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Estimation of repetitions to failure for monitoring resistance exercise intensity: building a case for application

Daniel A. Hackett[1], Stephen P. Cobley[1] and Mark Halaki[1]

1. Discipline of Exercise and Sport Science, The University of Sydney, Sydney, New South Wales, Australia

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Correspondence: Daniel Hackett

Email: daniel.hackett@sydney.edu.au

Address: Discipline of Exercise and Sport Science

Faculty of Health Sciences

The University of Sydney

75 East St, Lidcombe NSW 2141 AUSTRALIA

Phone: +61 2 9351 9294

Fax: +61 2 9351 9204

ABSTRACT

The purpose of this study was to 1) examine the accuracy of Estimated Repetitions to Failure (ERF) during resistance exercise between two sessions, and 2) compare ERF to RPE (Rating of Perceived Exertion) for determining proximity to momentary failure. Forty-eight adults with recreational resistance training experience performed 3 sets of 10 repetitions at 70% 1RM and 80% 1RM for the chest press and leg press respectively. At the completion of each set, participants reported their ERF and then continued repetitions to failure to determine actual repetitions to failure (ARF). Two sessions following the same experimental protocol were performed with 48 hours between bouts. For session 1, error in ERF was greater during the first sets compared to third sets for the chest press (2.0 versus 0.6 repetitions, $p < 0.001$) and leg press (3.1 versus 1.6 repetitions, $p < 0.001$). No differences for error in ERF were observed between sessions 1 and 2 for the chest press ($p>0.944$), however less error in ERF was found for the leg press during set 1 of session 2 (3.1 versus 1.9 repetitions, $p<0.013$). Strong to very strong relationships were found between ERF and ARF ($r = 0.59$ to 0.87, $p <0.01$), whereas the majority of relationships for RPE and ARF were small to moderate ($r = 0.32$ to -0.42, $p <0.01$). Improvement in the accuracy of ERF following a single training bout is minimal whereas ERF compared to RPE appears to have greater sensitivity for discriminating momentary failure.

Key Words: Resistance training; RPE; training intensity; weight-lifting

INTRODUCTION

Resistance training intensity is generally prescribed from the percentage of a one-repetition maximum (%1RM) or the most load that can be lifted for a defined number of repetitions, known as a repetition maximum (RM). Whilst maximum effort is required during every set when resistance exercise is prescribed from RM, the effort required when performing sets at %1RM can vary greatly and ultimately depends on the number of repetitions that are performed. Furthermore, studies have shown inter-individual variation in the number of repetitions performed to momentary failure at fixed %1RM (1,12,21). Therefore, it is unlikely that the same degree of effort and/or training stimulus would result for two individuals performing sets of a specific number of repetitions (e.g. 10 repetitions) at a fixed %1RM. Furthermore, the number of repetition maximum at a fixed %1RM can be different for the same individual when performing different exercises. This problem could be solved via using RM so that effort amongst trainers/athletes is standardized. However, the high physiological and psychological demands of performing resistance training solely with RM may result in overtraining as well as injuries (24,25).

When resistance training is prescribed based on %1RM, the rating of perceived exertion (RPE) scale is often used to assist with standardizing training conditions between individuals (19). There are two types of RPE scales which include the 6-20 category scale and 0-10 category ratio scale (CR-10), although the latter is considered better suited for resistance exercise (7,17,23). Resistance exercise intensity can be estimated from the RPE as the scale assesses subjective effort, strain, discomfort and fatigue. However, several investigators have reported RPEs less than maximum during resistance exercise to volitional fatigue, indicating a mismatch between RPE and maximal effort (18,22).

An alternate approach to using the RPE scale to assist with assessing resistance exercise intensity is to have individuals report the number of repetitions possible following completion of a set. This can be performed with the use of the Estimated Repetitions to Failure (ERF) Scale which was previously validated in a cohort of experienced bodybuilders (9). The results of this prior study indicated that the margin of error in ERF was approximately 1 repetition across five sets performed for both the bench press and squat (9). More recently, Hackett et al. (8) examined the accuracy of ERF in a large group healthy adults with various levels of resistance training experience. It was shown that the error in ERF was ~ 1 repetition when 0-5 repetitions from momentary failure, was less for upper compared to lower body exercises, and that males were more accurate than females for lower body exercises. Furthermore, it was found that the accuracy of ERF was not influenced by resistance training experience. However, it remains largely unknown whether a repeated bout affects the accuracy of ERF and whether the ERF is just a surrogate to RPE.

