***International Journal of Sports Physiology and Performance*, (Ahead of Print)**
https://doi.org/10.1123/ijspp.2020-0065

Human Kinetics
ORIGINAL INVESTIGATION

The Effects of Lifting Lighter and Heavier Loads on Subjective Measures

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Background: Despite the progress made in the study of subjective measures in resistance training, some questions remain unanswered. Here the authors investigated if ratings of perceived exertion (RPE) can predict task failure and bar velocity across exercises and loads as a primary outcome and whether a battery of subjective measures differ as a function of the lifted loads as a secondary outcome. ***Methods:*** In this preregistered study, 20 resistance-trained subjects (50% female) first completed a 1-repetition-maximum test of the barbell squat and bench press. In the second and third sessions, they completed 2 sets of squats followed by 2 sets of bench press to task failure, using 70% or 83% of 1-repetition maximum, while bar velocity was recorded. RPE scores were recorded after every repetition. In addition to RPE, rating of fatigue, affective valence, enjoyment, and load preferences were collected after set and session completion. ***Results:*** Across conditions, RPE was strongly correlated with reaching task failure ($r = .86$) and moderately correlated with bar velocity ($r = -.58$). The model indicates that an increase in 1 RPE unit is associated with an 11% shift toward task failure and a 4% reduction in bar velocity, with steeper slopes observed in the heavier condition. Negligible differences were observed between the load conditions in rating of fatigue, affective valence, enjoyment, and load preference. ***Conclusion:*** RPE scores, collected on a repetition-by-repetition basis, accurately reflected reaching task failure across loads and conditions. Hence, RPE can be used to prescribe repetition numbers during ongoing sets. The negligible differences between load conditions in rating of fatigue, affective valence, enjoyment, and load preference indicate that when sets are taken to task failure, loads can be selected based on individual preferences.

Keywords: autoregulation, resistance training, RPE

Some research indicates that lifting light (eg, >60% of 1-repetition maximum [1-RM]) or heavy loads (eg, >60% of 1-RM) to task failure or approximate task failure can lead to comparable muscular hypertrophy and, to a lesser extent, muscle strength.[1–3] These findings are practically useful as they allow trainees to select loads aligned with their preferences, assuming approximate task failure is reached. We note that in this article we refer to task failure as an umbrella term that encompasses set termination due to subjects' perception of their inability to complete another repetition (ie, repetition maximum), as well as subjects' actual inability to complete a given repetition (ie, momentary failure). While numerous studies investigated the physiological responses resulting from lifting different loads,[1–3] a comprehensive investigation of the subjective responses is currently missing (but see Ribeiro et al[4] for an exception). Subjective responses include, but are not limited to, perception of effort, fatigue, and affective valence (expanded upon below). By measuring the subjective responses associated with lifting different loads, important pieces of information can be collected and acted upon when monitoring and prescribing resistance training programs.

Perceived effort can be defined in various ways, and measured using numerous rating of perceived effort (RPE) scales. Broadly speaking, RPE scales are meant to capture the extent of effort/resources invested in a given task relative to one's perceived maximum.[5] In regards to resistance training, a number of studies observed that when sets are taken to task failure with different exercises, RPE scores after set completion are similar regardless of the lifted load.[6–11] These studies shed light on the relationships between RPE scores reported after set completion and task failure across loads and exercises. A required next step is to investigate the relationship between RPE scores reported after each repetition and reaching task failure across loads and exercises. Assuming that subjects' RPE scores reported after every repetition can predict proximity to task failure, then sets can be terminated based on reaching certain RPE scores (eg, RPE of 8/10), rather than a predetermined number of repetitions (eg, 10 repetitions), regardless of the loads.

Lifting different loads can lead to different perception of fatigue, which can be defined as a feeling of diminishing capacity to cope with physical or mental stressors.[12] Higher levels of perceived fatigue can indicate insufficient recovery and hinder performance in subsequent sets or training sessions. Moreover, different loads can lead to different levels of affective valence, which can be defined as the extent by which one feels good or bad.[13] Negative affect during exercise is associated with lower levels of exercise adherence and a feeling of burnout.[14,15] Hence, if certain loads increase perception of fatigue and negative affect during, as well as after sessions, then this should be considered when selecting loads for resistance training programs. Excluding one recent study,[4] little is known about subjects perception of fatigue and affective responses when lifting heavier and lighter loads taken to task failure.

