[14] maximum number of repetitions[11] and rep range.[15]

In general, there is a shortage of studies that aim to establish a model for prescribing intensities for functional exercises, since, commonly in the traditional strength training the intensity of the movement is indicated by the amount of load lifted.[16] Only recently, the derivations of body mass percentage have been used in training prescription and strength evaluation.[17] On the other hand, this constitutes a very common technique in fitness programs,[18] despite the absence of studies to check its validity. Therefore, the aim of the study was to verify the reproducibility and sensitivity of the procedure of load prescription from percentages of high and body mass, respectively in rowing in suspension (RS) and deep back squat (BS).

Methods

Subjects

Ten athletes (age: 24.5 ± 3.7 years, weight: 77.8 ± 15.3 kg, height: 172.5 ± 5.1 cm) were evaluated. The inclusion criteria were: (1) to be engaged in resistance training programs during three or more times a week for at least 12 consecutive months, (2) to have previous experience in the proposed exercises and (3) to be without injuries neither in process of rehabilitation. The participants signed a free informed term of consent; the research project follows the ethical guidelines of the Declaration of Helsinki and respects

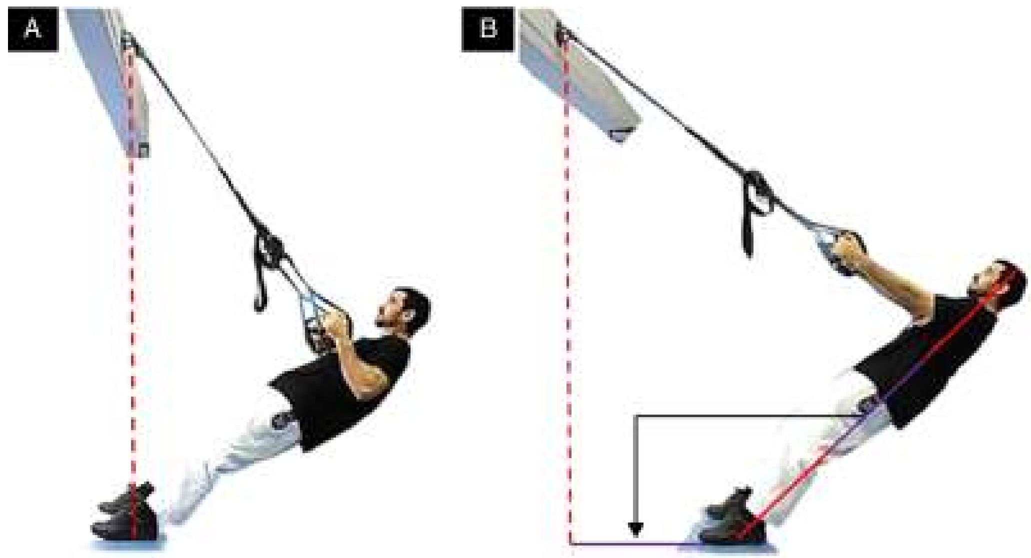

Fig. 1. Description of the experimental protocol for rowing in suspension in the zero position (RSP0) (A) and the 1/3 of the subject height (RSP1/3) (B).

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[6] 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
Descriptive measures[a] and intra class correlation coefficients (ICC).

	Mean (SD)	*t* test (*p*)	ICC (*p*)
Test RSP0 (reps)	31.9 (8.4)	1.30	0.79
Re-test RSP0 (reps)	35.0 (9.1)	(0.21)	(0.01)
Test RSP1/3 (reps)	94.5 (42.5)	0.70	0.90
Re-test RSP1/3 (reps)	100.7 (42.0)	(0.46)	(0.001)
Test BS25% (reps)	111.6 (65.2)	0.06	0.91
Re-test BS25% (reps)	110.6 (87.7)	(0.94)	(0.001)
Test BS50% (reps)	51.9 (35.5)	0.02	0.96
Re-test BS50% (reps)	52.0 (29.1)	(0.98)	(<0.001)

[a] 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: numbero 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.

Fig. 2 shows the maximum number of repetitions in BS and RS. Significant differences are observed between the exercises performed at different intensities. Correlations are shown in Fig. 3.

Table 2
Standard error of measurement (SEM), minimal detectable change (MDC) and their respective confidence intervals at 90%.