The ability to accurately monitor resistance exercise intensity is essential for coaches and athletes. If ERF proves to be an accurate method to determine proximity to momentary failure, this may be a more effective tool compared to RPE to monitor resistance exercise intensity. Potential advantages of ERF include the ability to better equate exercise intensity between athletes or trainers compared to %1RM, as well as the ability to indirectly monitor the rate of recovery or adaptation between training sessions. As such, ERF could be used by coaches to modify training session/programs to optimize adaptations.

The purpose of this study was to 1) examine the accuracy of ERF during resistance training between two sessions, and 2) compare ERF to RPE for determining proximity to momentary failure. It was hypothesized that the accuracy in ERF across sets would be similar between testing sessions. It was also speculated that ERF and not RPE would be strongly associated with actual repetitions to failure (ARF).

METHODS

Experimental Approach to the Problem

Each participant visited the laboratory on two occasions. The first visit involved one-repetition maximum (1RM) testing and experimental session 1, while the experimental session 2 was conducted during the next visit**.** During the experimental sessions participants performed 3 sets of 10 repetitions for resistance exercises at a fixed percentage of one-repetition maximum (%1RM). Exercises were performed with a pin loaded vertical chest press machine (Maxim, Kidman Park, South Australia) and a pin loaded horizontal leg press machine (Kolossal, Sydney, New South Wales). Participants briefly paused when the prescribed number of repetitions for each set was reached while they reported their ERF and RPE, and then continued to momentary failure. Two sessions following the same experimental protocol were performed with 48 hours between sessions to minimize confounding influences of previous exercise. Participants were instructed to maintain their normal diet during the days preceding visits, to consume their last meal at least two hours before exercise and to avoid using pre-workout supplements (3). Participants were further instructed to refrain from resistance training or any other strenuous type of exercise 48 hours prior to visits.

Absolute difference between ERF and ARF for each set and across sessions was used to determine changes in accuracy for ERF while associations were used to examine the discriminative ability of ERF and RPE to determine momentary failure.

Participants

Twenty eight males (age = 27.7 ± 9.2 years, body mass = 80.4 ± 10.6 kg, height = 175.6 ± 7.9 cm) and twenty females (age = 29.1 ± 10.0 years, body mass = 61.4 ± 9.1 kg, height = 163.6 ± 7.0 cm) participated in this study. The majority of participants (42 out of 48) reported having ≥1 year resistance training experience at the recreational level. Participants were informed of the study purposes, procedures provided, and all potential risks prior to consent. All participants provided written consent prior to participation in the study, which was approved by the University of Sydney Human Research Ethics Committee.

One-Repetition Maximum (1RM)

Participants warmed-up with 1-2 sets of 8-10 repetitions with light-moderate loads prior to 1RM testing for the chest press and leg press. Following warm-up, loads were adjusted to enable participants to perform ≤ 10RM so that 1RM for the exercises could be accurately estimated (20). If > 10 repetitions could be performed or failure was not reached prior to 10 repetitions, the load was increased and 5 minutes recovery was provided before the next RM attempt. The Brzycki 1RM prediction equation (5) was used to estimate the 1RM based on the load and repetitions performed. The equation is mathematically expressed as: 1RM = load / (1.0278 - (0.0278 * number of repetitions)). Standard error of estimate (SEE) of 1RM from the Brzycki equation for the chest press was previously found to be 1.67 and 3.00 kg at 5RM and 10RM respectively (20).

For the leg press the SEE was found to be 13.74 and 20.41kg at 5RM and 10RM respectively (20). The test-retest intra-class correlation coefficient (ICC) for the above testing 1RM estimation protocol in our laboratory is ≥ 0.90.

