

MONITORING EXERCISE INTENSITY DURING RESISTANCE TRAINING USING THE SESSION RPE SCALE

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ABSTRACT. Day, M.L., M.R. McGuigan, G. Brice, and C. Foster. Monitoring exercise intensity during resistance training using the session RPE scale. *J. Strength Cond. Res.* 18(2):353–358. 2004.—This study investigated the reliability of the session rating of perceived exertion (RPE) scale to quantify exercise intensity during high-intensity (H), moderate-intensity (M), and low-intensity (L) resistance training. Nine men (24.7 ± 3.8 years) and 10 women (22.1 ± 2.6 years) performed each intensity twice. Each protocol consisted of 5 exercises: back squat, bench press, overhead press, biceps curl, and triceps pushdown. The H consisted of 1 set of 4–5 repetitions at 90% of the subject's 1 repetition maximum (1RM). The M consisted of 1 set of 10 repetitions at 70% 1RM, and the L consisted of 1 set of 15 repetitions at 50% 1RM. RPE was measured following the completion of each set and 30 minutes postexercise (session RPE). Session RPE was higher for the H than M and L exercise bouts ($p \leq 0.05$). Performing fewer repetitions at a higher intensity was perceived to be more difficult than performing more repetitions at a lower intensity. The intraclass correlation coefficient for the session RPE was 0.88. The session RPE is a reliable method to quantify various intensities of resistance training.

KEY WORDS. strength training, Borg CR-10 scale, reliability

INTRODUCTION

The Borg rating of perceived exertion (RPE) scale was developed to enable simple, reliable, and valid estimations of exercise intensity (4, 18). Widely accepted as a method of quantifying aerobic exercise intensities, perceived exertion has been used only infrequently in resistance exercise prescription (19). Borg based the RPE scale on the idea that a measure of perceived exertion is the level of strain and/or heaviness experienced during physical effort, as estimated by a specific rating method (4). Since the unveiling of the original scale over 40 years ago, the CR-10 RPE scale has become a standard method to evaluate perceived exertion in exercise testing, training, and rehabilitation and has been validated against objective markers of exercise intensity (17, 18).

The RPE scale is used in exercise science primarily to monitor exercise intensity and is most often used as a method to quantify exercise intensities during aerobic training (11, 12, 20, 24). Commonly utilized to monitor perceived exertion during specific stages of exercises, Foster et al. (9–11) developed the idea of using a session RPE scale to quantify an entire aerobic exercise session. The findings of Foster et al. (9–11) indicated that the session RPE scale is an effective method of quantifying exercise through a wide variety of exercise types. Gearhart et al. (14) provided additional evidence of the effectiveness of

the Borg scale, which extended the use of the RPE scale to resistance exercise.

Studies have shown that the Borg CR-RPE scale is an effective method of measuring perceived exertion during resistance training (7, 13, 16, 21, 23). Additionally, the session RPE method has been shown to be an effective method of quantifying entire aerobic exercise bouts (11). However, no research has been conducted as to the effectiveness of the session RPE method as it relates to perceived exertion during an entire resistance-training workout.

The importance of monitoring exercise training load and intensity during resistance training is an integral part of a successful periodized exercise plan because careful manipulation of intensity, volume, and recovery phases is vital for optimal results (2, 3, 8). The effects of training are related to the type of exercise used, its intensity, and its volume (3). High-intensity exercise, such as resistance training, is particularly difficult to quantify as this type of exercise cannot be objectively evaluated using physiological global measurements such as heart rate (11). This problem supports the need for a valid and reliable method of monitoring global training intensity, applicable to resistance training. This method would allow for easy and reliable resistance-training program manipulations required for continued increases in strength (2, 3).

The purpose of this study was to evaluate the effectiveness of the session RPE method as a tool to quantify exercise intensity during resistance-training sessions. A secondary purpose of the study was to determine the reliability of the session RPE method of quantifying resistance training. In addition, this study was also designed to support the findings of Gearhart et al. (14), in which performing fewer repetitions using heavier weight was perceived as more difficult than lifting lighter weight with more repetitions.

