RESEARCH NOTE

Upper-Extremity Explosive Resistance Training With Older Adults Can Be Regulated Using the Rating of Perceived Exertion

Brandi S. Row Lazzarini,[1] Mitchell W. Dropp,[2] and William Lloyd[2]

[1]*Department of Exercise Science, Willamette University, Salem, Oregon; and* [2]*Kinesiology Program, Department of Physical Education, Health, and Recreation, Western Washington University, Bellingham, Washington*

Abstract

Row Lazzarini, BR, Dropp, M, and Lloyd, W. Upper-extremity explosive resistance training with older adults can be regulated using the rating of perceived exertion. *J Strength Cond Res* 31(3): 831–836, 2017—Explosive resistance training (ERT) improves muscle strength and power in older adults. Previous work has determined that the Borg rating of perceived exertion (RPE) scale can be used to regulate ERT loads for older adults on the leg press exercise. The purpose of this study was to assess the relationship between the Borg RPE scale and ERT loads relative to the 1 repetition maximum (%1RM) in older adults during the chest press exercise. Healthy seniors (n = 10 men, mean [SD] age 75.8 [7.9]; n = 10 women, age 73.0 [6.3]) took part in 2 sessions on nonconsecutive days. During the first session, subjects reported their RPE during multiple ERT repetitions on the chest press for 7 loads across the spectrum of "light" to "heavy", ranging from 20 to 105% body weight. The loads, concealed from the participants, were presented in randomized order. During the second session, a 1RM strength test was conducted. Each load experienced on the first visit was calculated as %1RM. Rating of perceived exertion was averaged across subjects for each 5% range of 1RM from 35% 1RM to 110% 1RM. Regression analysis was used to determine if RPE predicts %1RM during chest press ERT. Rating of perceived exertion predicted the %1RM corresponding with chest press ERT loads (R^2 = 97.6%, SEE 3.6, $p < 0.001$). Loads that would elicit both strength and power gains (70–90% 1RM) corresponded with an RPE of 14–17. As previously demonstrated with the leg press, ERT loads can be regulated for older adults during the chest press using RPE, allowing ERT to be conducted without maximal strength testing. This approach may increase the adoption of this training method for a broader spectrum of seniors.

Key Words muscle power, high-velocity resistance training, aging, chest press

Introduction

Upper-extremity resistance training is important for function in older adults, given that it improves upper-extremity strength (1) and the ability to complete reaching and pulling tasks that are commonly needed to be independent in activities of daily living (3). Power training, where the concentric phase of resistance training exercises is performed rapidly, improves the ability to rapidly complete whole-body activities of daily living more than traditional (slow speed) resistance training (14). The improvements in speed of functional performance because of power training are achieved along with equal improvements in upper-extremity strength (14) compared with traditional resistance training, making power training, also known as explosive resistance training (ERT), an important training option for older adults.

Explosive resistance training using relatively heavy loads (~70% 1RM) elicits simultaneous improvements in muscle strength and muscle power in older adults (2,6,17). Explosive resistance training at lower loads (~40% 1RM), however, improves power and balance performance (15), making both heavy and light ERT loads relevant to function. It is common to select ERT loads based on a maximum strength test (1 repetition maximum, 1RM) (2,6,17), but the 1RM test is a process that some older adults are unwilling to complete, because of concerns about lifting heavy loads and injury risk (16). The use of the Borg rating of perceived exertion (RPE) scale to regulate ERT loads has shown promise for older adults in modulating leg press ERT intensity by significantly predicting loads as a percentage of the 1RM (16), but its potential application during upper-extremity ERT exercise is unknown.

Regulating ERT with RPE would allow the elimination of 1RM tests with older adults while still selecting useful training loads for ERT. Presently, when exercisers self-select resistance

Address correspondence to Brandi Row Lazzarini, brow@willamette.edu.