In view of the above, the aims of this study were twofold. The primary purpose was to investigate whether RPE scores, reported after every repetition by resistance-trained subjects, can predict task failure and bar velocity in 2 exercises (squat and bench press) using 2 loads (70% and 83% of 1-RM). The secondary purpose was to examine if the 2 load conditions lead to different perception of

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fatigue, affective valence, enjoyment, and preferences of load, reported after sets and sessions completion. We expected that RPE will be strongly correlated with reaching task failure in both experimental sessions, and that in the heavier load condition RPE patterns will be steeper throughout the sets. This is because subjects would be able to perform less repetition using heavier loads and therefore would start the set closer to task failure. We also expected that under the heavier load condition, ratings of fatigue will be lower, ratings of affective valence and enjoyment will be higher, and that subjects will mostly prefer lifting heavier loads. This is because lifting lighter loads to task failure has been shown to lead to higher heart rate[16] and higher ratings of discomfort.[7,11]

Methods

Subjects

Sample size was determined a priori to be 20 subjects, as indicated by a statistical power calculation based on a similar study conducted in our laboratory. This sample would allow us to detect a medium–large effect size in this within-subject design. Specific details about the power analysis can be found in the preregistration form of this study available at https://rb.gy/gky7h8. Twenty resistance trained subjects volunteered to participate in this study (Table 1). Inclusion criteria included healthy subjects between the ages of 18 and 45 years; a bench press 1-RM of at least 1.2 and 0.7 times the bodyweight for men and women, respectively; and at least 1.2, and 1 times the bodyweight in the squat. Subjects had to have at least 1 year of resistance training experience, specifically at performing the free weight squat and bench press. In addition, subjects had to have some familiarity with taking sets to task failure. Each subject signed an informed consent on the first day. This study was approved by the Tel Aviv University institutional review board.

Table 1 General Demographics, Mean (SD); Range

Variable	Females (n = 10)	Males (n = 10)
Age, y	29 (4); 23–38	30 (4); 22–37
Height, cm	166 (6); 156–167	175 (6); 167–185
Weight, kg	62 (8); 52–75	78 (4); 72–86
Experience in RT, y	3 (2.3); 1–8	9 (4); 3–18
Mean workouts per week	3 (1);1–5	3.4 (0.8); 2–5
1-RM barbell bench press, kg	45 (10); 31–60	99 (14); 75–130
1-RM/body-weight bench press	0.71 (0.12); 0.5–0.9	1.29 (0.22); 1–1.7
Average velocity 1-RM barbell bench press, $m \cdot s^{-1}$	0.15 (0.02); 0.11–0.16	0.15 (0.04); 0.09–0.22
1-RM barbell squat, kg	73 (15); 55–100	126 (20); 100–155
1-RM/body-weight squat	1.18 (0.25); 0.8–1.2	1.6 (0.27); 1.2–1.6
Average velocity 1-RM barbell squat, $m \cdot s^{-1}$	0.28 (0.04); 0.20–0.38	0.27 (0.04); 0.20–0.26

Abbreviations: 1-RM, 1-repetition maximum; RT, resistance training.

Measures

Bar Velocity. Average concentric velocity (in meters per second) of the barbell was measured using GymAware PowerTool (GymAware, Canberra, Australia) linear position transducer. The GymAware was synced with a tablet application that displayed the average concentric velocity of each repetition and exported the data as an excel file. According to the instructions of the manufacturers, the unit was placed on the same marked area on the floor, perpendicular to the right side of the barbell. The cable was secured with a velcro strap ~4 cm inward to the right tip of the barbell.

Self-Report Measures. RPE was measured using a scale developed by Steele et al[17] as the instructions and anchors were thought to be best suited for the purpose of this study due to their focus on resistance training. The 11-point scale ranges from 0 (no effort) to 10 (maximal effort). Zero was anchored at total rest and 10 at reaching task failure in a given set. Subjects were asked to provide an answer to the question "how much effort did you exert?" at the top of the scale. Importantly, subjects were explicitly requested to only report their effort experienced during the set, rather than other perceptions such as fatigue or force.[5] Of note, here we refer to the terms "effort" and "exertion" synonymously. See Supplementary Materials (available online at https://rb.gy/tee1f1) for the test–retest reliability data of the RPE scores using this RPE scale in our laboratory. Since subjects were required to rate the scale on each and every completed repetition across all sets, a large (33 × 48 cm) poster of the RPE scale was hung on the wall in front of them when they were squatting and secured above their heads when they were bench pressing (see Figure 1). Subjects verbally rated their RPE after the completion of each repetition, that is, after the end of the concentric phase. The ratings were recorded with a tie-on microphone for later transcription and analysis. Subjects were requested to take a minimal break between repetitions to report their RPE. In practice, this resulted in ~2-second interval between the end of one repetition and the initiation of the next.