	Score	LL90%	Mean ± SD
SEM			
RSP0	3.85	24.36	32.0 ± 8.4
RSP1/3	13.45	72.31	94.5 ± 42.5
BS25%	20.63	77.56	111.6 ± 65.2
BS50%	7.94	38.80	51.9 ± 35.5
MDC			
RSP0	5.44	22.92	32.0 ± 8.4
RSP1/3	19.02	63.11	94.5 ± 42.5
BS25%	29.18	63.46	111.6 ± 65.2
BS50%	11.23	33.38	51.9 ± 35.5

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.

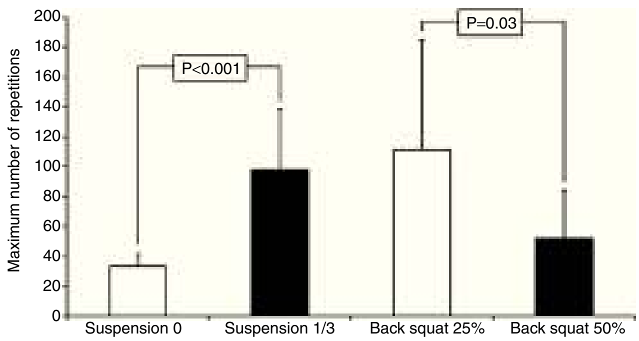

Fig. 2. Maximum number of repetitions in the suspension rowing and back squat exercises.

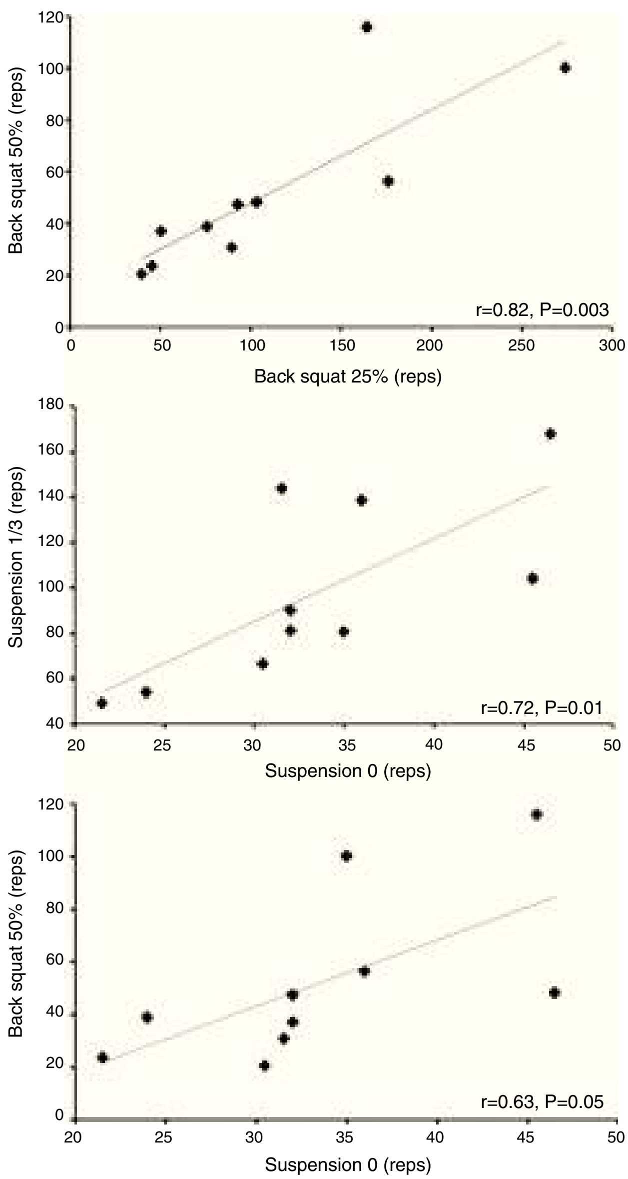

Fig. 3. Correlations among maximum number of repetitions in the different observations (reps: number of repetitions).

Discussion

The present study aimed to identify the reproducibility of performance in the RS and BS exercises, considering the individual's 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.[12]

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[12] 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,[4] likewise to warm-up before the principal exercise without causing muscle fatigue,[3] reducing the risk of injury, increasing joint stability[5,23] 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 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

