Monitoring Different Types of Resistance Training Using Session Rating of Perceived Exertion

Favil Singh, Carl Foster, David Tod, and Michael R. McGuigan

Purpose: To evaluate the effectiveness of session rating of perceived exertion (RPE) to measure effort during different types of resistance training. Method: Fifteen male subjects (age 26.7 ± 4.3 years) performed 3 protocols. All protocols consisted of same 5 exercises but with different intensities, rest periods, and numbers of repetitions. One-repetition maximum (1-RM) was defined as the maximal amount of weight that an individual could lift 1 time without support. The strength protocol included 3 sets of 5 repetitions at 90% of 1-RM with 3 minutes rest between. The hypertrophy session included 3 sets of 10 repetitions at 70% with 1 minute of rest, and the power session included 3 sets of 5 repetitions at 50% with 3 minutes of rest. Session RPE is a modification of the standard RPE scale. Session and standard RPE were measured after the completion of each set and 30 minutes postexercise, respectively. Results: Results showed a difference between both the 2 RPE values of the strength and hypertrophy protocols (P ≤ .05) but no difference between mean and session RPE values for the power protocol. During the familiarization session, session RPE was measured at 5-minute intervals for 30 minutes postexercise. There was a significant difference (P ≤ .05) between the mean RPE values at the fifth and tenth minutes postexercise when compared with 30 minutes postexercise. All other session RPE values showed no significant difference. Conclusion: The session RPE method appears to be effective in monitoring different types of resistance training, and session RPE after 30 minutes was a better indicator of the overall resistance sessions than average RPE.

Key Words: RPE, hypertrophy, power

Resistance training is a well-established mode of exercise conditioning for many different populations wishing to increase physical fitness and the primary method for increasing muscle strength, power, and hypertrophy.1-3 Resistance-training protocols designed to increase strength, power, or hypertrophy differ in

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their organization relative to variables such as intensity, number of repetitions, total work, and rest intervals. One problem facing strength athletes, coaches, and researchers is how to monitor the intensity of different modes and phases of resistance training. Unlike aerobic exercise, there is no universally accepted method of monitoring resistance-training exertion.

The rating of perceived exertion (RPE) has been investigated as a marker of exercise intensity and has been shown to correlate well with intensity of effort. RPE is defined by the intensity of discomfort or fatigue felt at a particular moment. Session RPE is a modification of the standard RPE scale, developed by Foster et al., that is used to rate the perceived exertion of the entire workout. The session RPE scale is an easy, simple, and effective method of quantifying a workout session. The session RPE scale has been shown to be a reliable and valid method of quantifying aerobic-exercise intensities and has been used to rate the perception of effort of individuals during a resistance-exercise session. Studies have found a higher average RPE for high-intensity exercises performed with a lower number of repetitions and a lower average rating for lower-intensity exercises performed with a high number of repetition. These studies have found RPE averaged across the workout to be comparable to the session RPE.

It is known that monitoring exercise-training load and exertion during resistance training is vital for a successful periodized exercise plan. Before a successful periodized plan with different exercise protocols can be developed, a measurement of exertion is required. Different types of resistance-training exercises and training approaches induce different responses from the muscles and neurological system, so it is critical that these differences be measured appropriately. This study examined the use of session RPE after different types of resistance-training programs. This would benefit athletes and coaches by providing a reliable method of assessing and monitoring different types of resistance-training workouts in their periodized plan. The session RPE method provided after each session would allow coaches to assess the perceived exertion levels for each athlete. Furthermore, coaches can always follow up on the previous data collected to look for signs of fatigue or even overtraining. There is clearly a need for a valid and reliable method of monitoring the different types of resistance-training exercises. Accordingly, the purpose of this study was to evaluate the effectiveness of using the session RPE scale to measure effort during different types of resistance-training protocols and to examine the validity of this scale in rating different types of resistance-training sessions. A secondary purpose was to track the session RPE after the exercise sessions to learn whether there were changes up to 30 minutes postexercise.