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training loads without calculating a %1RM, the loads are too light to effectively stimulate strength gains (5,7,11). Some guidance in selecting a training load seems to be warranted. The use of the RPE could improve the selection of appropriate ERT loads while not relying upon a 1RM strength test. The purpose of this study was to assess the relationship between the Borg RPE scale and ERT loads relative to the %1RM in older adults during the chest press and to investigate whether this relationship holds for both men and women. The hypotheses were that there would be a positive linear relationship between the Borg RPE scale and the load (%1RM) on the chest press and that men and women would not differ on the RPE for loads relative to %1RM.

Methods

Experimental Approach to the Problem

Because the purpose of this study was to evaluate an approach to identifying ERT loads for older adults without requiring the use of a 1RM test, the subjects rated chest press loads during the first testing session and only experienced a 1RM test during the second testing session. Thus, the RPE scores for the loads experienced during the first session were not influenced by a recent experience with a 1RM load, but rather were based on the immediate experience with the present load. The protocol was as described in our previous work with the leg press exercise (16). The subjects' RPE during ERT was recorded during the first session for loads ranging between 20 and 105% body weight (BW) on the chest press. During a second session, subjects performed a 1RM test on the chest press. The weight stack was also hidden from view of the subject, so that knowledge of the load would not influence the RPE score. The loads lifted during the first session were represented as %1RM by calculating the percentage of the load relative to the 1RM obtained during the second session. Regression analysis was used to determine whether RPE could predict relative ERT loads (%1RM) on the chest press. The repeatability of the RPE measure for this purpose was evaluated using an intraclass correlation analysis.

Subjects

This study was approved by the Institutional Review Board. The subjects were informed verbally and in writing of the benefits and risks of the investigation and received a demonstration of the procedures before signing the informed consent form for participation in the study. Healthy senior volunteers ($n = 20$ men and women; age range, 65–88 years; Table 1) recruited from a fitness center on (blinded university's) campus took part in 2 sessions on nonconsecutive days. All the subjects had experience in traditional, slow resistance training; those who could specify ($n = 14$) reported a range of 2–40 years (median = 14 years [*SD* 14.3 years]) of resistance training experience, most exercised 5 or 6 days per week, including walking and regular (2 or 3 days per week) exercise in the fitness center on campus. No subjects had experience with ERT on the chest press, and all reported that they do not routinely lift "heavy" loads. Inclusionary criteria were that the participants were of at least 65 years of age, had resistance training experience, had the ability to walk and climb stairs without an assistive device, and reported that they were free of pain and had full range of motion (ROM) in the shoulder, elbow, and wrist.

Table 1. Participants' characteristics.*

	Males	Females
No. participants	10	10
Age	75.8 (7.9)	73.0 (6.3)
95% CI	70.2–81.4	68.4–77.5
Height, m	1.78 (0.03)	1.65 (0.04)
95% CI	1.76–1.80	1.62–1.68
Body mass, kg	82.9 (8.7)	62.4 (8.5)
95% CI	76.7–89.2	56.3–68.5
BMI, $kg \cdot m^{-2}$	26.2 (3.1)	23.0 (2.6)
95% CI	23.9–28.4	21.1–24.8
1RM, kg	73.4 (15.9)	44.5 (10.7)
95% CI	62.4–84.7	36.9–52.1
1RM, %BW	88.2 (14.0)	73.6 (24.0)
95% CI	78.1–98.2	56.5–90.8

*Mean, *SD*, and 95% confidence intervals of the mean (95% CI) are displayed. Men were larger and stronger than women ($p \leq 0.05$), except for age and 1-repetition maximum (1RM) as %BW.

Procedures

For each testing session, subjects warmed up for 5 minutes on a stationary cycle or treadmill, followed by static stretching, and 8 slow repetitions (reps) on the chest press resistance training machine at 35% BW for men and 25% BW for women, because pilot testing identified this range as a comfortable warm-up load.