It was hypothesized that exercise intensity throughout an entire resistance-training session could be successfully quantified through the use of the session RPE scale. Additionally, performing fewer repetitions using a heavier weight was expected to be perceived to be more difficult than lifting a comparatively lighter weight with more repetitions.

METHODS

Experimental Approach to the Problem

A randomized, crossover experimental design was used for this study. Each subject participated for a total of 7 days, 6 of which were spent completing a high-, moderate-,

Table 1. Order of exercises and corresponding repetitions for high, moderate, and low intensities.

Exercise	Sets	H	M	L
		repetitions	repetitions	repetitions
Back squat	1	4–5	10	15
Bench press	1	4–5	10	15
Overhead press	1	4–5	10	15
Biceps curl	1	4–5	10	15
Triceps pushdown	1	4–5	10	15

and low-intensity lifting protocol (i.e., H, M, and L, respectively). Each protocol was performed twice to establish reliability of the RPE measurements. Day 1 consisted of a familiarization session that included informed-consent procedures, instruction on how to use the CR-10 RPE scale and its perceptual anchors (high and low), demonstration of each exercise, 1 repetition maximum (1RM) testing of each of the 5 exercises, and body composition analysis. An individual's 1RM was defined as the heaviest weight that could be used for 1 complete repetition of an exercise (8, 10). Each subject performed multiple sets of each exercise at submaximal resistance with stepwise increases in resistance until he/she could perform the lift with the maximal amount of resistance for 1 repetition. The 1RM for each exercise was used during the testing to determine the weight each participant was required to lift for each exercise. Each lifting protocol consisted of the 5 exercises listed in Table 1. One session was completed each day with at least 48 hours between sessions. Subjects were randomly assigned to the order they completed each of the training intensities.

Subjects

Twenty subjects were recruited for this study. Ten women (22.1 ± 2.6 years) and 10 men (24.7 ± 3.8 years) volunteered as participants. Nineteen subjects successfully completed the entire experimental protocol, with 1 subject withdrawing due to an injury unrelated to the study. Subjects were required to have had experience in resistance training for no less than 6 months, be familiar with the technique involved with the back squat and bench press and have no preexisting injuries that would limit their participation. All subjects provided written informed consent and completed a health history questionnaire prior to participation in the study. All experimental procedures were approved by the Institutional Review Board for the Protection of Human Subjects of the University of Wisconsin—La Crosse prior to commencement of testing.

Exercise Protocol

Before completing each exercise of the H, M, and L, each subject performed an exercise-specific warm-up consisting of 8 repetitions with 15% of the individual's predetermined 1RM (8). Following the warm-up set, the subjects performed the exercise according to the intensity and number of repetitions required for the session. This set was termed the working set. The rationale for using only 1 set for exercise was that it followed the American College of Sports Medicine guidelines (1) and it also simplified the perceptual cues compared with performing multiple sets of the different exercises. The training intensities and the corresponding number of repetitions are dis-

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	-
7	Very Hard
8	-
9	-
10	Maximal

FIGURE 1. Modification of the category ratio rating of perceived exertion (RPE) scale for this study (9). The verbal anchors have been changed slightly to reflect American English (e.g., light becomes easy; strong or severe becomes hard). Briefly, the subject is shown the scale approximately 30 minutes following the conclusion of the training bout and asked "How was your workout?"

played in Table 1. The resistance for each exercise was set to the nearest 2.5 kg of the appropriate percentage of each individual's 1RM. During the H, subjects were asked to complete 5 repetitions if they had not reached exhaustion upon completion of the fourth repetition. Each intensity was composed of 1 warm-up set and 1 working set of each exercise with a 2-minute rest period between exercises (14).

Subjects were asked to rate their perceived exertion following the completion of each working set based on the CR-10 RPE scale (5). This scale is represented in Figure 1. For assessing RPE during the exercise sessions, standard instructions and anchoring procedures were explained during the familiarization session (18). Subjects were asked to use any number on the scale to rate their overall effort. A rating of 0 was to be associated with no effort (rest) and a rating of 10 was considered to be maximal effort and associated with the most stressful exercise ever performed.