Methods

Subjects

Fifteen male subjects were recruited for the study. They all had at least 1 year of resistance-training experience and were familiar with the squat and bench-press exercises. All subjects were required to refrain from other resistance-training sessions during the course of the study. All subjects provided informed consent before participation, and the protocol had been approved by the university human subjects ethics committee. Table 1 displays the subjects’ characteristics.
Design
A randomized, crossover experimental design was used, with each subject performing 3 different whole-body workouts requiring approximately 60 minutes. Strength-, power-, and hypertrophy-training sessions took place on separate days, performed at least 48 hours apart. Subjects completed a familiarization session before data collection. This session included instructions on how to use the category-ratio-10 (CR-10) RPE scale (Table 2), demonstration of all 5 resistance-training exercises (bench press, squats, bench pull, shoulder press, leg extension), and the measurement of each individual’s 1-repetition maximum (1-RM). Session RPE was also recorded at 5-minute time intervals for 30 minutes after the 1-RM testing. Each 1-RM was determined using previously described methods.3,20

Methodology
The following procedure for determining the 1-RM was the same for all 5 exercises. Multiple warm-up trials were performed before 1-RM testing (percentages are given of subjects’ estimated 1-RM), 10 repetitions at 30% followed by 2 minutes rest, 7 repetitions at 50% followed by 2 minutes rest, 4 repetitions at 70% followed by 3 min rest, 1 repetition at 90% followed by 3 minutes rest. From the last warm-up set, the loading was increased based on subject feedback so that 1-RM could be

Table 1  Subject Physical Characteristics (mean ± SD)

<table>
<thead>
<tr>
<th>Subjects (N = 15)</th>
<th>Age (y)</th>
<th>Height (cm)</th>
<th>Body mass (kg)</th>
<th>Number of training years (1–15 y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>University students</td>
<td>26.7 ± 4.3</td>
<td>177.7 ± 8.6</td>
<td>82.1 ± 12.9</td>
<td>4.7 ± 3.9</td>
</tr>
</tbody>
</table>

Table 2  Rating of Perceived Exertion (RPE) Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Descriptor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>rest</td>
</tr>
<tr>
<td>1</td>
<td>very, very easy</td>
</tr>
<tr>
<td>2</td>
<td>easy</td>
</tr>
<tr>
<td>3</td>
<td>moderate</td>
</tr>
<tr>
<td>4</td>
<td>somewhat hard</td>
</tr>
<tr>
<td>5</td>
<td>hard</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>very hard</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>maximal</td>
</tr>
</tbody>
</table>
achieved within 3 additional trials. The reliability of this method of 1-RM testing in our laboratory is high (ICC = .98). Session RPE was also recorded during the familiarization session. RPE recording was started at the fifth minute after the completion of the 1-RM exercise bout and recorded at 5-minute intervals until 30 minutes postexercise.

The results from 1-RM testing for the 5 different resistance exercises were then used to calculate the required exercise intensity for the 3 different training sessions. Each subject was required to perform the same 5 resistance exercises for all the 3 training sessions. The order of the sessions was randomized. In this study, the workouts were split between upper body and lower body exercises, with the multiple-joint larger-muscle-group exercises performed first. Protocols for all 3 exercises are summarized in Table 3. Strength sessions are characterized by heavy resistance with a 3-minute rest period between sets. The hypertrophy session included the same exercises done at a lighter resistance with a shorter rest period of 1 minute. The strength- and hypertrophy-training sessions were typical weight-training protocols used for strength development and to increase muscle size, respectively.2,21 The power session required each resistance exercise to be performed at a fast lifting speed, with rest periods similar to the strength workout. During all training protocols, a 6-minute rest interval was allocated between exercises. The power workout was composed of exercises done at a rapid pace to maximize muscle power.2,20 This workout was different from the standard strength workout because both strength and velocity were emphasized during lifts.2 The subjects were required to execute the concentric phase rapidly and the eccentric phase slowly. Before commencing the workloads, subjects performed a warm-up set on each resistance exercise consisting of 6 repetitions at <30% of their 1-RM.

Stretching exercises for the selected muscle groups were also performed before the workout. Body positionings including grip width used by subjects were relative to their height and standardized for each exercise. All exercises were done with free weights except for leg extension.

### RPE Measures

For assessing averaged RPE during the exercise sessions, standard instructions and anchoring procedures were explained during the familiarization session.10,22,23 Subjects were asked to rate their perceived exertion after the completion of each lifting set based on the CR-10 RPE scale. A series of anchoring tests was used as explained by Gearhart et al.24 to establish high and low perceptual anchors. Thirty minutes after each training session, the subjects rated their perceived exertion.

