TITLE
Reliability of using Repetitions in Reserve (RIR) scale to program resistance training intensity in inexperienced male weight lifters.

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Reliability of using Repetitions in Reserve (RIR) scale to program resistance training intensity in inexperienced male weight lifters.

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ABSTRACT

This study investigated the reliability of using the repetitions in reserve (RIR) rating of perceived exertion (RPE) scale to quantify exercise intensity across sessions in inexperienced male weight lifters. Fifteen men (age (yrs): 17.6; height (cm): 176 ± 8.8; mass (kg): 71.3 ± 10.7; body fat (%): 16.0 ± 5.1) who reported a maximum of two years training experience with resistance machines and a maximum of four months experience of training with free weights volunteered to participate. During the initial session participants completed one repetition maximum (1RM) testing for deadlift and bench press exercises and completed anchoring procedures for the RIR RPE scale. Participants then completed one familiarisation session and two trial sessions lifting 3, 5 and 8 repetitions at progressively heavier loads for deadlift and bench press, giving each set a RIR rating upon completion. When the participant determined they could only perform one more repetition an RIR of 9 was stated and the load was recorded. The mean %1RM for 3, 5 and 8 repetitions was 89, 84 and 78% for deadlift and 92, 86 and 78% for bench press therefore demonstrating that RIR RPE can be used to program intensity and still elicit the same intensities as a traditional %1RM training. There were no significant differences reported between sessions ($p > 0.05$). However, significant differences were reported between the mean load lifted at 3, 5 and 8 repetitions and between bench press and deadlift ($p < 0.05$). The RIR RPE scale can be used as a reliable tool to program intensity for inexperienced weight lifters.

Key words: RPE, Strength training, Training load

INTRODUCTION

Traditionally resistance training loads within periodised programs are determined through using specific percentages of the athletes predetermined one repetition maximum (1RM) (11,12,44). Quantifying training intensity for resistance exercise using 1RM can be potentially inappropriate for inexperienced trainees who may not have the ability to produce an accurate 1RM either through inefficient technique or lack of experience of maximal training, so therefore a more simplistic method of assessing intensity in less experienced participants is needed. More recently there has been an emergence of a body of research which has looked at the use of rates of perceived exertion (RPE) in resistance training concerning various indices of intensity, tracking progress and, quantifying and prescribing intensity (13,15,16,18,19,22,45). There are gaps in the current literature and it is currently unclear what percentages of repetition maximum (%RM) will be lifted when participants are asked to complete exercises at specific repetition schemes and RPEs, how these values will differ on a session to session basis and whether they can be used accurately with less experienced participants. These factors are important because in order to elicit a required training adaptation from the participant the training methods must be specific to that adaptation. Greater improvements in muscular strength have been demonstrated with loads of 90% RM for three repetitions so therefore it is important for a practitioner to be confident when prescribing RPE values as indices of intensity that they are going to relate to those intensities. It is equally important for the RPE method to also be reliable in that each session the same intensities are being produced and it is not highly variable.

The concept of periodised training programs are well documented to elicit greater improvements in performance related goals then non-periodised programmes. A well periodised program is said to optimise ‘specific adaptations to imposed demands’ (SAID)

principles alongside progressive overload implying that the participant will gradually adapt to a steady increase in the volume and intensity of a program. Based on the SAID principles Siff developed a periodised program that autoregulated volume and intensity for the participant(43). Auto-regulatory progressive resistance exercise (APRE) training monitors training intensity by session and adjusts load based on athlete performance allowing for continual systematic neuromuscular adaptation to changing program variables(26). Mann, Thyfault, Ivey and Sayers (26) reported that APRE was more effective in increasing strength than traditional linear periodization due to the constant adjustment of repetitions dependent on athlete feedback. The use of RPE to program intensity is a simpler version of APRE in that load will vary by session depending on athlete performance, however, RPE allows the athlete to monitor the intensity by set and can make changes intra-session if required (18,45). Although repetitions remain constant the autoregulation of load will mean that overall work completed would be similar to that of an APRE program (26). Fairman et al. (9) analysed how autoregulated resistance training programs can help treat oncology patients. It was rationalised that the autoregulatory properties of the RPE scale could be beneficial to cancer patients as the response to training must be monitored to ensure appropriate prescription. Furthermore research from Horschig, Neff and Serrano (20) used APRE to rehabilitate anterior cruciate ligaments injuries in high school athletes. Both sets of researchers concluded that the use of RPE scales will allow daily load variations based on individual training response such as accelerated or attenuated progress (9,20).Ratings of perceived exertion (RPE) have been a longstanding popular measure of intensity within aerobic endurance activities (8,33,40) to estimate maximal functional capacity from submaximal exercise which is beneficial when monitoring training status of the athlete (7). RPE during resistance exercise has been shown to increase with added resistance regardless of the work performed (24,27) and in line with physiological markers such as lactic acid concentrations and muscle activity (21,24,41). The original RPE scale was developed by