Thirty minutes following each exercise session, the subjects were asked to rate their perceived exertion for the entire resistance-training session based on the same scale by answering the question "How was your workout?" (9–11). This use of RPE is different from the more conventional approach that asks the subject to rate with highly standardized verbal instructions how difficult they perceived the exercise to be at a particular moment. The session RPE rating was taken 30 minutes following the end of the session so that particularly difficult or easy elements toward the end of the session would not skew the subject's rating of the entire resistance-training bout (11). The session RPE represents a single global rating of the perceived intensity for the entire training session. During previous investigations, we have not encountered difficulties with the subjects understanding our intent, particularly with the slightly modified verbal anchors that are used (see Figure 1) (9–11).

Instrumentation

All familiarization and testing sessions were completed in the Musculoskeletal Research Center at the University

Table 2. Descriptive characteristics of subjects.

	Men mean \pm SD (n = 9)	Women mean \pm SD (n = 10)
Age (years)	24.7 \pm 3.8	22.1 \pm 2.6
Height (cm)	180.8 \pm 5.7*	168.7 \pm 5.9
Mass (kg)	94.2 \pm 21.1*	60.7 \pm 4.9
Body fat (%)	14.5 \pm 3.8*	20.8 \pm 2.5
Squat 1 \dagger RM (kg)	148.2 \pm 29.8*	71.4 \pm 18.3
Bench 1 RM (kg)	122.7 \pm 18.3*	44.1 \pm 9.8
Press 1 RM (kg)	72.2 \pm 11.2*	31.8 \pm 5.5
Curl 1 RM (kg)	56.3 \pm 5.7*	28.6 \pm 4.2
Pushdown 1 RM (kg)	100.8 \pm 6.2*	52.1 \pm 8.8

* Denotes significant difference between genders ($p < 0.05$).

\dagger 1 RM = 1 repetition maximum.

of Wisconsin—La Crosse. Body composition data was obtained via anthropometry (height, weight; and triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf, chest, and midaxilla skinfolds for bodyfat percentage) (22). The 1RM testing and data collection were completed using the procedures previously described. RPE has been shown to be related to the percentage of 1RM lifted during exercise (23). Additionally, the RPE scale has been shown to be a valid instrument in which to evaluate perceived exertion and thus the regulation and quantification of exercise intensity in a variety of populations (4, 9–11, 13, 16, 23).

Statistical Analyses

A 2-way within-subjects repeated measures analysis of variance (ANOVA) was to test for differences in RPE among the H, M, and L. Each subject's 5 RPE values were averaged and compared to his/her session RPE rating. These values were tested for significant differences as part of the within-subjects repeated measures ANOVA. This test was completed to identify if significant differences exist between the session RPE rating and the accumulated RPE ratings obtained during each resistance-training session. Interclass correlation coefficients (ICC) and coefficient of variation (CV) were calculated to establish the reliability of the session RPE method.

RESULTS

Descriptive characteristics of the subjects are presented in Table 2.

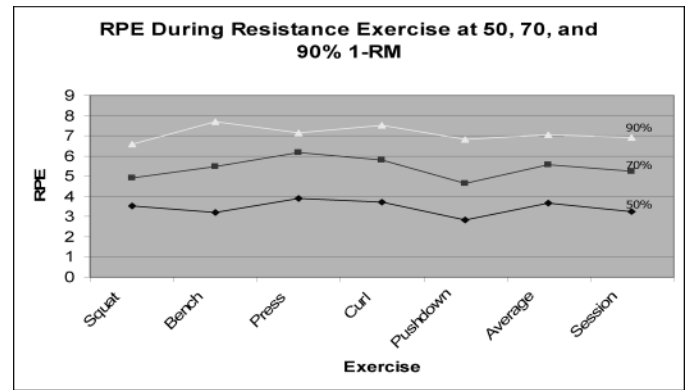
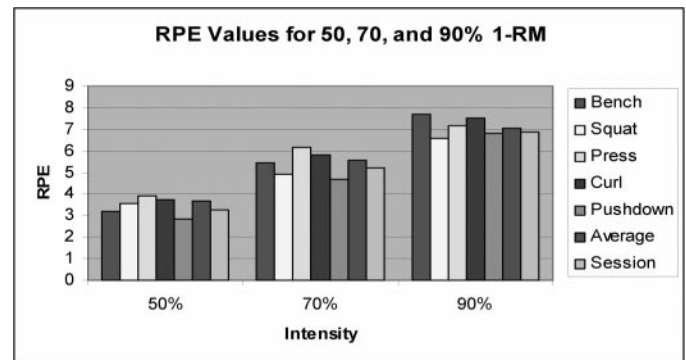
The trial 2 mean RPE values for each exercise and the trial 2 average and mean session RPE values were calculated for the 3 exercise intensities. These values are found in Table 3 and are represented in Figures 2 and 3. A within-subjects repeated measures ANOVA showed a significant difference among the mean RPE values of each intensity ($p \leq 0.05$) for each lift. The 70% intensity RPE values were significantly higher than the 50% intensity RPE values, and the 90% intensity RPE values were significantly higher than the 50% and 70% intensity RPE values as displayed in Figures 1 and 2.