Familiarisation of ERF and RPE scales

After 1RM testing, participants received information on how to use the ERF and RPE scales during the resistance exercises. Participants were instructed to use a memory-anchoring procedure to enable the linking of exercise intensities with their full ERF and RPE response range. This involved asking each participant to think of times during training when they reached levels of exertion that were equal to verbal cues at the bottom and top of the scales. Participants were also told that they would be asked to report their RPE and ERF at the completion of each set 10 of repetitions. Both scales were written on a board and placed directly in front of participants during the exercises. From the RPE scale, participants were asked “how would you rate your effort for the set?” A rating of ‘0’ was associated with ‘no effort’ (rest), and a rating of ‘10’ was considered to be maximal exertion (Table 1). From the ERF scale, participants were asked “how many additional repetitions can you perform?” For example, a ‘0’ indicated that the participant estimated that no additional repetitions could be completed (momentary failure reached) (Table 2).

[INSERT TABLES 1 & 2]

Experimental sessions

For sessions 1 and 2, participants performed 3 sets of 10 repetitions at 70% and 80% 1RM for the chest press and leg press respectively, with 2-3 minutes recovery between sets. The rationale for different %1RM used for the chest and leg exercises was to have participants perform a similar number of repetitions to failure. Based on results from pilot testing ≤ 20 repetitions to failure were performed with 70% 1RM and 80% 1RM for the chest press and leg press respectively. During lifts, participants were encouraged to complete each repetition through a full range of motion without deviating from the proper technique, while keeping the lifting speed constant. Upon completion of 10 repetitions, participants paused briefly (i.e. for 5 seconds) at the end of the concentric phase and were then required to report their RPE and ERF (in that order). Participants then continued with the set performing repetitions until momentary failure which was defined as the participant achieving volitional failure or the incapacity to perform the exercise with proper execution. The actual number performed to momentary failure was referred to as the ARF. Verbal encouragement (i.e. shouting positive words) was provided throughout sessions to ensure that 'true' momentary failure was achieved.

Statistical Analysis

The error in estimation of repetitions to failure was calculated as the absolute difference between ERF and ARF for each set. To assess the error a 4 factor analysis of covariance (ANCOVA) was used with sets, exercise and session serving as within subject factors, sex as a between subject factor and experience as a covariate. Tukey post hoc tests were used when significant ANCOVA results were found. ARF for each exercise between sessions (for corresponding sets) were analysed using independent t-tests. Associations between ERF and ARF across sets for each participant and exercise were examined using Pearson's correlations and linear least-products regression (15). These parametric tests were used to compare ERF and ARF since the data were interval, normally distributed (checked using the Kolmogorov–Smirnov test), and had similar variances. A Bland-Altman analysis between ARF and ERF for the chest press and leg press for sessions 1 and 2 was used to assess bias and the limits of agreement. Associations between RPE and ARF were evaluated using a Spearsman's rank correlation due to RPE being a non-parametric variable. Strength of the associations were qualitatively assessed using the following criteria: trivial ($r < 0.1$), small ($r > 0.1$ to 0.3), moderate ($r > 0.3$ to 0.4), strong ($r > 0.5$ to 0.7), very strong ($r > 0.7$ to 0.9), nearly perfect ($r > 0.9$), and perfect ($r = 1.0$) (13). All analyses were performed using Statistica version 10.0 (StatSoft Inc, Tulsa, Arizona, USA). Data are presented as means ± standard deviation (SD) and level of significance was set at $p < 0.05$.

RESULTS

Following completing the 10 repetitions and ERF, participants performed repetitions ranging from 0-11 repetitions. However, 0 repetitions were performed only in three instances (sets) for different participants and during one set a participant performed 11 repetitions. Therefore, the majority of additional repetitions performed following participants ERF ranged from 1-10 repetitions. Table 3 shows the actual repetitions performed for all sets of exercises (chest press and leg press) during sessions 1 and 2. For set 3 of the chest press the actual repetitions to failure were greater in session 2 (1.1 repetitions, $p<0.05$). There were no other differences for actual repetitions to failure between sessions for the corresponding sets of exercises. There was a systematic increase in the error between ARF and ERF with increasing number of repetitions as shown by a significant regression and significant positive slope for both the chest press (Figure 1 A, B; $p = 0.001$) and leg press (Figure 1 C, D; $p = 0.001$) during sessions 1 and 2.