This method would be used in the field without a previous 1RM experience, so to obtain naive ratings of the loads during the first session (session 1), participants' ratings for various chest press loads were obtained during session 1, which was before experiencing a 1RM test during the second session (session 2). Seven loads ranging from 20 to 105% BW were presented to the participants in random order (using a previously generated list of random sequences). On average, the lowest load experienced by the subjects was 35.3% (*SD* 9.7%) BW (men: 40% [*SD* 8.4%] BW, women: 29.3% [*SD* 7.8%] BW), and the highest was 71.7% (*SD* 16.1%) BW (men: 80.7% [*SD* 11.8%] BW, women: 60% [*SD* 13.4%] BW). A cable-pulley seated chest press machine was used for testing. The weight stack was concealed by a curtain so that the subjects would remain naive to the load before experiencing and rating it. Participants completed 3 repetitions that increased in speed (first repetition = "slow", second repetition = "medium speed", third repetition = "as fast as safely possible"). The slow- and medium-speed repetitions were used to acclimate the participant to the feeling of lifting the concealed load before conducting the final repetition at maximum speed. The subjects then rated the load during only the high-velocity repetition using the Borg RPE scale (range, 6–20 points). The subjects were instructed to always perform the eccentric phase slowly, under control, and to include a pause before and after the concentric phase was performed. Subjects rested for 1-minute between each set.

The loads presented during session 1 were based on the goal of exposing the participant to loads that would elicit RPE ratings across the spectrum of "light" to "heavy". Some planned loads were not presented for some participants if the previous trials made it apparent that the load would either exceed the participants' capabilities or that the load would be below a "very, very light" rating already achieved.

The influence of previous experience with chest press loads on the subjects' RPE was prevented by concealing the weight stack from the subjects by a curtain at all times during the study. Because they could never see the load, the subject only became aware of the magnitude of the load upon lifting the first repetition of the set, and this was always conducted in a slow and controlled manner with subsequent repetitions increasing in velocity. Repeatability of the RPE ratings was assessed for 4 loads following the initial presentation of loads during session 1. The subjects were not informed that they would lift some loads twice, but rather were instructed that they would lift a variety of loads ranging from light to heavy.

The qualitative descriptors accompanying the original Borg 6–20 point RPE scale (4) were presented to the subjects alongside the numerical ratings (7: very, very light, 9: very light, 11: fairly light, 13: somewhat hard, 15: hard, 17: very hard, 19: very, very hard). In addition, the subjects were asked whether they felt that the handlebars would have projected from their hands when pushing as fast as they could. These answers were recorded after the experience of each load. Unlike for the leg press exercise (16), light loads did not pose a risk of projecting from the subjects hands during light loads when they were conducted at maximum speed, because the subjects maintained a firm grip on the handlebars.

During session 2, a 1RM strength test was conducted for the chest press between 2 to 7 days after session 1. The 1RM procedure included a warm-up of 5 minutes of stationary cycling or treadmill walking, static stretching, and 8 slow repetitions at the load closest to but under an RPE of 15 from session 1. Subjects were then asked to complete 2 repetitions through the full ROM at each load using a sustained effort and a slow speed. The load was increased by 5–10% BW from the warm-up load until an increase of this magnitude could not be achieved, and then it was increased instead by 2.5–5% BW. Participants were asked to not push through pain and to avoid breath holding. The test was stopped if the full ROM could not be achieved for 2 repetitions, or if the participant asked to stop.

Initially, 22 participants participated in session 1 and session 2, but only 20 were included in the analysis. Only 12 subjects completed an actual 1RM, and 7 completed a 2RM, where the smallest possible incremental increase in the load on the resistance training unit was too large to achieve a true 1RM and resulted in a failed attempt to lift the load. Three subjects requested to stop the test before it was certain that a 2RM was reached, because of an unwillingness to lift such high loads. One of these subject's scores was accepted as a 2RM because of the high RPE rating (20) at the time of discontinuation, but the other 2 participants discontinued the 1RM test at a load that the participants rated as only 16–18 on the Borg RPE scale, and so these 2 participants were not included in the analysis.