The within-subjects repeated measures ANOVA revealed no significant difference between the average RPE value and the session RPE value during each intensity. Also, no significant differences were found between the mean bench press RPE value and the session RPE value and the mean back squat RPE value and the session RPE value for each intensity. Significant differences existed

Table 3. Individual exercise, session, and average RPE values for high, moderate, and low intensities.

Exercise	50% 1 RM* mean RPE \pm SD	70% 1 RM mean RPE \pm SD	90% 1 RM mean RPE \pm SD
Squat	3.5 \pm 1.5	4.9 \pm 1.4	6.6 \pm 1.9
Bench	3.2 \pm 1.2	5.5 \pm 1.2	7.7 \pm 1.8
Press	3.9 \pm 1.3	6.2 \pm 1.6	7.2 \pm 1.3
Curl	3.7 \pm 1.6	5.8 \pm 1.7	5.8 \pm 1.7
Pushdown	2.8 \pm 1.0	4.7 \pm 1.1	6.8 \pm 1.4
Average	3.7 \pm 1.2	5.6 \pm 1.3	6.9 \pm 1.4
Session	3.3 \pm 1.4	5.2 \pm 1.5	6.9 \pm 1.4

* 1 RM = one repetition maximum.

**FIGURE 2.** Rating of perceived exertion (RPE) during resistance exercise at 50, 70, and 90% 1 repetition maximum.**FIGURE 3.** Rating of perceived exertion (RPE) values at 50, 70, and 90% 1 repetition maximum.

between the mean overhead press RPE value and the session RPE value, the mean biceps curl RPE value and the session RPE value, and the mean triceps pushdown RPE value and the session RPE value ($p \leq 0.05$) for each intensity.

A test for reliability of the session RPE to predict the same value across 2 different trials of the same intensity was also performed. The ICC was 0.88 with the 95% confidence interval of 0.70–0.96. The CV was 14.5%.

DISCUSSION

The purpose of this study was to evaluate the effectiveness of the session RPE method as a tool to quantify exercise intensity during resistance-training sessions. This study was also performed to further validate the findings

of Gearhart et al. (14), in which performing fewer repetitions of a heavier resistance was perceived to be more difficult than performing more repetitions of a comparatively lighter resistance. The results of the present study indicated that performing 15 repetitions of a lighter resistance was perceived to be less difficult than performing 10 and 5 repetitions of heavier intensities. Additionally, performing the least number of repetitions at the highest absolute intensity was perceived to be the most difficult when compared with a moderate number of repetitions performed at a moderate intensity and performing high repetitions at a low intensity. No significant differences were found when comparing the session RPE with each subject's average RPE. In addition, the session RPE method of quantifying resistance training was shown to be a reliable measure across 2 different trials of the same training intensity.