Gunnar Borg in 1970 and consisted of ratings of between 6-20 based off heart rate relating to 60 and 200 beats per minute, making it difficult to use it for anything but aerobic endurance training (3). Borg further developed the original scale and created the Borg CR10 scale which was based on exertion ratings from 1-10 making its use more relevant to resistance training (10). As resistance exercise is typically bouts of high intensity exertion followed by rest periods it was obviously difficult to use the traditionally RPE scale and base exertion off of heart rate during the resistance exercise. The decrease in the number of possible RPE's also made the scale more accurate and simpler to use for the participant. The OMNI Scale developed by Robertson (34) was the first scale to use pictorial interfaced anchoring procedures eliminating the need for numerical specific ratings (10). The Omni Scale was further developed to include pictorial specific scales for various different exercise modes to include cycling (2), walking/running (35,41), stepping and resistance exercise (32). Using the OMNI resistance scale Robertson et al. (32) was able to predict 1RM muscular strength in 10-14-year-old girls and boys. The study concluded that the OMNI resistance scale was a practical and accurate way of predicting 1RM in children. Limitations of the OMNI resistance scale however, are that submaximal RPE scores are often recorded even when maximal repetitions are performed (16,30,37). It is suggested that the exertional perceptions between aerobic and resistance exercise differ as resistance training relies on feedback from skeletal muscle as opposed to the cardiorespiratory metabolic functions of aerobic training (13,14). However, according to Borg's model of the Effort Continua (4) all individuals will demonstrate similar responses to the perceptual-physiological link meaning that RPE will be similar when the intensity is similar relative to the individual's maximal level (15).

Hackett et al. (16) explored the limitations of OMNI resistance scale further by examining the measure of estimating repetitions remaining by the lifter showed a higher degree of accuracy

in rating exertion than previous RPE scales. Zourdos et al. (45) further developed this scale where the RPE value corresponds to a number of repetitions left which he termed the Repetitions in Reserve RPE Scale (RIR). Zourdos et al. (45) took 29 male (n = 23) and female (n = 6) participants and separated them into two groups; experienced squatters and novice squatters. It was reported that the experienced group reported a higher RPE at 1RM then the novice group which the researchers suggested was due to the novice group being unable to perform a true 1RM due to their inexperience of training with maximal or near maximal loads. Interestingly the novice group recorded an average 1RM RPE of 9.0 compared to the elite groups 9.8 RPE. The researchers concluded the RIR-based scale would be suited to more experienced lifters and that more research was needed to explore the individual differences in repetitions allowed at given intensities as well as the weekly load progressions between sessions. Furthermore it has been suggested that the more repetitions performed whilst using the RIR system the less user friendly it becomes so therefore the more qualified the user needs to be (6).

Table 1: RPE scale based on repetitions in reserve.

10	Could not do more reps or load
9.5	Could not do more reps but could do slightly more load
9	Could do 1 more repetition
8.5	Could definitely do 1 more repetition, chance at 2
8	Could do 2 more repetitions
7.5	Could definitely do 2 more repetitions, chance at 3
7	Could do 3 more repetitions
5-6	Could do 4-6 more repetitions
1-4	Very light to light effort

The benefits of autoregulated programming has similar benefits for less experienced athletes as there are multiple factors which can affect performance which is not reflected in the programming of intensity. Delayed onset of muscle soreness from the previous session, cumulative fatigue from the training cycle, poor nutrition, lack of sleep, stress or a change in training time can all affect the athlete's ability to perform at the pre-set intensity. The use of RPE to program intensity within resistance training is beneficial as it allows the intensity to be customised to how the athlete is feeling during that session (26,31). Therefore, actual training load may vary between sets or sessions, however, the risk of over training or injury will be reduced through the self-monitoring of intensity by the athlete. Equally the athlete may be adapting to the physiological response of the training program quicker than the coach has programmed for, in this case RPE will allow the athlete to increase their training load to cause a larger training effect (26,31). Added benefits include the elimination for the need for repeated 1RM testing and the associated risk of injury that can accompany if the correct procedures are not followed (5,29) as well as the potential of giving a limited value through atypical lifting performance or test administration errors (45). Inaccurate 1RM values can lead to inadequate training prescriptions resulting in insufficient stimuli for training adaptation (45).

For the effective use of RPE in resistance training it is important to establish what %RM will be lifted at the prescribed repetitions and RPE and whether that %RM is specific to the goal of the athlete. Despite multiple physiological adaptations taking place during all ranges of repetitions the specificity principle of training dictates the dominant outcome that is obtained from a certain training load (1). The relationship between 1RM and the number of repetitions that can be performed at that load enable the strength and conditioning professional to assign

load and repetitions to target specific training goals. Similarly, a relationship between RPE, repetitions and percentage of 1RM must also exist to ensure that athlete is being trained specifically to their goal. Within the current body of research RPE has mostly only been assigned to assess the intensity of a set load (16,18,25,42,45), and the small of number of studies that have used it as a set value have used singular repetitions (15,22,24,37). Lagally et al. (23) found that the average percentage of 1RM lifted at RPEs of 3, 6, and 9 were 50, 69, and 88% for chest press and 56, 74, and 90% for knee extension respectively. The researchers found that there was an increased reliability as the target RPE increased which is in line with other research which also found increased reliability with higher pre-set RPE ratings within aerobic training (8,38). It was theorised that there were a large number of possible resistances that could be perceived as a 3 by the participant but far less that could be perceived as a 9. It is apparent therefore that when using RPE's alongside resistance training higher RPE's would produce more accurate results and if RPE is kept consistently high (e.g. 9) then the practitioner would be able to manipulate intensity through number of repetitions performed. The research therefore proposes to assess what %RM is being lifted at set repetitions of 3, 5 and 8 when the RPE is set at 9 using an RIR scale.