[INSERT FIGURE 1]

ANCOVA results indicated that there was a significant main effect for sex ($p<0.001$) with males exhibiting less error in ERF than females, for set ($p<0.001$) with post hoc results indicating that the error in ERF during set 1 was greater than set 2 ($p<0.001$) and both sets 1 and 2 exhibited greater error than set 3 ($p<0.001$, $p=0.020$ respectively). No other main effects were significant ($p>0.076$). There was a significant interaction between session, exercise and set ($p=0.032$) with post-hoc results indicating as follows. All other interaction effects were not significant ($p>0.05$).

Initial session

The error in ERF tended to decrease as sets progressed. For the chest press there was greater error for set 1 (2.0 repetitions) compared to set 3 (0.6 repetitions) ($p < 0.001$) with no difference between sets 1 and 2 (1.2 repetitions) ($p=0.143$) nor between sets 2 and 3 ($p=0.467$). For the leg press during the first session, the error in ERF was greater for set 1 (3.1 repetitions) compared to sets 2 (1.8 repetitions) ($p <0.001$) and 3 (1.6 repetitions) ($p <0.001$) with no difference between sets 2 and 3 ($p=0.999$). Between exercises, there was less error in ERF for chest press compared to the leg press during sets 1 ($p=0.005$) and sets 3 ($p=0.013$) with no difference during sets 2 ($p=0.575$) (Figure 2).

[INSERT FIGURE 2]

Second session

For the chest press, the error in ERF was greater for set 1 (2.4 repetitions) compared to sets 2 (1.2 repetitions) ($p <0.001$) and 3 (0.9 repetitions) ($p <0.001$) with no difference between sets 2 and 3 ($p=0.999$) (Figure 2). However, for the leg press there was no difference in the error in ERF across sets ($p>0.053$) (Figure 2). Between exercises, there was no difference in the ERF to failure for chest press compared to the leg press during all sets ($p>0.733$) (Figure 3).

[INSERT FIGURE 3]

Between the first and second sessions

There were no differences between sessions in the error in ERF for chest press during any of the sets ($p>0.944$). However, the error in ERF to failure for leg press was higher during set 1 (3.1 versus 1.9 repetitions, $p<0.013$) with no difference during sets 2 and 3 ($p>0.922$).

Ratings of perceived exertion and muscular failure

Strong to very strong relationships were found between ERF and ARF for sessions 1 and 2 ($r = 0.59$ to 0.87, $p <0.01$) (Figure 4). In contrast, there were only two sets where strong relationships were found between RPE and ARF ($r = -0.54$ and -0.55, $p <0.01$), while the rest of the relationships were either small to moderate ($r = -0.32$ to -0.42, $p <0.01$) or trivial ($r = -0.15$ and -0.18 $p > 0.05$).

[INSERT FIGURE 4]

DISCUSSION

This investigation found that improvements in the accuracy of ERF during resistance exercises are minimal following a single session. This was observed with improvement in accuracy of ERF only for the initial set of the leg press during the second session, which partially supports our original hypothesis. Also in agreement with our hypothesis, strong correlations were found between ERF and ARF across all sets of exercises, while weaker correlations were found between RPE and ARF. This suggests that ERF may be a more appropriate method to monitor resistance exercise performance in relation to proximity to momentary failure. The study also showed that the accuracy in ERF is greater for the chest press compared to leg press but only during the initial session.