Several studies have demonstrated the Borg scale to be an effective method of quantifying resistance training (7, 13, 16, 21, 23). Gearhart et al. (14) examined the RPE in active muscle (RPE-AM) during a high intensity (H) and low intensity (L) lifting protocol. Each protocol consisted of performing 1 set of each of 7 exercises. The H involved lifting 90% 1RM for 5 repetitions with RPE-AM values obtained following each repetition. The L protocol involved lifting 30% 1RM for 15 repetitions with RPE-AM values obtained following every third repetition. This study found that performing fewer repetitions using heavier weight was perceived as more difficult than performing more repetitions of a lighter weight when total external anaerobic exercise capacity was held constant. Lagally et al. (16) examined the RPE during resistance training in women by having subjects perform 3 sets of the biceps curl exercise. Each subject was randomly assigned to the intensity she would complete first, 30%, 60% or 90% of 1RM, performing 12, 6, and 4 repetitions, respectively. This combination of intensity and repetitions allowed for total anaerobic exercise capacity to be held constant. Data for the RPE-AM and overall RPE (RPE-O) were collected on the completion of each set. This study also found corresponding increases in RPE-AM and RPE-O with increases in exercise training intensity. Suminski et al. (23) also examined the perception of effort during resistance exercise. This study involved 7 exercises at 50% 1RM and 70% 1RM to fatigue. RPE-O was obtained immediately following each set. The researchers found the increase in intensity resulted in an increase in RPE-O, which supported the use of the Borg scale for monitoring resistance-exercise intensity (23). The results of the present study further support the findings of these previous studies in that performing few repetitions with a heavier weight is perceived as being more difficult than lifting lighter weights for more repetitions.

The experimental protocol of this study did not keep external exercise work performed constant. The training intensities and their corresponding repetitions allowed for variation in the amount of work performed among intensities. Performing 15 repetitions at 50% 1RM is actually more total work than performing 70% 1RM for 10 repetitions or 90% 1RM for 4 or 5 repetitions. The low-intensity protocol produced the lowest RPE, despite that this intensity required the most total anaerobic exercise capacity to be performed. This finding indicates the overriding importance of the intensity of training on RPE. Despite the complex nature of resistance exercise, which in-

volves a range of physiological cues depending on the type of training undertaken, there does appear to be a fundamental similarity to the use of RPE with monitoring aerobic exercise.

As previously demonstrated, muscles forced to overcome a heavy load require greater tension development, which requires an increase in motor unit recruitment and firing frequency (13, 18). For greater motor unit recruitment to be accomplished, the motor cortex may send stronger signals to the sensory cortex; this gives rise to increased perception of effort (14). It has been theorized that these stronger corollary signals may be the primary cause of the differences in RPE of varying intensities as shown by previous studies and the present study (6, 14, 16, 18, 23). The difference in RPE has also been observed in increasing intensities of aerobic cycling (13), suggesting that the increase in RPE demonstrated by this and several previous studies pertains not only to the anaerobic energy system but to the aerobic energy system as well. Gearhart et al. (14) have proposed that something other than the energy system utilized during exercise influences an individual's RPE. This speculation prompts further investigation of the underlying mechanism that produces increasing RPE values for increases in exercise intensity and suggests electromyography to investigate the intensity at which the motor signal triggers an active muscle contraction (14).

The average RPE for each trial (i.e., average RPE of the 5 lifts) was compared with its corresponding session RPE value. A statistical analysis of this data found no significant difference between the 2 RPE values. Despite the vast use of the RPE scale during various modes of exercise, the session RPE method is a relatively new instrument, with very few studies examining its ability to quantify entire bouts of exercise. This is the first study confirming the ability of the session RPE method to accurately complement an average RPE value during an entire bout of resistance training. The accuracy of the session RPE value to correspond with the average RPE given throughout the training session found in the present study supports the session RPE method as a valid method of quantifying entire bouts of resistance training intensity.