The hypotheses of the research are fourfold. Firstly, it was hypothesised that the average percentage of repetition maximum lifted by inexperienced weight lifters for 3 repetitions to be 89-91%, 84-85% for 5 repetitions and, 77.5-79% for 8 repetitions. Secondly, it was expected that there would be significant differences in the means of the 3, 5 and 8 repetition groups for both absolute (kg) and relative values (%RM). Thirdly it was hypothesised that there would not be significant differences between the absolute and relative means of the repetition groups between sessions. Finally, it was hypothesised that there would be no significant differences

between the relative means of upper and lower body exercise and that effect sizes would be small (<.20).

METHODS

Experimental Approach to the Problem

Fifteen recreationally trained males volunteered to participate. Each participant was physically active and reported resistance training frequency of no more than three sessions per week and a maximum of four months' experience of training with free weights. During the assessment session participants completed anthropometric testing for height, weight and body fat and also completed 1RM testing for deadlift and bench press. During three subsequent visits participants were asked to perform 3, 5 and 8 repetitions progressively heavier loads until and RIR RPE of 9 was reached for both deadlift and bench press. Prior to participation, each volunteer read and signed an informed consent document that had been previously approved by the ethics review board at St. Marys University.

Subjects

Sixteen male participants (age (yrs): 17.6; height (cm): 176 ± 8.8; mass (kg): 71.3 ± 10.7; body fat (%): 16.0 ± 5.1) were recruited for this study with fifteen successfully completing the entire study protocol voluntarily. One participant was withdrawn due to time commitments. All participants were required to have been training with free weight resistance exercises for a maximum of four months and completed no more than three resistance sessions a week. Sample size was determined for the statistical power required to demonstrate a three-factor interaction effect. Using a power of 0.80, an α of 0.05, and an effect size of 0.9, it was determined that a minimum group size of 15 was needed (39). Risks and benefits were explained to the participants and their parents/guardians if under the age of 18 with written consent to participate being given and medical clearance sought. Ethics clearance was sought and approved through St. Marys University.

Procedures

Participants completed a total of four individual sessions which were broken up into: one assessment session, one familiarisation session and two experimental trials. The sessions were conducted one week apart over a four-week period in a crossover design. During the research participants continued training but were instructed not to increase volume or intensity and not to train with resistance exercises up to 48 hours before any of the research sessions.

Table 2: Participant characteristics. Values are mean ± SD.

	Mean ± SD (N = 15)
Age (years)	17 ± 0.9
Height (cm)	176 ± 8.8
Mass (kg)	71.3 ± 10.7
Body Fat (%)	16.0 ± 5.1
Bench Press 1 RM (kg)	58.2 ± 18.6
Deadlift 1 RM (kg)	118.1 ± 27.4

Assessment Session

One week prior to the familiarisation session, all participant's height, weight and body fat percentage was measured along with the 1RM for deadlift and bench press. A 20kg Olympic barbell, IPF approved bench press rack, solid black Olympic bumper plates and fractional plates down to 0.5kg to allow a minimum of 1kg between loads was used. Subjects were instructed on proper weight lifting technique and the use of the RIR RPE scale. Body fat percentage was assessed using the Durnin and Wormsley four site skinfold test (28). The 1RM test protocol was completed after the participants performed a dynamic warm up. Participants performed progressive warm up sets that consisted of 5 repetitions at 20% of estimated RM followed by 3 repetitions at 50% and 2 repetitions at 75%. Finally, single repetitions were performed at 85% and progressively heavier loads that were selected by the researcher. A 1RM

was recorded by the participant giving an RPE of 10 and the researcher agreeing that an increase in load would not be achieved or by the participant giving an RPE of 9/9.5 and then failing the following lift. In line with International Powerlifting Federation guidelines (36) a failed deadlift was when the participants were unable to lock the knees whilst standing erect with shoulders back. A bench press was deemed unsuccessful if the participant was unable to press the bar to straight arm's length with elbows locked. All lifts were judged by an UKSCA qualified coach.

RIR RPE Scale

The RIR RPE scale was introduced to the participants during the assessment session with appropriate anchoring procedures (41). These procedures consisted of the participant being asked to assign the load an RPE rating based off the RIR scale (table 1) (45) after each 1RM attempt, effectively associating the participants with what an RPE of 9 or 10 felt like.

Familiarisation and Trial Sessions

An exercise specific dynamic warm up was completed by performing 8 repetitions with 20% of the participants pre-determined 1RM for deadlift. Participants then performed three increasingly heavier warm up sets at 65%, 70% and 75% of 1-RM for 8 repetitions whilst reporting an RPE value based off of the RIR scale after each lift effectively telling the researcher how many more reps the participant felt they could do once they had reached the prescribed number of repetitions. The participants were then required to deadlift steadily increasing loads starting at 80% of 1-RM for repetitions of 8 until the participant felt they could only perform one more repetition and an RIR RPE of 9 was reported. The amount of increase in load was judged by the researcher dependent on what RPE score the participant gave and how easily the participant lifted the weight. The participant could rest 2-3 minutes between sets

and the RIR scale was made clearly visible at all times during the lift. Participants were asked to leave the room at the end of their lift and whilst the bar was being loaded to avoid them calculating the load and pre-empting the exertion. For the same reason only black Olympic bumper plates were used.