Participants were shown to underestimate ERF for first sets by ~2-3 repetitions, with subsequent improvements in accuracy as sets progressed and an error in ERF of ~1 repetition in the final sets. Similar to the findings from previous studies, the proximity to momentary failure when reporting ERF was shown to influence the accuracy of ERF (8,9). Therefore, it appears that exertional sensations (e.g. muscle activation, afferent signals from Golgi tendon organs, muscle spindles and mechanoreceptors) play an important role towards improvement in ERF accuracy (6,14,16). Further, the general lack of improvement in accuracy of ERF during the second session may indicate that participants relied heavily on their first set of an exercise as a reference point to make their estimation. So it appears that current rather than previous exertional sensations are most influential for improving the accuracy in ERF. However, potentially two sessions is not enough time for participants to improve their accuracy when the error in ERF is not great (i.e. error of ~1-2 repetitions). This supported by the accuracy of ERF improving during the second session for the first set of leg press, in which the corresponding set during the initial session was the only instance where the error in ERF was > 3 repetitions.

Consistent with the findings from a previous study (8), the accuracy of ERF was greater when performing the chest press compared to leg press during the initial session. However, during the second session no difference in accuracy of ERF was observed between exercises. An explanation for this finding is likely related to the improvement in accuracy of ERF for the first set of leg press during the second session. The greater error in ERF for the leg press compared to chest press during the initial session could be related to participants having lower self-efficacy for the leg press, perhaps associated with the heavier absolute loads used. Therefore, at least one session is required with utilising the ERF for the leg press to ensure that the accuracy of ERF is similar to that of the chest press.

Males compared to females were more accurate with reporting of ERF and this topic has been previously discussed (8). Briefly, a potential mechanism that may explain this finding could be the anatomical-physiological differences in male and female muscles which may influence the sensory information to be input into the central nervous system to allow for the effort to be perceived (10). Future research is needed to confirm whether the accuracy of ERF during resistance training differs between sexes and if confirmed, further exploration of possible mechanisms. Even though it may seem that ERF may be a less effective tool for females to monitor resistance exercise intensity, it is possible that females may improve their ability to ERF with further practice and this should also be explored in futures studies.

Previous studies have demonstrated that active muscle RPE ratings increase during resistance exercise, when lifting heavier loads, and when approaching muscular failure (6,14,16). In the present study, relationships between RPE and repetitions to momentary failure were mainly small to moderate, compared to the stronger relationships between ERF and momentary failure. Further, it could be argued that based on the findings from the present study that momentary failure cannot be determined based solely on RPE. This is in agreement with previous studies where an RPE of less than 10 has been reported despite momentary failure being reached (18,22). Based on the evidence from the present study, the case is being built towards ERF compared to RPE being a more appropriate method for monitoring of resistance exercise intensity.

Potentially the ability of RPE to discriminate momentary failure may be improved with the "repetitions in reserve" (RIR) scale which combines both RPE (CR-10) (11). The RIR scale is gaining popularity amongst resistance trainers and coaches to quantify and practically utilize RPE for training purposes. Zourdos et al., (26) found that experienced compared novice resistance trainers were more accurate with reporting RIR during squats. However, it should be noted that Zourdos et al., (26) did not directly assess accuracy, rather it was inferred based on the %1RM – RM continuum (2). Also, it is highly likely that the number of repetitions performed to failure (RM) at %1RM would differ between experienced and novice squatters (21), thus limiting conclusions made concerning accuracy. The responses using the CR-10 also increase in a non-linear and positively accelerating manner during exercise (4). Therefore, it seems unlikely that using the CR-10 would lead to a one point movement along the scale equating with approximately 1 repetition. Since the CR-10 is being modified so that it relates to repetitions in reserve (e.g. RPE 9 = 1 repetition remaining), a better decision would be to not combine these two methods. Further, the inverse relationship between RPE rating and RIR is not intuitive and aligned with the idea of capturing remaining capability under fatigue or when performing sets to momentary failure. Therefore, it seems more logically appropriate to use ERF instead which resolves these issues.