Foster et al. (11) examined the session RPE method as a tool to quantify exercise intensities during entire sessions of aerobic training. Their study compared the session RPE method with the summated heart rate zone method of quantifying aerobic exercise. Subjects either performed steady-state and interval aerobic exercise on an electrically braked cycle ergometer or practiced basketball. For each type of exercise, the session RPE method was found to give a higher score than the summated heart rate zone method. However, using regression analyses, the 2 methods were found to be highly correlated and suggested that either method could be used to quantify training intensities for various modes of aerobic exercise. The results of the present study support the concept proposed by Foster et al. (11) in that the session RPE value was shown to accurately correspond with the average RPE value obtained throughout the resistance-training session. Previous work in our laboratory has provided support for the use of this method as a subjective estimate of training load during non-steady-state exercise, including high-intensity interval training and team sport practice and competition (9–11). Using this single

measure that can be used across different modes of training, would provide the coach and athlete with a simple and reliable method of monitoring training. This measure could be easily recorded in a training diary and accessory indices of training, such as monotony and strain, could be calculated.

One of the primary goals of the present study was to establish the reliability of the session RPE method to quantify entire bouts of resistance training. This was achieved by comparing the RPE value from trial 1 to the RPE value from trial 2 for each of the 3 training intensities. The ICC of 0.882 indicates the ability of the session RPE method to reproduce a near identical value between trials with a relatively high degree of accuracy. As previously stated, little research has been completed concerning the use of the RPE scale during resistance training. The establishment of reliability of the session RPE scale corresponds with the findings of Gearhart et al. (14), in which 5 subjects repeated exercises in each of the high-intensity and low-intensity protocols to evaluate the test-retest reliability of the RPE measure. The *r*-values ranged from 0.73 to 1.00 for this data.

Based on the data, the session RPE method appears to be a reliable method of quantifying resistance-training intensities. This was demonstrated by the corresponding increase in the session RPE value with an increase in training intensity. The session RPE value was also found to consistently match the average RPE during the training session, further demonstrating the usefulness of this method when attempting to quantify resistance-training bouts. It should be noted that only 1 set per exercise was used during the exercise sessions. Further research needs to be completed investigating the validity and reliability of the session RPE method during multiple set workouts, which are recommended for continued progression in intermediate to advanced individuals (2).

PRACTICAL APPLICATIONS

The results of this study have shown the session RPE method to be a reliable and useful tool for researchers, strength coaches, athletes, and recreational lifters to assess exercise intensity during resistance training. On the basis of the results of this study, the session RPE method can be considered a reliable technique to monitor training intensities and provide for progressive increases in resistance. The existence of a session RPE scale would be of great significance to all those involved in resistance training. Through the use of a session RPE scale, one could choose an intensity at which to exercise (e.g., RPE 7) prior to the start of a workout and be confident that the exercise intensity will stay within the very hard range, without requiring RM testing to be performed. This would be much easier than having to use multiple measures of RPE throughout a workout. A session RPE scale would be an easy and effective method to prescribe work intensities for resistance-training sessions as well as to provide for progressive increases in intensity that have been found to be necessary for continued increases in strength (2, 3).