Participants rested for a further 5 minutes before performing the protocol again but this time for 5 repetitions of deadlift. The protocol was completed once more for deadlift with the participant completing 3 repetitions. The participant was then allowed to rest 10-15 minutes before completing the same protocol for bench press. The sessions lasted between 1.5-2 hours total and the order in which the repetitions were performed was randomised.

Statistical Analysis

The average %1RM lifted was calculated across the trial sessions for both exercises at each set repetition to assess the intensities produced at each RPE rating. A one way repeated measures ANOVA test was used to analyse the absolute (kg) differences between repetition schemes and sessions for both deadlift and bench press in a statistical software package (IBM SPSS Statistics 22, SPSS Inc, Chicago, IL). A second one way repeated measures ANOVA test was used to calculate significant differences between the relative (%1RM) amounts lifted across exercises, sessions and repetition schemes. Bonferroni post-hoc corrections were used with the alpha level for significance set at .05. Effect sizes (Cohen *d*) were used to evaluate the size of the differences in the amount of load lifted at the three set repetitions between sessions for absolute (in kg) and relative (%1RM) values. Effect sizes for relative resistance lifted were also calculated at set repetitions between upper and lower body exercises. Threshold values of 0.2, 0.6, 1.2 and 2.0 were used to represent small, moderate, large and very large effects. To assess the reliability of the resistances lifted at set numbers of

repetitions intra-class correlation coefficient *r* scores and their *p* values were calculated across the two trial sessions.

RESULTS

The average weight lifted (mean ± SD) at three, five and eight repetitions across both sessions in kg and %RM can be seen in table 3. The mean %RM lifted at three, five and eight repetitions for bench press were 93, 88 and 80% respectively which were deemed to be statistically significant according to a repeated measures analysis of variance test ($F(2, 28) = 346.31$, $p = .0005$, ES = 0.96), see figure 1. The mean %RM lifted at three, five and eight repetitions for deadlift were 90, 84 and 78% respectively, which was also determined to be statistically significant ($F(2, 28) = 206.11$, $p = .0005$, ES = 0.94). Maulchy's test indicated that the assumption of sphericity had been violated, $\chi_2 (2) = 7.33$, $p = .026$, therefore Greenhouse-Geisser corrected tests are reported ($\varepsilon = .70$). The mean load lifted at three, five and eight repeptitions was 80, 75 and 69 kg which was reported to be significantly different ($F(1.033, 14.457) = 111.245$, $P < 0.0005$, ES = 0.89). Post hoc tests using the Bonferroni correction revealed significant differences between the loads lifted at three and five repetitions ($F(1, 14) = 86.619$, $P < 0.0005$, ES = 0.86) and five and eight repetitions ($F(1, 14) = 133.178$, $P < 0.0005$, ES = 0.91) stating that the numbers of repetitions performed directly influenced the intensity of the set.

Table 3: Mean and SD for absolute and relative loads lifted across sessions.

Session	Exercise	3 Repetitions		5 Repetitions		8 Repetitions	
		Mean	SD	Mean	SD	Mean	SD
1	Bench Press, kg	53.80	15.15	51.03	14.38	46.10	12.76
	%1RM	92.44	8.45	87.69	8.05	79.21	7.11
	Deadlift, kg	105.23	21.65	100.53	20.84	94.13	19.06
	%1RM	89.13	3.74	85.15	3.24	79.73	4.11
2	Bench Press, kg	54.40	16.26	50.60	15.11	46.57	14.70
	%1RM	93.47	6.04	86.94	6.40	80.01	7.66
	Deadlift, kg	106.27	24.54	97.40	20.59	89.80	18.41
	%1RM	90.01	2.57	82.50	3.47	76.06	4.94
M[1, 2]	Bench Press, kg	54.10	15.44	50.82	14.50	46.33	13.53
	%1RM	93.75	7.22	88.12	7.18	80.21	7.26
	Deadlift, kg	105.75	22.75	98.97	20.42	91.97	18.54
	%1RM	89.88	3.16	84.25	3.57	78.45	4.83

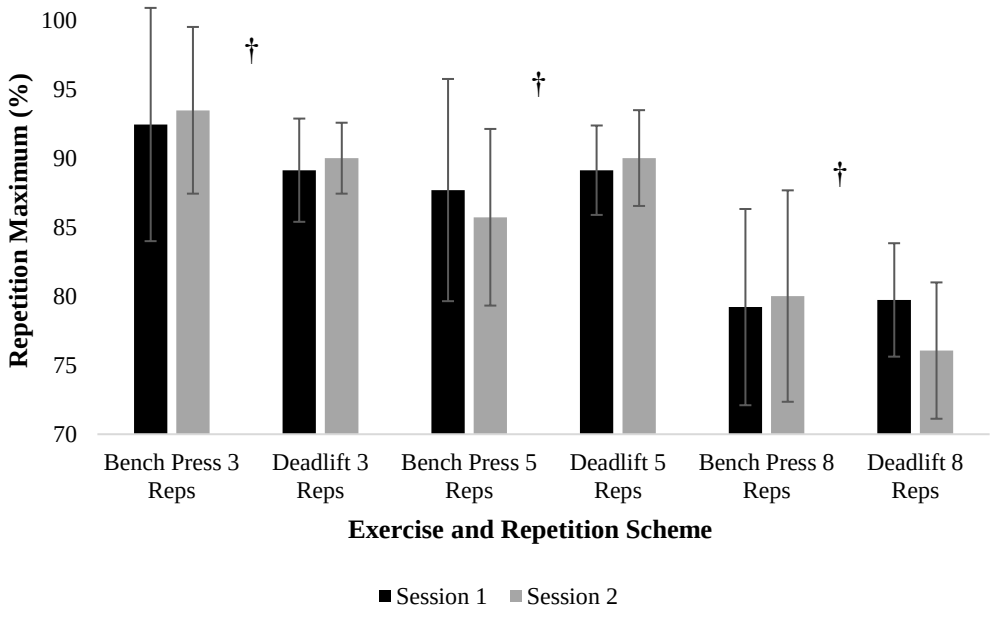

Figure 1. Comparison between exercise and number of repetitions for the relative amount of load lifted across sessions.† $p < 0.0005$ vs corresponding repetition ranges.