Affective valence was measured using the feeling scale (FS).[18] The FS is an 11-point scale, ranging from +5 (very good) through 0 (neutral) to −5 (very bad). Subjects were asked to provide an answer to the question "How do you feel?" presented at the top of the scale within ~10 seconds after set completion.

Fatigue was measured with the rating of fatigue scale (ROF).[12] The 11-point scale ranges from 0 (not fatigued at all) to 10 (total fatigue and exhaustion—nothing left). Subjects were required to rate how fatigued they were at that moment. Subjects were asked to provide an answer to the question "How fatigued are you?" presented at the top of the scale within ~10 seconds after set completion. The ~10-second time period was selected for FS and ROF as we aimed to collect these measures as soon as possible post set completion, while still allowing subjects to sit down and observe the scales prior to rating them, as some preferred.

Exercise enjoyment was measured with the exercise enjoyment scale.[19] The 7-point scale ranged from 1 ("not at all") to 7 ("extremely"). Subjects were asked to provide an answer to the question "How much did you enjoy the exercise session?" presented at the top of the scale 3 minutes after the last set and after 3, 6, and 24 hours. The rationale for including the different time frames is that immediately postexercise the experience of enjoyment could be affected by physiological responses (eg, lactate) in contrast to few hours later. Finally, we asked subjects which condition they preferred if they were to incorporate such a training method in their regular regime (higher load/lower load) 48 hours after the final session.

Figure 1 — Depiction of the experimental setup. Subjects verbally rated their rating of perceived exertion after each completed repetition in both exercises. A poster of 33 × 48 cm was hung on the wall in front of them and secured above their heads during the squat and bench conditions, respectively.

We note that in this study we also collected subjects' estimation of the number of repetitions they expected to complete prior to each set. However, due to word restriction and the fact that this topic is remote from the questions at hand, the analysis, results and brief discussion of this measure are reported in the Supplementary Materials (available online at https://rb.gy/tee1f1). Since this study was conducted in Hebrew, all scales first underwent the necessary translation and validation processes. For a detailed account please see Emanuel et al.[20]

Procedures

All sessions were performed in the same facility and ran by the same experimenter at approximately the same hour of the day (±2 h). A minimum of 3 and a maximum of 8 days between sessions were allowed. Subjects were asked to refrain from an intense training session 24 hours prior to testing days that may lead to performance decrements and muscle soreness, involving the squat and bench-press exercises. Subjects were also asked to avoid a heavy meal and caffeinated drinks or supplements at least 3 hours before sessions.

1-RM Tests and Familiarization (Session 1). At the beginning of the first session, subjects were weighed, indicated their height, age and experience in strength training. They were then introduced to the 4 single-item scales and briefed on the study's aims. All subjects then performed a squat to a height adjustable box which was individually set to achieve a knee angle of ~115° to 120° (mean knee angle = 118, SD = 5.93). Subjects then completed a general warm-up followed by a specific squat warm-up leading to the squat 1-RM test. They then completed a specific bench-press warm-up leading to the bench press 1-RM test. The warm-up and 1-RM protocols are reported in detail in Emanuel et al.[20] Briefly, the general warm-up consisted of dynamic stretching and calisthenics, and a 5-minute individualized self-selected warm-up. The specific warm-up consisted of a gradual increase of the lifted loads toward an estimated 1-RM. At the end of the session, subjects performed familiarization sets of 5 to 8 repetitions of the experimental procedure with an empty barbell—2 sets of squats and 2 sets of bench presses. Subjects verbally rated their RPE after every repetition during the set and were requested to attempt and complete the concentric portion of the lift as fast as possible. ROF and FS were rated between sets.

Experimental Sessions (Sessions 2–3). At the beginning of each session, subjects were reminded of the self-report measures and performed the warm-up protocols. The 70% and 83% loads were selected as they are within the recommended range for development of hypertrophy and strength across novice, intermediate and trained practitioners.[21] Yet, lifting these 2 loads to task failure can be expected to lead to considerable differences in the number of repetitions people are able to complete.[6,20] Two of the warm-up sets were used to practice the experimental procedure, in which subjects rated all scales. Following the last warm-up set, subjects rested for 2 minutes and performed 2 sets to task failure with either 70% of 1-RM in the squat followed by the bench press, or with 83% of 1-RM. About 6 minutes of rest were provided between sets and exercises. Subjects were instructed to perform the concentric portion of the lifts as fast as possible, while maintaining a controlled ~2-second descend until lightly touching the box below them after which they immediately began the concentric portion. Within each set, subjects rated their RPE after each repetition. Ten seconds after set completion, they provided their ROF and FS ratings. Task failure was determined either by the following: (1) inability to complete a repetition, (2) subjects' decision to terminate the set based on their assumption that they cannot complete another repetition, or (3) technical failure which was determined by the experimenter (eg, extreme rounding of the lower back or knee valgus).