1. Lagally KM, Cordero J, Good J, Brown DD, McCaw ST. Physiologic and metabolic responses to a continuous functional resistance exercise workout. J Strength Cond Res. 2009;23:373–9.
2. Snarr RL, Esco MR, Witte EV, Jenkins CT, Brannan RM. Electromyographic activity of rectus abdominis during a suspension push-up compared to traditional exercises. JEPonline. 2013;16:1–8.
3. Quelch F, Lichter E. Applying suspension training to football. NSCA's Perform Train J. 2010;7:15–9.
4. Dannelly BD, Otey SC, Croy T, Harrison B, Rynders CA, Hertel JN, et al. The effectiveness of traditional and sling exercise strength training in women. J Strength Cond Res. 2011;25:464–71.
5. Thomas SM, Sil S, Kashikar-Zuck S, Myer G. Can modified neuromuscular training support the treatment of chronic pain in adolescents? Strength Cond J. 2013;35:12–26.
6. Bettendorf B. TRX suspension training bodyweight exercises: scientific foundations and practical applications. California: Fitness Anywhere LLC; 2010. Available in http://www.trxtraining.com/shop-by-interest/TRX%C2%AE_Suspension_Training%C2%AE_Bodyweight_Exercise.pdf [accessed 18.07.13].
7. Ratamess N. Strength and conditioning for grappling sports. Strength Cond J. 2011;33:18–24.
8. Boudreau SN, Dwyer MK, Mattacola CG, Lattermann C, Uhl TL, McKeon JM. Hip-muscle activation during the lunge, single-leg squat, and step-up-and-over exercises. J Sport Rehabil. 2009;18:91–103.
9. Swinton PA, Lloyd R, Keogh JWL, Loannis A, Stewart AD. A biomechanical comparison of the traditional squat, powerlifting squat, and box squat. J Strength Cond Res. 2012;26:1805–16.
10. Straub RK, Cipriani DJ. Influence of infrapatellar and suprapatellar straps on quadriceps muscle activity and onset timing during the body-weight squat. J Strength Cond Res. 2012;26:1827–37.
11. Iglesias E, Boullosa DA, Dopico X, Carballeira E. Analysis of factors that influence the maximum number of repetitions in two upper-body resistance exercises: curl biceps and bench press. J Strength Cond Res. 2010;24:1566–72.
12. Shimano T, Kraemer WJ, Spiering BA, Volek JS, Hatfield DL, Silvestre R, et al. Relationship between the number of repetitions and selected percentages of one repetition maximum in free weight exercises in trained and untrained men. J Strength Cond Res. 2006;20:819–23.
13. Taipale RS, Mikkola J, Vesterinen V, Nummela A, Häkkinen K. Neuromuscular adaptations during combined strength and endurance training in endurance runners: maximal versus explosive strength training or a mix of both. Eur J Appl Physiol. 2013;113:325–35.
14. Day ML, McGuigan MR, Brice G, Foster C. Monitoring exercise intensities during resistance training using a session RPE scale. J Strength Cond Res. 2004;18:353–8.
15. Ronnestad BR, Hansen EA, Raastad T. Effect of heavy strength training on thigh muscle cross-sectional area, performance determinants, and performance in well-trained cyclists. Eur J Appl Physiol. 2010;108:965–75.
16. Dorgo S, King GA, Rice CA. The effects of manual resistance training on improving muscular strength and endurance. J Strength Cond Res. 2009;23:293–303.
17. McRae G, Payne A, Zelt J. Extremely low volume, whole-body aerobic-resistance training improves aerobic fitness and muscular endurance in females. Appl Physiol Nutr Metab. 2012;37:1124–31.
18. Smith MM, Sommer AJ, Starkoff BE, Devor ST. Crossfit-based high-intensity power training improves maximal aerobic fitness and body composition. J Strength Cond Res. 2013;27:3159–72.
19. Hickson RC, Hidaka K, Foster C. Skeletal muscle fiber type, resistance training, and strength-related performance. Med Sci Sports Exerc. 1994;26:593–8.
20. Mayhew JL, Ball TE, Bowen JC. Prediction of bench press lifting ability from submaximal repetitions before and after training. Sports Med Train Rehabil. 1992;3:195–201.
21. Hoeger WWK, Hopkins DR, Barette SL, Hale DF. Relationship between repetitions and selected percentages of one repetition maximum: a comparison between untrained and trained males and females. J Strength Cond Res. 1990;4:47–61.
22. Kuramoto AK, Payne VG. Predicting muscular strength in women: a preliminary study. Res Q Exerc Sport. 1995;66:168–72.
23. Snarr RBS, Esco MR. Push-up with knee tuck using a suspension device. J Strength Cond Res. 2013;35:30–2.
24. McGill SM, Cannon J, Andersen JT. Analysis of pushing exercises: muscle activity and spine load while contrasting techniques on stable surfaces with a labile suspension strap training system. J Strength Cond Res. 2014;28:105–16.