The mean %RM lifted across all repetition schemes between session one and session two were 86.33% and 85.22% respectively which was not statistically significant ($F(1, 14) = 6.76$, $p >$

.05, ES = 0.33). Similarly, when mean absolute loads (kg) were compared, which were 75.12 kg for session one and 74.17 kg for session two, no statistical significance was reported ($F(1, 14) = 2.291$, $p > 0.05$, ES = 0.14). Furthermore, no significant interaction existed between exercise type and session number ($F(1, 14) = 2.261$, $p > .05$, ES = 0.14) stating that the difference between the mean %RM lifted for both exercises across both sessions stayed consistent with small variation suggesting that using RPE to program resistance training sessions will cause similar intensities to be lifted across different sessions.

The mean %RM lifted for upper (bench press) and lower body (deadlift) exercises was 87.36% and 84.19% which was deemed to be a statistically significant difference ($F(1, 14) = 5.05$, $p = .05$, ES = 0.27) suggesting that participants on average lifted higher intensities on bench press then they did on deadlift when compared to their percentage of repetition maximum (see figure 2). Conversely the average absolute load lifted for bench press was 50.42 kg compared to 98.89 kg lifted for deadlift which was also statistically significant with a large ES ($F(1, 14) = 472.246$, $p = 0.0005$, ES = 0.97) showing that absolute deadlift loads were significantly higher than that of bench press. A significant interaction was reported between exercise type and repetition number ($F(1.711, 23.957) = 4.65$, $p < 0.05$, ES = 0.25) for relative load (%RM). Within subject contrasts test showed that there was no interaction for three and five repetitions across bench press and deadlift but there was a significant interaction between repetitions five and eight as the difference between the means decreased. This interaction is displayed in figure 3.

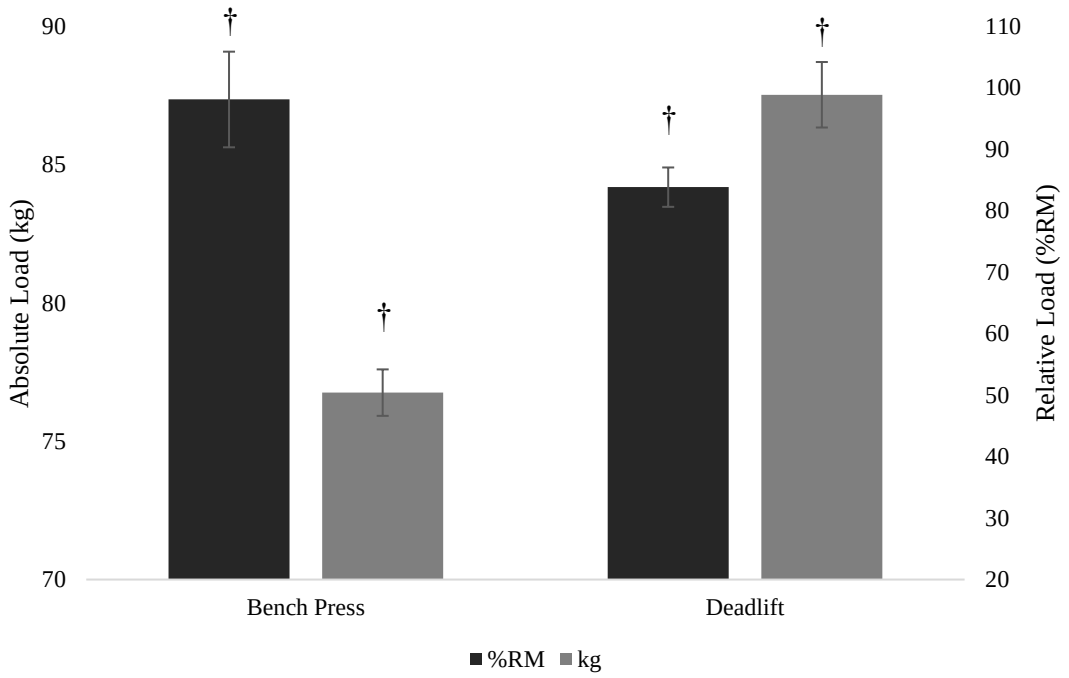

Figure 2: Comparison of upper and lower body exercises in absolute and relative loads.

† $p < 0.05$ vs corresponding exercise at the same value.