REFERENCES

1. AMERICAN COLLEGE OF SPORTS MEDICINE. Position stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. *Med. Sci. Sports Exerc.* 30:975–991. 1998.
2. AMERICAN COLLEGE OF SPORTS MEDICINE. Position stand: Progression models in resistance training for healthy adults. *Med. Sci. Sports Exerc.* 34:364–380. 2002.
3. BAECHLE, T.R., AND R.W. EARLE. *Essentials of Strength Training and Conditioning*. Champaign, IL: Human Kinetics, 2000.
4. BORG, G. *Borg's Perceived Exertion and Pain Scales*. Champaign, IL: Human Kinetics, 1998.
5. BORG, G., P. HASSMEN, AND M. LANGERSTROM. Perceived exertion in relation to heart rate and blood lactate during arm and leg exercise. *Eur. J. Appl. Physiol.* 65:679–685. 1985.
6. CAFARELLI, E., AND B. BIGLAND-RITCHIE. Sensation of static force in muscles of different length. *Exp. Neurol.* 65:511–525. 1979.
7. DISHMAN, R.K., R.W. PATTON, J. SMITH, R. WEINBERG, AND A. JACKSON. Using perceived exertion to prescribe and monitor exercise training heart rate. *Int. J. Sports Med.* 8:208–213. 1987.
8. FLECK, S.J., AND W.J. KRAEMER. *Designing Resistance Training Programs* (2nd ed.). Champaign, IL: Human Kinetics, 1997.
9. FOSTER, C. Monitoring training in athletes with reference to overtraining syndrome. *Med. Sci. Sports Exerc.* 30:1164–1168. 1997.
10. FOSTER, C., E. DANIES, L. HECTOR, A. SNYDER, AND R. WELSH. Athletic performance in relation to training load. *Wis. Med. J.* 95:370–374. 1996.
11. FOSTER, C., J.A. FLORHAUG, J. FRANKLIN, L. GOTTSCHALL, L. HROVATIN, S. PARKER, P. DOLESHAL, AND C. DODGE. A new approach to monitoring exercise testing. *J. Strength Cond. Res.* 15(1):109–115. 2001.
12. GARCIN, M., J.F. VAUTIER, H. VANDEWALLE, AND H. MONOD. Ratings of perceived exertion (RPE) as an index of aerobic endurance during local and general. *Ergonomics* 41:1105–1115. 1998.
13. GEARHART, R.F. JR, F.L. GOSS, K.M. LAGALLY, J.M. JAKICIC, J. GALLAGHER, AND R.J. ROBERTSON. Standardized scaling procedures for rating of perceived exertion during resistance exercise. *J. Strength Cond. Res.* 15(3):320–325. 2001.
14. GEARHART, R.F. JR, F.L. GOSS, K.M. LAGALLY, J.M. JAKICIC, J. GALLAGHER, K.I. GALLAGHER, AND R.J. ROBERTSON. Ratings of perceived exertion in active muscle during high-intensity and low-intensity resistance exercise. *J. Strength Cond. Res.* 16(1): 87–91. 2002.
15. HOEGER, W.W.K., D.R. HOPKINS, S.L. BARETTE, AND D.F. HALE. Relationship between repetitions and selected percentages of one repetition maximum: A comparison between untrained and trained males and females. *J. Appl. Sport Sci. Res.* 4:47–54. 1990.
16. LAGALLY, K.M., R.J. ROBERTSON, K.I. GALLAGHER, F.L. GOSS, J.M. JAKICIC, S.M. LEPHART, S.T. MCCAW, AND B. GOODPASTER. Perceived exertion, electromyography, and blood lactate during acute bouts of resistance exercise. *Med. Sci. Sports Exerc.* 34:552–559. 2001.
17. NOBLE, B.J., G. BORG, I. JACOBS, R. CECI, AND P. KAISER. A category-ratio perceived exertion scale: Relationship to blood and muscle lactate and heart rate. *Med. Sci. Sports Exerc.* 15: 523–528. 1983.
18. NOBLE, B.J., AND R.J. ROBERTSON. *Perceived Exertion*. Champaign, IL: Human Kinetics, 1996.
19. O'CONNOR, J.P., M.S. POUDEVIGNE, AND J.D. PASLEY. Perceived exertion responses to novel elbow flexor eccentric action in women and men. *Med. Sci. Sports Exerc.* 34:862–868. 2001.
20. PANDOLF, K.B., AND B.J. NOBLE. The effect of pedaling speed and resistance changes on perceived exertion for equivalent power outputs on the bicycle ergometer. *Med. Sci. Sports Exerc.* 6:132–136. 1973.
21. PIERCE, K., R. ROZENEK, AND M.H. STONE. Effects of high volume weight training on lactate, heart rate, and perceived exertion. *J. Strength Cond. Res.* 7:211–215. 1993.
22. POLLOCK, M.L., D.H. SCHMIDT, AND A.S. JACKSON. Measurement of cardio-respiratory fitness and body composition in the clinical setting. *Compr. Ther.* 6(9):12–27. 1980.
23. SUMINSKI, R.R., R.J. ROBERTSON, S. ARSLANIAN, J. KANG, A.C.

- UTTER, S.G. DASILVA, F.L. GOSS, AND K.F. METZ. Perception of effort during resistance exercise. *J. Strength Cond. Res.* 11: 261-265. 1997.
24. WENOS, D.L., J.P. WALLACE, P.R. SURBURG, AND H.H. MORRIS. Reliability and comparison of RPE during variable and constant exercise protocols performed by older women. *Int. J. Sports Med.* 17:193-198. 1996.

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