<table>
<thead>
<tr>
<th>Exercise protocol</th>
<th>Load (% of 1-RM)</th>
<th>Number of sets</th>
<th>Number of repetitions</th>
<th>Rest interval (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>90</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Hypertrophy</td>
<td>70</td>
<td>3</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Power</td>
<td>50</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
based on the CR-10 RPE scale by answering the following question: “How was your workout?” The subjects would verbally indicate a number. Numbers from 0 to 10 on the scale were used to rate the intensity of the entire workout session. A rating of 0 was associated with rest, and the highest rating, 10, referred to maximal effort. This use of rating the perceived exertion of the whole session was different from the more standard approach of asking subjects to rate how difficult they perceived a particular exercise or set to be. The aim of the session RPE was to provide an RPE for the overall resistance-training sessions and to integrate the myriad of exercise-intensity cues.

**Statistical Analysis**

A 2-way, within-subjects, repeated-measures analysis of variance (ANOVA) was used to test for differences in RPE among the different types of training protocols. Each subject’s 5 mean RPE values from 3 sets of each exercise during each protocol were further averaged and compared with his session RPE rating. These values were tested for significant differences as part of the within-subjects, repeated-measures ANOVA. Averages of each exercise were also compared with the session RPE to identify any significant differences. Selected bivariate relationships were analyzed using Pearson product–moment correlation coefficients. The average RPEs at different time intervals were compared with the session RPE at 30 minutes to identify any significant difference. Statistical significance was set at $P \leq .05$. The magnitude of the differences between values was also interpreted using effect size. Effect size was calculated as $(M_2 - M_1)/s$, where $M_2 = $ within-group average of 1 group, $M_1 = $ within-group average of 1 group, and $s = $ pooled standard deviation for all subjects combined.

**Results**

**Session RPE Versus Average RPE**

Descriptive characteristics of subjects are presented in Table 3. The average length of training background was $4.7 \pm 3.9$ years. The correlation between the average and session RPEs was $r = .74$. The average RPE and session RPE for all 3 different types of resistance training are shown in Figure 1. The average RPE values for the strength, hypertrophy, and power workouts were $7.9 \pm 0.9$ (mean $\pm$ SD), $7.5 \pm 1.0$, and $3.8 \pm 0.9$, respectively. The session RPE values for the 3 workouts were $5.9 \pm 1.8$, $6.4 \pm 1.6$, and $3.2 \pm 1.4$, respectively. A 2-way, within-subjects, repeated-measures ANOVA showed significant differences among the average RPE and the session RPE values of both the strength and hypertrophy protocols ($P \leq .05$). There was a significant difference ($P \leq .05$) for both average and session RPE values between the strength and hypertrophy protocols compared with the power protocol. No difference was found between the strength and hypertrophy protocol for either RPE value, as shown in Figure 1.

Effect sizes for the differences between exercise protocols were calculated as follows: Session RPE – strength and power 1.29, strength and hypertrophy 0.22, and power and hypertrophy 1.51; average RPE – strength and power 1.94, strength and hypertrophy 0.16, and power and hypertrophy 1.78.
Average RPE values for each of the 5 exercises for all 3 modes of resistance-training workouts were compared with the session RPE. Both the strength and hypertrophy RPE training sessions resulted in higher values for RPE than did the power-training session (Figure 2). The strength and hypertrophy protocols had similar ratings for the bench pull and leg extension, but the bench press and squat

Figure 1 — Ratings of perceived exertion (RPE) for the different types of resistance training. *Significant difference ($P \leq .05$) between RPE values. **Significant difference ($P \leq .05$) between session RPE values of strength and hypertrophy to power. ***Significant difference ($P \leq .05$) between average RPE values of strength and hypertrophy to power.

Figure 2 — Ratings of perceived exertion (RPE) during resistance exercises for different types of resistance training. *Significant difference ($P \leq .05$) between average RPE values of exercises and session RPE.
exercise had higher RPE ratings in the strength workout. Subjects perceived the shoulder-press exercise to be harder in the hypertrophy workout. A significant difference ($P \leq .05$) was evident in the average RPE values of all exercises in the strength protocol compared with session RPE values. No difference was found in average bench-press RPE for hypertrophy and power. Average RPE values for the squat exercise showed no difference for hypertrophy but had a significant difference ($P \leq .05$) versus the power protocol. A significant difference ($P \leq .05$) was observed for all other exercises in the hypertrophy protocol. No significant difference was revealed in any other exercises except for the leg-extension exercise for the power protocol.

### Session RPE Over Time

The within-subjects, repeated-measures ANOVA revealed a significant difference ($P \leq .05$) between the average session RPE values at 5 and 10 minutes postexercise compared with 30 minutes postexercise (Figure 3). All other session RPE values had no significant difference compared with the 30-minute mark.