Statistical Analysis

Primary Outcomes. To assess the relationships between RPE and failure proximity and bar velocity, we transformed the raw data of repetition number and bar velocity into percentage. This was done to reduce the between-subject variability stemming from the different number of repetitions subjects were expected to complete, and different bar velocities between subjects. For failure proximity, we divided each completed repetition by the last repetition within a given set for each subject and multiplied these fractions by 100 to turn them into percentage (eg, the fifth and tenth repetitions out of 15 completed are considered to be 33% and 75% away from task failure, respectively). With bar velocity, velocities of all repetitions were divided by the fastest one and multiplied by 100. We then tested linear, and quadratic mixed models once with failure proximity and once with bar velocity as the dependent variable and RPE as the predictor, nested within subjects (RPE was treated as a continuous variable following the recommendations of Rhemtulla et al[22]).

We examined the best-fitted trend by comparing the linear and quadratic models for the best goodness of fit, as indicated by the deviance statistic. We then examined whether this trend differs between loads by testing if the condition variable (dummy coded as light condition = 0) increases model fit compared with the previous best-fitted model. We added random slopes as recommended by Bliese and Ployhart[23] as long as their addition did not result in a convergence error. We used the same approach to examine exercise differences (bench press exercise was dummy coded as 0). Conditional R^2 for mixed regression models was calculated to quantify the explained variance of each model. We also calculated repeated-measures correlations[24] between RPE and each dependent variable, to ease the linear regression interpretation.

Secondary Outcomes. We analyzed FS and ROF ratings as the dependent variables in a 2 (condition: light/heavy) × 2 (exercise: bench press/squat) repeated-measures analysis of variance. We tested whether enjoyment was affected by either load or time in a 2 (condition: light/heavy) × 4 (time: immediately postexercise/3 h postexercise/6 h postexercise/24 h postexercise) repeated-measures analysis of variance. If the assumption of sphericity was violated, as indicated by Mauchly test, we employed a Greenhouse–Geisser correction. Post hoc contrasts were Holm corrected for multiple comparisons. Last, to estimate subjects' preference, we calculated the proportion of choices for the high-load condition. Significance was set at $P < .05$. When relevant, 95% confidence intervals (CIs) are reported. Statistical analyses and figures were carried out with R (version 3.6.0; R Core Team, R Foundation for Statistical Computing, Vienna, Austria) using the following packages: lme4, lmeTest, ez, emmeans, afex, multcomp, piecewiseSEM, rmcorr, and ggplot2.

Results

Summary statistics of repetitions performed in each set are presented in the Supplementary Materials (available online at https://rb.gy/tee1f1). Summary statistics and CIs of the differences between conditions, exercises, and sets of the final RPE repetition, ROF, FS and estimation accuracy are presented in Table 2. The data used for the main analyses are available at https://rb.gy/tee1f1.

Primary Outcomes

Prediction of Failure Proximity From RPE. Due to the negligible difference between the linear and quadratic models for the failure proximity and velocity, here we report the results of the linear model with a random intercept in the failure proximity and velocity analyses and a comparable full analysis using the quadratic model in the Supplementary Materials (available online at https://rb.gy/tee1f1). Across conditions, a quadratic ($R^2 = .80$) model better fitted

Table 2 Absolute Mean (SD) Values of All Variables for Both Exercises Under Both Load Conditions Across the 2 Sets

Exercise	Condition	Set 1	Set 2
Last repetition RPE			
Bench	70%	9.6 (0.6)	9.5 (0.6)
	83%	9.4 (0.6)	9.5 (0.5)
Mean and 95% CI		0.1 (−0.2 to 0.5)	0 (−0.3 to 0.2)
Squat	70%	9.5 (0.5)	9.4 (0.5)
	83%	9.5 (0.5)	9.6 (0.5)
Mean and 95% CI		0 (−0.2 to 0.2)	−0.1 (−0.4 to 0.2)
Feeling Scale			
Bench	70%	2.3 (1.8)	2.0 (2.0)
	83%	1.85 (2.1)	2.6 (1.9)
Mean and 95% CI		0.5 (−0.10 to 1.0)	−0.5 (−1.0 to −0.1)
Squat	70%	1.9 (1.9)	1.9 (2.1)
	83%	1.8 (2.0)	1.8 (2.4)
Mean and 95% CI		0.1 (−0.6 to 0.7)	0.1 (−0.2 to 0.5)
Rating of fatigue			
Bench	70%	5.7 (1.6)	6.2 (1.8)
	83%	5.6 (0.9)	6.2 (2.0)
Mean and 95% CI		0.1 (−0.4 to 0.7)	0 (−0.8 to 0.8)
Squat	70%	6 (2.0)	6.7 (2.0)
	83%	6.2 (1.9)	6.7 (1.8)
Mean and 95% CI		−0.2 (−1.0 to 0.68)	0 (−0.9 to 0.9)