Table 2. Mean and *SD* are presented for the 1-repetition maximum (%1RM) within each 5% range of loads relative to maximum strength.*

%1RM	*n* (No. participants)	Mean (*SD*) load within this range (%1RM)	Mean (*SD*) RPE for this load
30–34%	3	32.7 (1.5)	8.7 (1.5)
35–39%	5	37.6 (1.1)	10.2 (2.4)
40–44%	7	42.7 (1.5)	9.8 (1.8)
45–49%	11	47.4 (1.3)	9.5 (2.0)
50–54%	11	51.9 (1.4)	11.0 (2.4)
55–59%	12	56.9 (1.6)	12.2 (2.2)
60–64%	13	62.0 (1.4)	13.0 (1.1)
65–69%	14	67.1 (1.4)	14.0 (2.1)
70–74%	13	72.4 (1.3)	13.8 (2.2)
75–79%	12	77.3 (1.3)	15.8 (1.7)
80–84%	17	82.0 (1.1)	16.0 (1.9)
85–89%	12	87.3 (1.1)	16.3 (1.9)
90–94%	8	92.6 (1.6)	16.9 (1.5)
95–99%	2	96.0 (1.4)	17.0 (0.0)
100–104%	2	100.0 (0.0)	18.0 (2.8)
105–109%	2	106.5 (0.7)	19.0 (1.4)

*The number of participants who achieved a load within this range and the corresponding mean rating of perceived exertion (RPE) for this load are identified. If a subject achieved more than one load within a given range, a mean score was included in the analysis for that subject.

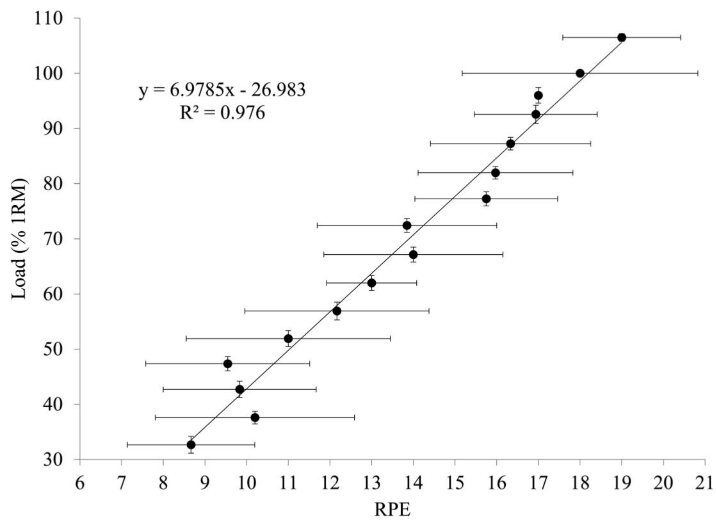

Figure 1. Rating of perceived exertion significantly predicted load on the chest press, relative to the 1 repetition maximum. Error bars are standard deviations.

Statistical Analyses

Each load experienced and rated for RPE during session 1 was calculated as %1RM by dividing by the highest load lifted during session 2 and multiplying by 100. A regression analysis that would include all data points (up to 7 loads) for all subjects combined could not be conducted without violating the assumption of independence that each observation is from a different subject. Because of this, the RPE scores were averaged across subjects for each 5% range of 1RM from 35% 1RM to 110% 1RM. For each 5% 1RM range, a different number of subjects were included in the calculation of the mean %1RM and RPE, according to how many subjects had attempted a load that fell within that range (Table 2). Regression analysis was used to determine if the average RPE for each load predicts the average %1RM during chest press ERT. Previous research has revealed no difference in RPE between sexes for resistance training (9,11). Therefore, results from both men and women were included in the single regression analysis. All subject characteristics, RPE, and %1RM variables passed tests of normality (Kolmogorov-Smirnoff, Shapiro-Wilk) and the Levene's test for equality of variances between the sexes. Two-tailed, independent *t*-tests were used to test for (a) sex differences on subject characteristics (age, height, and weight) and (b) sex differences on the RPE for 2 loads: a high-intensity (80–85% 1RM) load relevant to strength and power (4) and a low-intensity load (45–50% 1RM) relevant to balance function (15). Four loads were repeated during session 1 to evaluate the repeatability of the RPE using the Intraclass Correlation Coefficient (ICC) between the first and second experience with the load during session 1.