### Discussion

The purpose of the study was to evaluate the effectiveness of using the session RPE scale to measure physical effort during different types of resistance-training exercises and to examine the validity of this scale in rating the entire resistance-training session of different workouts and intensities. Differences were found between the session RPE values of the strength and hypertrophy protocols compared with the power protocol. These results are comparable to those of other studies.

![Figure 3 — Session ratings of perceived exertion (RPE) at different time intervals. *Significant difference ($P \leq .05$) between average RPE values.](image-url)
Session RPE and Resistance Exercise

using resistance-training models. Several studies have found the Borg scale to be an effective method of quantifying resistance training. The results of the present study further support this concept in that higher-load training such as in the strength and hypertrophy protocols is perceived to be more difficult and require more effort than lower-load training such as power workouts.

The present study did not keep the total exercise work performed constant between the workouts. Variation was allowed in the amount of work performed for all the different training protocols, but all protocols were consistent with normal resistance-training practices. The hypertrophy protocol, in which participants performed 10 repetitions at 70% of their 1-RM, had the most total work performed, followed by the strength protocol performed at 90% of 1-RM with 5 repetitions, and the power protocol performed with 5 repetitions at 50% of 1-RM had the least work performed. The lowest-load protocol (ie, power protocol) produced the lowest RPE values, but the other 2 protocols had similar RPEs. This supports the concept that the absolute intensity of training influences RPE when one considers that the strength protocol had a higher load and it was completed with lower repetitions than the hypertrophy protocol. Many studies have found that greater tension development, which requires an increase in motor-unit recruitment and firing frequency, is required for a muscle force to overcome a heavy load. As explained by Gearhart et al, to achieve greater motor-unit recruitment, the motor cortex sends stronger signals to the sensory cortex, giving rise to an increase in perception of effort. It is been agreed in various studies that these corollary signals could be the main cause of the variation in RPE of changing intensities.

It has previously been shown that there is no significant difference between the average RPE and the session RPE. The findings in this study showed a difference between the 2 RPE values for both the strength and hypertrophy protocols, but no difference was found for the power protocol. The correlation between the 2 measures across all modes of exercise, however, was quite high ($r = .74$). This study differed from similar studies in certain aspects. Day et al and McGuigan et al found no difference between the average and session RPE values. Both studies concluded that the session RPE was a reliable and valid method for quantifying resistance-training intensity. Both studies concluded that the session RPE measurements that were provided 30 minutes after an entire workout were as precise at measuring effort as the sum of actual RPE measurements, taken after each set of each exercise. During the present study, we found that only the RPE values of the power protocol had similar results, but results were different for the other 2 protocols. Despite the large experience with the RPE scale during various modes of exercise, the session RPE method is still a relatively new instrument. The session RPE values were consistently lower than the average RPE values for the strength and hypertrophy workouts. Another study, by Sweet et al, investigated the ability of the session RPE method to quantify aerobic and resistance training. Those findings were comparable to the present results in that there was a difference between the 2 RPE values for strength and hypertrophy protocols.

Several factors could have influenced these differences. In the present study, RPE values were taken after each of the 3 sets (per exercise) as compared with only 2 sets in the study of McGuigan et al and 1 set in the study of Day et al. As explained by Sweet et al, the second set of exercise was often perceived
to be more difficult than the first set. Subsequently, the third set would be more
difficult than the second set, contributing to a higher perceived exertion. Woods et
al.\textsuperscript{25} found similar results despite manipulating the rest intervals between the sets.
Their results showed a significant increase in the average RPE between all 3 sets
of each exercise. Measuring RPE for the third set increased the average RPE for
any given resistance-training intensity. Rhea et al.\textsuperscript{31} compared the number of sets of
equal intensity for eliciting strength and found that 3 sets of weight training were
superior to 1 set. They concluded that because multiple sets elicit greater strength
gains, weight training with multiple sets puts a greater stress on the neuromuscular
system. The increase on stress in the neuromuscular system would in turn increase
the perception of effort.