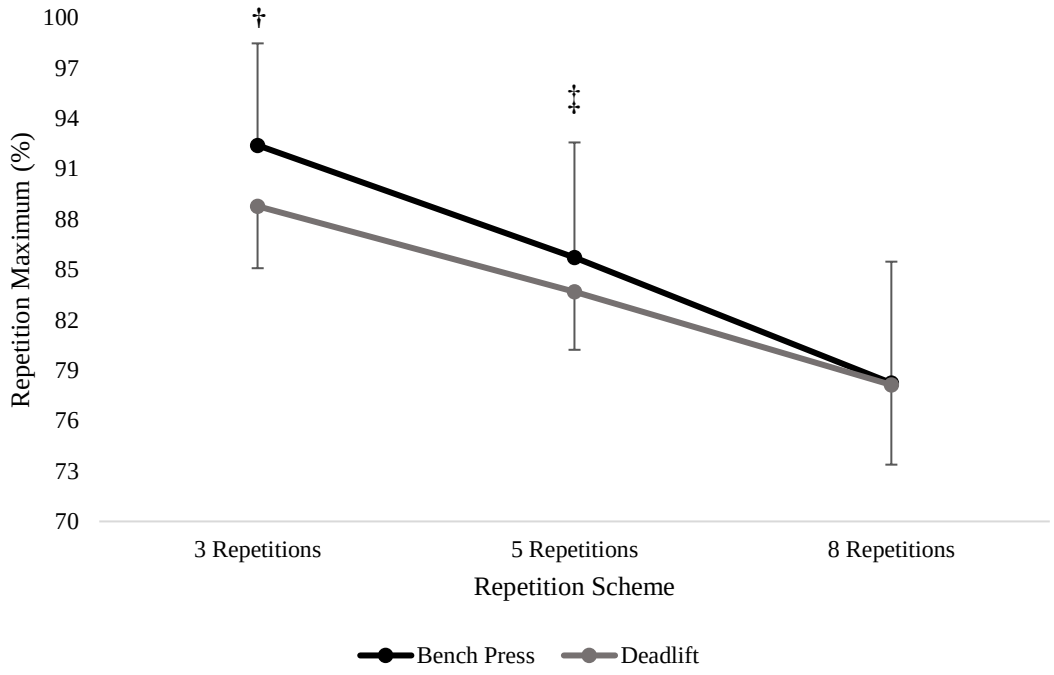

Figure 3: Comparison of average load lifted (%RM) between bench press and deadlift for 3, 5 and 8 repetitions.† $p < 0.0005$ between bench press and deadlift at the same repetition scheme.

‡ $p < 0.05$ between bench press and deadlift at the same repetition scheme.

Overall no significant interactions were seen for relative ($F(1.276, 17.869) = 1.904$ $p > 0.05$, ES = 0.120 and absolute ($F(1.144, 16.018) = 3.649$ $P > 0.05$, ES = 0.21) values across all variables (exercise vs session number vs repetition scheme) with small effect sizes.

Intra-class correlations (ICCs, table 3) were calculated for bench press and deadlift analysing the reliability of the values across session one and session two for three, five and eight repetitions. Three (r = 0.991), five (r = 0.990) and eight repetitions (r = 0.984 repetitions showed excellent test reliability for bench press. Comparable results were found for deadlift as three (r = 0.989), five (r = 0.993) and eight (r = 0.975) repetitions showed excellent test re-test reliability.

DISCUSSION

The aims of the research were to establish if using the RIR RPE scale to program intensity was both valid and reliable for male weightlifters who were inexperienced in lifting with free weights. The primary findings of the study were that using the RIR RPE scale with an RPE of nine will cause the intensities lifted to be in line with that reported by Zourdous (2016) for deadlift only.

The results for bench press indicated that the intensities lifted at three, five and eight repetitions were larger then that predicted by Zourdos (45) and larger than is reported in Prelipin's chart (cited in Hammer (17)) as well as the 'RM continuum' proposed by Fleck and Kraemer (12) which both state the maximum number of repetitions that can be performed at given intensities. Given that the intensities lifted are larger than what is predicted by both Zourdos (45), Prelipin (17) and Fleck and Kraemer (12) across all three repetition ranges it is reasonable to presume that the 1RM test did not report a true 1RM value and the participants were too cautious during the test due to not being accustomed to lifting heavy loads for this exercise.

As previously reported the use of RPE in resistance training relies upon the feedback from skeletal muscles and it is theorised that in the recreationally trained participants used in the study this was unaccustomed and therefore resulted in a higher RPE rating during 1RM testing. It is worth mentioning however, that if this was performed in a practical setting and the intensity of exercise was prescribed as a %1RM the participant would have been potentially prescribed loads that were lower than is recommended. The fact that the participants in the study went on to lift at higher intensities then expected shows first-hand the benefits of using RPE to program intensity in the inexperienced. Nevertheless, the loads lifted will still bring about the required adaptations sought after from the set repetition scheme. According to Shimano et al. (37)

strength gains are more pronounced at repetitions of 1-6 but found that optimal levels for untrained participants was with loads of ≥90% RM. Therefore, if a practitioner programmed their athlete using the proposed method with three or five repetitions it wouldn't affect the desired adaptation if the athlete then lifted more than the expected %RM raising potentially interesting questions regarding whether the current traditional repetition scheme is inappropriate for inexperienced lifters. This confirms the previous research into the area suggesting that using RPE with inexperienced participants was to be used with caution as loads selected can be inconsistent. In response to that however, is the benefits of using an RPE scale are its autoregulatory properties in that each session may produce a different load dependent on the athletes perceived exertion which may be affected positivity through adaptation or negatively through overtraining, poor nutrition, delayed onset of muscle soreness or lack of sleep for example (16,18,45). The significant differences observed between upper and lower body exercises were conversely opposite for both the relative and absolute values in that participants lifted significant more of their %RM during bench press then they did for deadlift yet more absolute load was lifted for deadlift than bench press (Figure 2). It was expected that there would be a significant difference in the absolute values between exercises due to the larger musculature involved in the deadlift versus the bench press (37). However, it was not expected that the relative value of bench press would be significantly different to that of deadlift.