Descriptive statistics (mean and *SD*, and confidence intervals [CI]) were calculated for the 1RM (in %BW). Both absolute and relative 1RM, height, and weight, were compared between sexes using independent *t*-tests. The alpha level of significance for all tests conducted was $p \leq 0.05$.

Table 3. The predicted 1-repetition maximum (% 1RM) corresponding with each Borg rating of perceived exertion (RPE) level is displayed for the chest press in older adults.*

Qualitative description	RPE	Predicted %1RM†
Maximal	20	113
Very, very hard	19	106
	18	99
Very hard	17	92
	16	85
Hard	15	78
	14	71
Somewhat hard	13	64
	12	57
Fairly light	11	50
	10	43
Very light	9	36
	8	29
Very, very light	7	22
	6	15

*The predicted %1RM was obtained from the regression equation (Figure 1).
†Rounded to the nearest whole number.

Results

Rating of perceived exertion significantly predicted the %1RM corresponding with chest press ERT loads (R^2 = 97.6%, SEE 3.6, $p < 0.001$; Figure 1). The predicted %1RM at the maximal rating (RPE = 20) exceeded 100% 1RM (Tables 2 and 3 and Figure 1). This may reflect the difficulty in obtaining a true 1RM in some older adults; 3 participants lifted a higher load during session 1 than during the 1RM test on session 2. Rating of perceived exertion demonstrated moderate repeatability between the first and second exposures of the same load during session 1 (ICC = 0.778).

Males had significantly greater body size and absolute load lifted than females for all subject characteristics. The 1RM (as %BW) and age were not different between men and women (Table 1). Men and women perceived high loads equally, when they were calculated relative to their maximum strength. For a heavy load in the range of 80–84% 1RM, rated by 17 participants (10 men, 7 women), the load was larger for men as both an absolute load (mean [*SD*] for men: 60.2 [12.7] kg, and for women: 36.5 [9.5] kg, $t(15) = -4.182$, $p = 0.001$) and as a load relative to BW (mean [*SD*] for men: 72.25 [10.96] %BW, and for women: 56.63 [14.5] %BW, $t(15) = -2.538$, $p = 0.023$). However, for both men and women, because this load was 80–85% 1RM for each participant, there was no sex difference in the RPE for this load (mean [*SD*]: RPE of 16.0 [1.8] and 15.9 [2.0] for men and women, respectively; $t(15) = -0.076$, $p = 0.94$). This rating of ~16 corresponds with "hard" to "very hard" on the Borg RPE scale. For a light load in the range of 45–49% 1RM, rated by 11 participants (5 men, 6 women), the load was larger for men as both an absolute load (mean [*SD*] for men: 40.8 [10.0] kg, and for women: 21.3 [5.0] kg, $t(9) = -4.206$, $p = 0.002$) and a load relative to BW (mean [*SD*] for men: 49.0 [13.9] %BW, and for women: 33.8 [7.7] %BW, $t(9) = -2.313$, $p = 0.046$). However, for both men and women, this load was calculated as falling between 45 and 49% 1RM. There was no sex difference in the RPE for this load (mean [*SD*] for men: 9.2 [1.8] and for women: 9.8 [2.2]; $t(9) = 0.511$, $p = 0.62$). This rating of ~9–10 corresponds with "very light" to "fairly light" on the Borg RPE scale.

Discussion

As demonstrated in our previous work with the leg press exercise (16), ERT loads relative to the 1RM were well predicted by RPE for older adults during the chest press exercise. This is consistent with findings from previous research studying the perceived exertion of young adults with traditional resistance training loads on the leg press and chest press (20). It is important to note that the RPE was recorded for loads during session 1 before it was known how the loads related to the subjects' 1RM, which was conducted during session 2. This means that the subjects' ratings were not influenced by a recent experience with the load representing their maximum strength on the chest press exercise. Instead, the subjects were naive to the load; their ratings were not anchored by a recent experience with the 1RM load, unlike in some previous studies (8,13).