Abbreviations: CI, confidence interval; last repetition RPE, rating of perceived exertion from the last repetition of the set. Note: Mean differences and 95% CI of the absolute differences are also reported.

the data compared with the linear model ($R^2 = .78$), but without a considerable difference. Overall, across exercises and loads, RPE ratings were highly associated with failure proximity ($r = .86$, $P < .001$, 95% CI, .85 to .87; see Table 3), as presented by the following equation:

$$\text{Failure proximity} = -26 + 11.67 \times \text{RPE}$$

The addition of the condition variable increased model fit ($P < .001$). This model further revealed a steeper slope in the heavier ($b = 14$) compared with the lighter ($b = 11.4$, $P < .001$) condition (see Figure 2). In other words, an increase in one unit of RPE corresponds to 11.4% and 14%, approach toward task failure in the 70% and 83% conditions, respectively (note that 0 represents no repetitions completed within a set whereas 100% represents task failure). No significant differences in slopes were found between exercises ($b = -0.5$, $P = .734$; 95% CI, –0.32 to 0.23).

Prediction of Velocity From RPE. Overall, across exercises and loads, RPE ratings were moderately associated with barbell velocity ($r = -.58$, $P < .001$; 95% CI, −.61 to −.54; see Table 3), as presented by the following equation:

$$\text{Velocity} = 108.21 - 4.30 \times \text{RPE}$$

The addition of the condition variable increased model fit ($P < .001$). This model further revealed a steeper slope in the heavy

Table 3 Mixed Model Regression Results

Model	Term	Estimate (*b*)	SE	*t* statistic (df)	*P*	95% CI (LL to UL)	Model R^2
Prediction of proximity to failure from RPE							
Baseline	RPE	11.67	0.16	72.02 (1776.40)	<.001	11.35 to 11.99	.78
Condition interaction	RPE × condition	18.07	2.66	6.78 (1765.24)	<.001	12.98 to 23.36	.79
Lighter condition only	RPE	11.39	0.18	63.24 (1165.57)	<.001	11.03 to 11.79	.81
Heavier condition only	RPE	14.04	0.31	44.40 (599.12)	<.001	13.39 to 14.62	.81
Prediction of velocity from RPE							
Baseline	RPE	–4.30	0.15	–27.75 (1543.02)	<.001	–4.59 to –3.99	.43
Condition	RPE × condition	–9.52	2.61	–3.64 (1526.74)	<.001	–14.58 to –4.81	.45
Lighter condition only	RPE	–3.93	0.17	–22.25 (1021.58)	<.001	–4.29 to –3.56	.42
Heavier condition only	RPE	–5.87	0.31	–18.46 (517.07)	<.001	–6.48 to –5.25	.53

Abbreviations: CI, confidence interval; LL, lower limit; RPE, rating of perceived exertion; UL, upper limit.