This may have already been partially explained through atypical lifting performance in the 1RM test as mentioned above. Shimano et al. (37) is currently the only other study that has compared the effects of inexperienced participants performing a free weight bench press at various indices of intensity. When asked to perform maximum repetitions at set intensities they found that the untrained participants performed significantly more repetitions at bench press at

heavier loads (>90% 1RM) then their trained counterparts but didn't see the same differences at lighter loads (60 and 80% 1RM). The researchers theorised this was due to the lighter absolute resistances used causing the relative increase in performance. Meaning that due to the relative smaller load being lifted any changes equate to a much larger percentage. This theory is further supported in the current study by the data showing significant differences in relative load lifted between exercises at three and five repetitions but not at eight repetitions. This interaction is displayed in figure 3 and suggests that at higher intensities (>90% RM) bench press performance in inexperienced participants is vastly increased compared to that of deadlift. This performance seems to decrease in line with Shimano et al. (37) suggestions at intensities of 80% RM. Further research may be of interest here to examine if this interaction continues with lighter loads and higher repetitions. Gearhart et al. (13,14) state that exertional ratings between aerobic and resistance training differ due to the reliance on feedback from skeletal muscle. It would be interesting to examine if higher repetitions that fell within the RM continuum of muscle endurance elicited the same responses as strength training due to less reliance on skeletal muscle force and more emphasis on the aerobic capacity of the muscle. As the number of repetitions increase so does the waste by products of anaerobic energy production causing an accumulation of lactic acid. It could be theorised that this is more similar to aerobic exercise and therefore the feeling is much more familiar to a participant who is not accustomed to lifting heavy loads. As the participant would be unaccustomed to the demands placed on the central nervous system during heavy lifting this could therefore bring about a larger perception of exertion.

The load used in exercise appears to be dependent on the RPE and repetitions that are set. For all repetition ranges the differences between sessions was deemed to be insignificant meaning that the variations in load when using RPE to program intensity across sessions was minimal.

Equally the ICC results confirm that the reliability of the data across the repetition schemes and sessions is excellent. Thus, these findings provide evidence that the RIR RPE scale can be used reliably to program resistance training programs as the loads lifted in each session are more likely to be variable due to fatigue or positive adaptation rather than the inaccuracy of RPE.

Previous studies have reported that the use of lower levels of RPE, i.e. three and six, have been less reliable when the %RM lifted at these RPEs were compared across groups and that a higher RPE, i.e. nine, is more likely to produce greater accuracy (23,24). The results of the present study confirm this aspect, in that the when a singular high RPE is used there is little variability between sessions or groups. Lagally, Amorose and Rock (23) reported mean %RM standard deviations of 8 and 9.3 for chest press and leg extension respectively when using an RPE of 9. When compared to the current study the standard deviations presented for bench press and deadlift for %RM at an RPE of 9 were 6.07 and 3.69. This variance could be attributed to the difference in exercise type (resistance machine vs free weight) however it would be expected that the free weight exercise would cause a greater degree of variation due to the importance of individual technique (37). Therefore, it is more likely that the variance was due to the use of the RIR RPE scale vs the OMNI-RES RPE scale and that the RIR could be a more reliable measure to be used with inexperienced participants. More research is needed here however, that further compares the two RPE scales against each other across multiple training sessions.

Application of the results presented here should be done so in the context of the following limitations. The RPE was fixed at nine for each set so any variation in this may produce different results then those reported. Participants completed the lifts needed for both bench press and deadlift across all the repetition schemes in one visit per session, with each visit

lasting approximately two hours. This is a significant amount of volume for an inexperienced participant and despite appropriately recovery times being allocated neural and mental fatigue could have impacted on results. All the repetition scheme lifts were completed for deadlift before moving onto bench press. Although alternating the exercises for each set repetition might have alleviated some of the fatigue accrued it was decided it would mean having to conduct a warm up protocol after each change in exercise and potentially increase the risk of injury through the improper completion of these protocols.

In conclusion, the %RM that is lifted when using the RIR RPE scale with set repetitions are similar to the targets that are consistent with recommended resistances programmed at those intensities. Furthermore, RPE can be used reliably to program intensity for inexperienced trainees as the variation to loads across sessions is minimal. Different exercises produce varying results in terms of the %RM being lifted and this should be noted. However, if a high RPE is used then the required adaptation of the program will not be compromised.

PRACTICAL APPLICATION

The practical application of the present findings is that the RIR RPE scale is a reliable tool that can be used to program intensity for inexperienced participants. The resulting loads from the exercise prescription may differ from loads commonly implemented in resistance exercise and therefore it is recommended that a high RPE rating is used (9-10) initially to ensure targeted adaptations are met. Consequently, RPE can be used to individualise resistance training programs and eliminate the need for 1RM testing. The RIR RPE scale would be an easy and effective method of prescribing exercise intensities for large groups of inexperienced weight lifters due to its autoregulatory properties.