Explosive resistance training loads that would elicit both strength and power gains (70–90% 1RM) (4) corresponded with an RPE of 14–17 in the present study. This range of RPE may be useful as a starting point for older adults when selecting ERT loads with the intention to improve both strength and power. Explosive resistance training loads that are associated with balance function when applied to the lower extremity (40–60% 1RM) (16) corresponded with an RPE of 10–12. The latter range, around 50% 1RM, may be relevant for chest press, because it was the %1RM where peak power for the chest press occurred for resistance-trained young men (19). Similarly, for older adults trained using high-velocity power training on the leg press, peak power shifted from a higher relative load (67% 1RM) before training to a lower load (52% 1RM) after training (18), a range which would be found around 11–13 on the RPE scale for the chest press in the present study that tested older adults with resistance training experience. Previous studies have reported conflicting results regarding the equivalence of RPE at a given relative resistance training load for individuals who are strength trained and those who are novice lifters (12,20), though none have tested the effects of resistance training experience on RPE ratings of older adults using ERT. That the results of the present study are highly similar to our previous findings for ERT loads on the leg press exercise for older adults (16), suggesting a similarity in the subjective rating of ERT loads in the upper and lower extremities for the multijoint exercises of leg press and chest press for older adults.

The significance of the present study's results is that the use of the Borg RPE scale to select ERT loads is simple to use as it does not require an anchoring method, and it avoids maximal strength testing. This may encourage the adoption of ERT for a broader spectrum of seniors in exercise and rehabilitation settings where muscle strength and power gains are the focus. The use of this approach throughout an ERT exercise program with older adults has not yet been evaluated, though it has been demonstrated that the absolute loads at specific ratings on the OMNI scale increased throughout a resistance training intervention, indicating that the scale was useful for tracking the relative load throughout a resistance training program (10). New evidence suggests that these relationships may not sustain under conditions of fatiguing exercise (21). The affect this may have on the use of RPE for an ERT program has not yet been evaluated.

Limitations of this study include the use of a healthy older adult population, so it is not known whether the results of this study are applicable to frailer older adults. Furthermore, it cannot be projected whether the results apply to single-joint exercises, to other exercises not tested here, or even to chest press using alternate equipment. Lastly, the small sample size limits generalizability.

In conclusion, the results of the present study confirm that loads using the chest press, a multijoint upper-extremity exercise, can be selected for ERT using the RPE scale, as has previously been found using the leg press exercise. This may ease the ability to select useful loads for ERT with older adults. The use of this approach for ERT with older adults throughout a training program has not yet been evaluated.

Practical Applications

This study confirms that ERT of the upper extremity using the chest press exercise can be regulated using the Borg RPE scale. This approach has now been demonstrated in a lower-extremity (16) and an upper-extremity multijoint exercise. This approach confirms that a 1RM test is not necessary to select ERT loads to begin a training program, but rather the loads can be selected based on RPE, simplifying the process for personal trainers and older adult exercisers. The numbers on the RPE scale can be a guide when selecting ERT loads. For example, an RPE between 14 and 16 corresponds with loads in the range of ~70–90% 1RM for ERT, a stimulus that is known to significantly improve strength and power simultaneously in older adults (7). Additionally, an RPE of 12 and lower corresponds with loads less than ~60%, which is the range of ERT intensity that is related to balance function in the lower extremity (33) and may relate to rapid recovery movements in the upper extremity.

It not yet known whether RPE would be effective for regulating training intensity throughout the course of an ERT intervention (e.g., would an RPE of 16 relate with a relative load of ~85% 1RM for the duration of an ERT program?), though perceived exertion ratings using the OMNI scale seem to be useful for confirming loads throughout a progressive resistance training intervention (10). It is also unknown whether the load-RPE relationship identified here would apply similarly to other exercises beyond the leg press (16) and chest press.

Even given the remaining unknowns surrounding this approach, the present study's results can be used by exercise professionals who aspire to improve strength and power in their older adult clients by implementing an ERT program that does not require maximal strength testing. This can be done by asking the exercise participant to use the Borg RPE scale to select the intended load by rating how heavy or light the load feels when performing the concentric phase rapidly, while the eccentric phase is performed slowly, and making adjustments until a load in the intended range is identified.

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