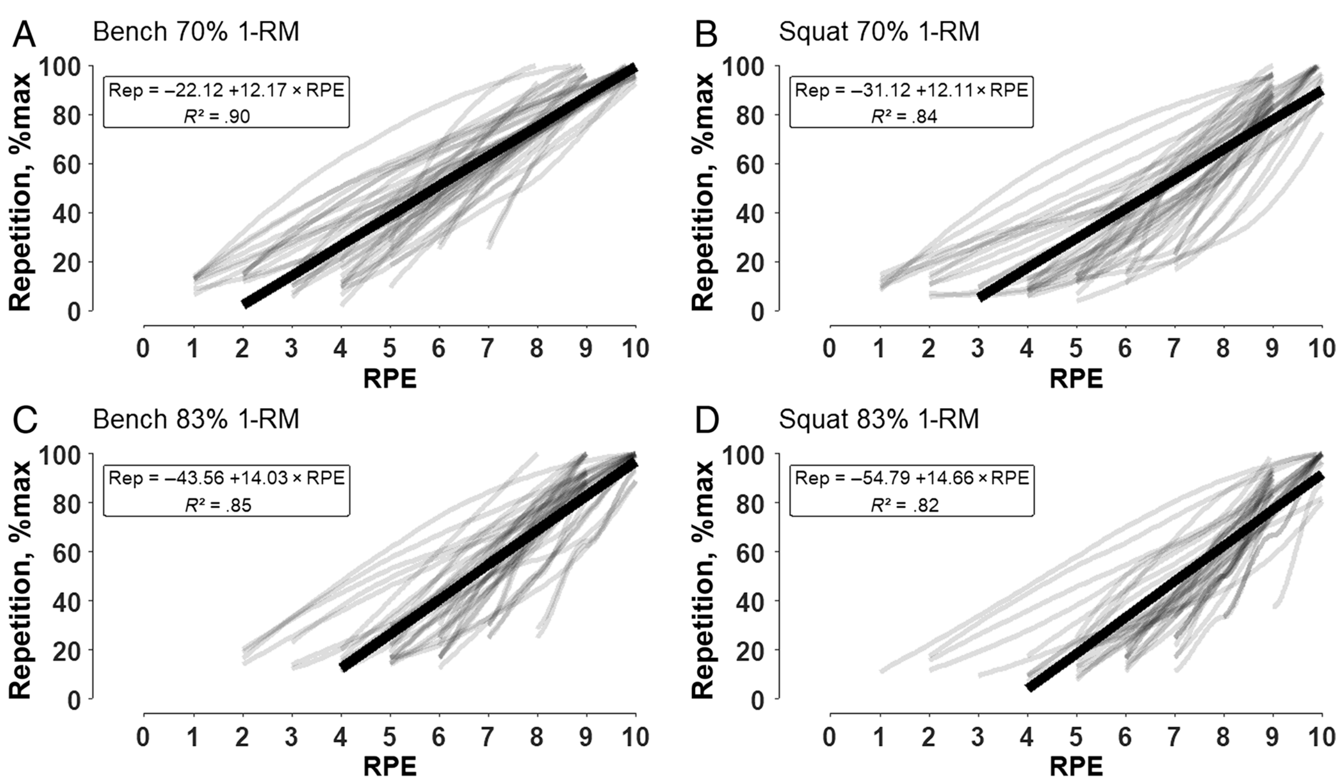

Figure 2 — Fitted mixed regression models predicting failure proximity from RPE ratings. Panels A to D depict the trend of RPE over failure proximity for each subject using the LOESS method in gray lines and the fitted regression model in a black line. (A) Bench 70% 1-RM, (B) squat 70%1-RM, (C) bench 83% 1-RM, and (D) squat 83%1-RM. 1-RM indicates 1-repetition maximum; LOESS, locally estimated scatterplot smoothing; RPE, ratings of perceived exertion.

($b = -5.8$) compared with the light condition ($b = -3.9$, $P < .001$; see Figure 3). In other words, an increase in one unit of RPE corresponds to 3.9% and 5.8%, decrease in barbell velocity in the 70% and 83% conditions, respectively (note that 0 represents no velocity whereas 100% represents the fastest repetition completed within a set). A significant difference was found between exercises ($b = -0.75$, $P < .001$; 95% CI, −1.03 to −0.46), indicating that the slope in the bench press ($b = -5.68$, $P < .001$; 95% CI, −6.12 to −5.24) was steeper than the slope in the squat ($b = -3.81$, $P < .001$; 95% CI, −4.17 to −3.42).

Secondary Outcomes

Overall Differences in ROF and FS. No significant difference in ROF ratings was found between conditions ($F_{1,19} = 0.001$, $P = .969$, $\eta_p^2 < .001$) and exercises ($F_{1,19} = 2.38$, $P = .138$, $\eta_p^2 = .11$). No significant difference in FS was found between conditions ($F_{1,19} = 0.007$, $P = .931$, $\eta_p^2 < .001$), but a significant difference was found between exercises ($F_{1,19} = 7.82$, $P = .011$, $\eta_p^2 = .29$). This indicates that compared with bench press (mean = 2.20, SD = 2.00), FS ratings were lower after completing the squat (mean = 1.86, SD = 2.12). No significant exercise by condition interactions was found for either the ROF or the FS (see Table 2).

Exercise Enjoyment. No effects were found for either condition ($F_{1,16} = 0.05$, $P = .814$, $\eta_p^2 = .004$), time ($F_{3,48} = 1.55$, $P = .212$, $\eta_p^2 = .09$), or the time by condition interaction ($F_{3,48} = 2.60$, $P = .062$, $\eta_p^2 = .06$). The ratings across conditions, exercises and time points remained stable around the score 5 (0.3).

Discussion

In this study, subjects performed 2 sets of bench press and squat using 2 different loads (70% and 83% of 1-RM). Subjects reported RPE after each repetition, ROF and FS after each set, enjoyment immediately after the session, as well as 3, 6, and 24 hours postsession completion, and their load preference 48 hours after the final session. RPE scores were highly associated with failure proximity across exercises and loads, and moderately associated with bar velocity. However, RPE increased in a steeper manner under the heavier load condition. No meaningful differences were observed in ROF, FS, and enjoyment across exercises and loads, and 50% of subjects preferred the heavier load condition.