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Appendix

Ethics Approval

6 February 2017 **Unique Ref: SMEC_2016-17_047**

Simon Lovegrove (SHAS): 'Using Rate of Perceived Exertion (RPE) scales to predict **exercise intensity in recreationally trained 16**-18 year old weight lifters'.

Dear Simon

University Ethics Sub-Committee

Thank you for submitting your ethics application for the above research.

I can confirm that your application has been considered by the Ethics Sub-Committee and that ethical approval is granted.

Yours sincerely

Prof Conor Gissane
Chair, Ethics Sub-Committee

Cc Dr Stephen Patterson

Participant Consent Form

Name of Participant: _____

Title of the project: **Using RPE scales to predict exercise intensity in recreationally trained 16-18 year old weight lifters**

Main investigator and contact details: Simon Lovegrove, 01256 306342, simon.lovegrove@bcot.ac.uk

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)……..

Signed……..…… Date…….....

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: _____

I WISH TO WITHDRAW FROM THIS STUDY

Name: _____

Signed: _____ Date: _____

Participant Information Sheet

Using RPE scales to predict exercise intensity in recreationally trained 16-18 year old weight lifters.

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Please ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this:

What is the purpose and aim of the research?
Traditionally within resistance training loads are programmed using a percentage of the maximum an individual can lift. Rates of perceived exertion are a potentially safer and quicker way to programme loads, especially in novice and recreationally trained lifters. The aim of the research is to investigate if RPEs can be used to programme for specific aspects of muscular fitness (i.e. power, strength, hypertrophy (size) etc…).

Why have I been invited?
You have been invited because you are a healthy male, who is recreationally trained and is over the age of 16 and under the age of 21.

Who is organising the research?
The research is being organised by Simon Lovegrove (Faculty Head for Service Industries, Basingstoke College of Technology) and supervised by Dr Stephen Patterson (Senior Lecturer Exercise Physiology, St. Mary's University) and Paul Read (Senior Lecturer Strength and Conditioning, St. Mary's University).

What will happen to the results of the study?
The results will be given within a "summary of findings" document after the study is complete. You will only be given overall results and not the results of any other participant that took part. No further individuals or organisations will be given these findings.

Source of funding for the research
There are no sources of external funding for this study.

Contact for further information
Simon Lovegrove simon.lovegrove@bcot.ac.uk

Do I have to take part?
It is up to you to decide whether or not to take part. If you decide to take part you will be given this information sheet to keep and be asked to sign a consent form and PAR-Q. Your parents will also be given a parental consent form to sign, they will also be given a copy of this information sheet. You are free to withdraw at any time with no questions asked and no penalty.

What will happen if you agree to take part?

You will be needed on a total of four occasions in the gym at Basingstoke College of Technology. The visits will comprise, one familiarization session and three data collection sessions. Every session will take between 1.5-2 hours at the same time of day, across a 2-week period. During the familiarization session, your height, weight and body composition will be measured. You will then be tested to find your one repetition maximum in the deadlift and bench press. Any final questions that you might have in regards to the procedures can be asked here or throughout the rest of the study. During the three data collection trials, you will follow the procedure provided below.

Whether there are any special precautions you must take before, during or after taking part in the study

You will be asked to refrain from consuming alcohol for 24 hours prior to each study. We will also ask you to avoid any strenuous exercise at all for 48 hours prior to the study.

On the day of the trial the testing protocol will be the following:

You will arrive at Basingstoke College of Technology (room F005). Height, weight and body composition will be measured using the Durnin and Wormesley method. The RPE scales will then be introduced and explained to you. You will then begin a standardised warm up on the treadmill. Following the warm up you will begin to test for your one repetition in the deadlift and then the bench press exercises. During the testing you will be shown the RPE scales and asked to rate each lift in order to standardised the scale. You will not be told the result.

For the next three sessions you shall meet at the gym at the required time and follow the same standardised warm up protocol. Following the warm up the researcher will load the bar with a load based of of a percentage of your repetition maximum, this load will not be communicated to you. Then you will be asked to perform either 3, 5 or 8 repetitions at that given load and feedback a perceived exertion score. After each set you will be asked to leave the room whilst the researcher loads the bar. You shall then re-enter the room and perform another set at the same number of repetitions as perform. This process will continue until you have reached an RPE of 9. There will then be a period of rest and you will be asked to complete the same protocol for the bench press. You will be asked to perform the exercises a total of three times each attempting to find an RPE of 9 for 3, 5 and 8 repetitions for both the deadlift and bench press.

Are there any risks or side effects?

Any research involving humans will always have an element of risk. High intensity resistance training can cause injury, however, the relevant precautions needed to reduce the likelihood of injury have been taken.

Agreement to participate in this research should not compromise your legal rights if something goes wrong

In the event that taking part in the research should cause you any harm it is important that you are informed of your rights. Your wellbeing and safety are of utmost importance and every care will be taken during the course of the study to ensure this. Basingstoke College of Technology and St. Mary's University both have insurance arrangements in place should something go wrong and you are harmed as a result of your participation in the study.

What will happen to any information/data/samples that are collected from you?

Only the researcher will have access to the data collected during the study. However, your identity will not be revealed. All information which is collected about you during the course of the research will be kept strictly confidential. We will keep a record that you have taken part in the study but will not keep any other personal information about you. Professional standards of confidentiality will be adhered and the handling, processing, storage and destruction of data will be conducted in accordance with the Data Protection Act (1998).