The training status of the subjects used could also affect the results. Compared
with the study of Day et al.,\textsuperscript{10} who included individuals with only 6 months experi-
ence, the present study had a subject criterion requiring at least 1 year of resistance-
training experience. Subjects in the current study might have perceived both the
strength and hypertrophy protocols to be more difficult during the workouts them-
selves. Because these subjects have been training longer, however, their recovery
from these workouts might have been faster, leading to lower session RPE values.
Because of the adaptations resulting from overloading over the months of consistent
training,\textsuperscript{2} their recovery from the intense loading of the 2 protocols might have
been faster than that of the subjects in the study of Day et al.\textsuperscript{10} The same subjects
performed all 3 protocols, but as explained earlier no difference between average
and session RPE was found for the power protocol. This protocol was completed
with a lower absolute intensity and volume, although the exercises were performed
explosively. Linnamo et al.\textsuperscript{32} indicated that these exercises seem to facilitate
the function of the neuromuscular system rather than produce fatigue. The subjects
perceived this protocol to be the easiest among the three. Linnamo et al.\textsuperscript{32} also noted
that a power protocol produced less fatigue than a strength protocol.

The RPE measurements taken after each exercise varied widely depending on
the type of exercise performed during the protocol. These results were similar to
previous findings by Day et al.,\textsuperscript{10} McGuigan et al.,\textsuperscript{17} and Sweet et al.\textsuperscript{18} All resistance-
training exercises were perceived to be more difficult than the session RPE across
all protocols, but not all exercises for all 3 protocols had significant differences.
Many factors could have influenced differences in RPE measurements, such as
motor-unit recruitment, muscle groups, order of exercises, and energy expenditure.
Resistance-training exercises such as squats and bench presses use larger-muscle
groups than shoulder press and leg extensions. These large-muscle groups require a
larger number of motor units to be recruited.\textsuperscript{1,2,5} Larger muscles have higher energy
expenditure and metabolic needs, thus making the perception of effort more evi-
dent.\textsuperscript{18} Exercises that use a range of motion through multiple joints might increase
RPE. Single-joint large-muscle exercises such as leg extensions\textsuperscript{2} can also increase
RPE, as shown in Figure 2. This could result from the pH disturbance associated
with high-intensity, isolated muscle exercise\textsuperscript{1} and influences the perception of
effort.\textsuperscript{30} The order of exercise could also alter the RPE. If the squat exercise were
performed first rather than last in a training session, the session and average RPE
values might have been lower. Muscle fatigue would increase closer to the end
of a training session than at the start.\textsuperscript{4,28} As mentioned by Kraemer and Ratamess\textsuperscript{2}
and Tan, it is recommended that these multiple-joint large-muscle exercises be performed early in the workout for strength training.

In this study, session RPE was measured at 5-minute time intervals for 30 minutes after the familiarization session. The results indicated a significant difference between the first 2 time intervals compared with 30 minutes postexercise. These results confirm the suggestion of Foster that session RPE should be taken 30 minutes after the end of a workout so as to prevent particularly difficult or easy elements near the end of the exercise session from distorting the entire rating of the session. The aim of the session RPE is to provide an RPE for the overall resistance-training workout sessions and to simplify the myriad of exercise-intensity cues. Many factors could have influenced variations in the RPE measurements, such as motor-unit recruitment, energy expenditure, recovery, and the type of resistance-training exercise performed—that is, large-muscle group versus small-muscle group.

Practical Application

To obtain optimal results from a successful periodized exercise plan, monitoring exercise training load and perception of effort during resistance training is vital. Before designing and completing a successful periodized plan with different exercise protocols, an accurate measurement of the intensity of testing protocols is required. The results from this study complement the results from previous research and suggest that using the session RPE method after each testing session would allow coaches to assess the intensity levels that correspond to the level of the training program. Coaches would also be able to compare the previous session’s RPE values to determine whether there were increases or decreases in the perception of effort. Collecting session RPE once, after 30 minutes, would appear to be easier than taking multiple measures of RPE throughout the workout and rest period. Ideally this information should be obtained 30 minutes after the completion of the workout, but obviously this is not practical in all situations, and it could be obtained after completion of the cool-down, which could be approximately 10 to 15 minutes after the last exercise bout. Practitioners should also be aware that the RPE does not always directly relate to the relative intensity used during resistance training and appears to depend on the mode of resistance exercise that is used.

Conclusion

The results of this study have shown that the session RPE is a useful tool of measuring the different intensities of different resistance-training sessions. The power protocol had the lowest session RPE values compared with the hypertrophy session and the strength protocol. It was also found in this study that the session RPE values did not correspond with the average RPE values for the strength and hypertrophy protocols, but both RPE values did correspond for the power protocol. Furthermore, there was a significant difference between the session RPE values at different time intervals and session RPE values at the 30-minute mark. For future studies on session RPE, it would be of interest to investigate other modes of training and manipulation of acute training variables to see how sensitive this measure is.
References