To our knowledge, the current study is the first to investigate the relationship between RPE scores reported on a repetition-by-repetition basis, and the point of reaching task failure. The strong and nontrivial linear relationship observed between RPE and task failure has practical benefits. Mainly, the results imply that RPE ratings can be used if one wishes to terminate a set at a certain percentage away from task failure, or after a certain percentage of bar velocity loss. For example, our equations predict that RPE scores of 8 and 9 roughly correspond to reaching 70% and 80% of task failure, and to a 25% and 30% loss of bar velocity, respectively, regardless of exercise and load. More precise estimation can be achieved if using the equations presented in Figures 2 and 3, which are exercise and load specific. Given that improvement in muscular hypertrophy and strength occur when sets are taken to task failure, or approximate task failure, regardless of loads lifted,[1–3,25,26] then deciding on set

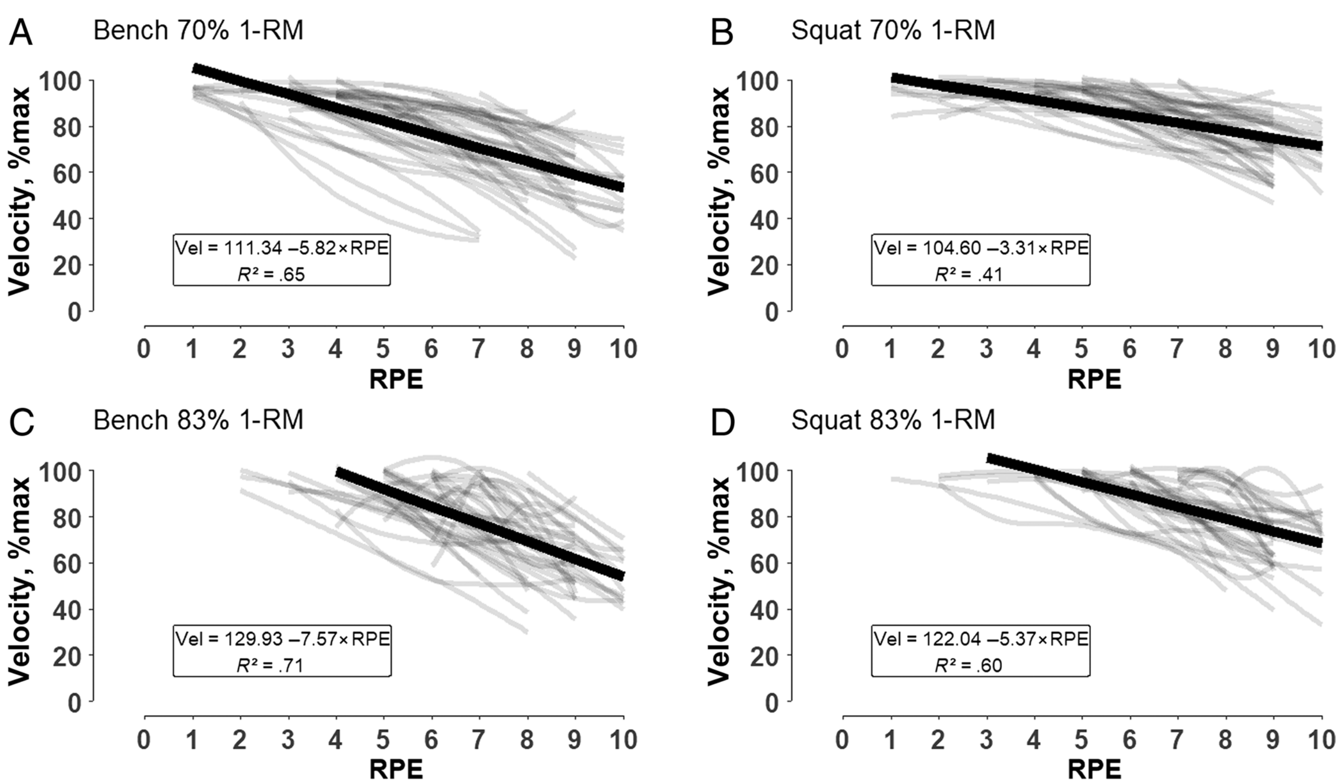

Figure 3 — Fitted mixed regression models predicting barbell velocity from RPE ratings. Panels A to D depict the trend of RPE over failure proximity for each subject using the LOESS method in gray lines and the fitted regression model in a black line. (A) Bench 70% 1-RM, (B) squat 70% 1-RM, (C) bench 83% 1-RM, and (D) squat 83% 1-RM. 1-RM indicates 1-repetition maximum; LOESS, locally estimated scatterplot smoothing; RPE, ratings of perceived exertion.

termination based on RPE scores can be used as an effective training strategy. Such an approach has recently shown to be effective in a recent study conducted among older adults over a 12-week period. Prescribing set termination based on RPE scores (8/10) led to similar muscular adaptations compared with a traditional prescription strategy, based on a predetermined number of repetitions.[27]

Several studies compared RPE scores between loads in sets taken to task failure. However, RPE scores were mostly collected after set completion,[6,7,11] which does not allow for a direct comparison with the present study. A few studies collected RPE scores after each repetition during sets taken to task failure across different loads and exercises.[8–10] Yet, since these studies attempted to answer different questions, the relationships between RPE and failure proximity were not reported, which limits our ability to compare between studies. Accordingly, future work should directly and conceptually replicate this study, by examining how RPE changes during ongoing sets as a function of loads, training backgrounds, and exercises. This would help solidify and expand upon the observed relationships between RPE collected during sets and failure proximity, as well as bar velocity.

The ROF, FS, and enjoyment ratings were similar between exercises and loads. This was somewhat unexpected because lifting lighter loads lead to higher heart rate,[16] higher ratings of discomfort,[7,11] and lower ratings on the FS[4] compared with heavier loads, when sets are taken to task failure. A number of reasons can account for these findings. First, the load differences in this study were smaller compared with other studies, and thus the manipulation may not have been strong enough to elicit clear differences between conditions. However, this explanation is less likely given that the average number of repetitions completed across sets and exercises in the 70% 1-RM was nearly double as the 83% 1-RM condition (14.7 vs 7.6; see Supplementary Materials [available online at https://rb.gy/tee1f1]). Alternatively, the scales may lack the required sensitivity to capture the differences that may exist between the 2 loads. In addition, no clear load preference emerged as half of the subjects preferred the heavier load and the other half the lighter load condition. The findings that both conditions elicited similar perception of fatigue, affective valence and enjoyment, support the notion that load selection should be based on individual preferences.

This study has several strengths and limitations. First, we analyzed over 1800 repetitions across sessions in a preregistered manner, which provided this study with ample statistical power. Second, by measuring RPE on a repetition-by-repetition basis we explored how RPE changes throughout a set which adds applied and theoretical knowledge to the field of exercise science. However, this measurement technique can also be viewed as a limitation. The fact that subjects reported RPE ratings after each repetition could have affected their responses, for example, by desensitizing them. Third, for logistical reasons we did not counterbalance the exercises' order which could have influenced the performance and psychological variables. Fourth, the results of this study are limited to a relatively narrow range of loads, sets and exercises. While 70% and 83% of 1-RM are commonly used in a variety of programs, 2 exercises performed for 2 sets might not mimic a typical training session.

Practical Applications

The strong linear relationship between RPE and failure proximity suggests that RPE ratings can be used to prescribe the extent of effort put forth relative to one's maximum (ie, reaching task failure). This finding is particularly useful in view of the research indicating that muscular hypertrophy and strength can occur when sets are taken to approximate task failure, regardless of the weight lifted.[1–3,25,26] RPE scores can therefore be employed as an easy to use, cost-free tool, to confirm that trainees invest the required effort in a given session (eg, an RPE of 8 to reach ~70% of task failure). Moreover, using RPE as a prescription strategy better account for individual differences than using a predetermined number of repetitions. To illustrate, consider 2 athletes that are requested to terminate a set at 70% of task failure with a given load. The first athlete completes 12 repetitions while the second completes 22 repetitions, yet both report an RPE score of 8. Despite the dissimilar number of repetitions, both athletes are expected to be approximately the same relative distance from reaching task failure, which in a sense, equalizes their efforts (for the sake of this conceptual example, we assume that that all other variables are equal between athletes). The fact that perception of fatigue, affective valence, enjoyment, and load preference revealed no meaningful differences between the load conditions strengthens the notion that load should be selected based on personal preferences when sets are taken to task failure.

Conclusion

The aims of this study were to investigate whether RPE scores collected after each repetition during sets taken to task failure across exercises and loads can predict task failure, and if the 2 load conditions will result in similar ROF, FS, enjoyment and load preference. In line with our expectations, RPE scores accurately reflected reaching task failure across 2 loads and 2 exercises, supporting the notion that RPE can be used to prescribe repetitions number within sets. In contrast to our expectations, we found negligible differences between the heavier and lighter loads in ROF, FS, enjoyment and load preference, which indicates that when sets are taken to task failure, loads can be selected based on individual preferences.

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