A limitation of this study is that the conditions for the experimental sessions were different with 1RM testing occurring only prior to session 1. Therefore, it should be acknowledged that the ability to ERF during the first session may have been influenced by prior 1RM testing. The exertional sensations experienced from the 1RM testing may have assisted participants with ERF during the first experimental session, at least for the initial sets of each exercise. Closer proximity to momentary failure during exercise sets may have resulted from prior 1RM testing as a result of fatigue and assisted participants with ERF during the first experimental session. However, a significant difference in the actual repetitions to failure was found for only set 3 of the chest press between sessions 1 and 2 (1.1 repetitions greater in second session). Therefore it appears that differences in proximity to failure as a result of prior 1RM testing may not have influenced ERF. It is also important to note that the findings from this study can only be extrapolated to the loading intensities used and the specific exercises that were performed. Future research is needed to examine whether the accuracy of ERF found in present study can be achieved with more complex resistance exercises (e.g. squats and deadlifts). Previously the accuracy of ERF for the bench press and squat has been shown to be good (error in ERF of approximately 1 repetition) in male bodybuilders (9). However, to date, no study has examined the accuracy of ERF with single-joint exercises (e.g. bicep curls and leg extensions).

In conclusion, the results suggest there is little improvement in the accuracy of ERF following a single training bout. However, there appears to be a greater chance of improving accuracy of ERF following a single session if error in ERF for an exercise is > 3 repetitions during the initial session. RPE did not correlate as strongly as ERF with actual repetitions to failure, providing evidence that RPE is less sensitive for discriminating momentary failure. Therefore ERF compared to RPE appears to be better suited for monitoring resistance-exercise intensity.

PRACTICAL APPLICATIONS

The ERF scale provides coaches, trainers and athletes with a method to monitor proximity to momentary failure during resistance exercise with reasonable accuracy. In contrast, the RPE scale appears unable to discriminate momentary failure as well as being a subjective measure for which its accuracy cannot be quantified. The accuracy of ERF reported by a resistance trainer can be readily assessed periodically by coaches. Although, it needs to be emphasized that the accuracy of ERF is affected by the repetition range from momentary failure, with accuracy increasing as a lifter approaches failure. Also, caution is required when using ERF the scale with females due to their lower accuracy compared to males. However, with repeated application and user experience, the reliability and accuracy of ERF is likely to improve over time. As identified, repetitions performed to momentary failure at specific %1RM can vary considerably between individuals (1,12,21). This can lead to large differences in exertion/fatigue responses between individuals when prescription is based on a selected number of repetitions to be performed at a %1RM. Therefore coaches could implement the use of the ERF scale within resistance training programs to better equate performances between athletes. Coaches could also use the ERF scale to help identify whether loads need to be adjusted and to help their athletes train at intensities that are more closely matched. For example, loads could be selected leading towards an ERF of 2-3 following sets of 10 repetitions. Another benefit of the ERF scale is that individual responses reported can assist with monitoring the rate of recovery or adaptation between training sessions. If ERF values are greater or less between training sessions where the similar exercises and loads were used, this could assist coaches with modifying the training session/program to optimize adaptations.

Conflicts of interest: None

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Figure Legends

Figure 1. Bland–Altman plot for ERF and ARF for both sessions 1 and 2

ERF = estimated repetitions to failure; ARF = actual repetitions to failure

Figure 2. Accuracy in estimation of repetitions to failure for males versus females

* denotes significant differences between males and females ($p<0.05$)

† denotes significant difference to session 1 ($p<0.05$)

^ denotes significant difference between exercises for the corresponding session ($p<0.05$)

Figure 3. Accuracy in estimation of repetitions to failure between initial and second sessions

* denotes significant differences between sessions ($p<0.05$)

† denotes significant difference to set 1 ($p<0.05$)

^ denotes significant difference between exercises for the corresponding set ($p<0.05$)

Figure 4. Associations between actual repetitions to failure and estimated of repetitions to failure in comparison to rating of perceived exertion.

ERF =estimated repetitions to failure; ARF = actual repetitions to failure; RPE = rating of perceived exertion

* denotes significant association ($p<0.05$)

Table Legends

Table 1. Category-ratio rating of perceived exertion scale

Note: The verbal anchors have been changed slightly (e.g., light becomes easy; strong or severe becomes hard). The participants were shown this scale at the conclusion of the exercise set and asked ""how would you rate your effort for the set?"

Table 2. Estimated repetitions to failure scale

Participants were shown this scale at the conclusion of the exercise set and asked "how many additional repetitions can you perform?" An estimated repetitions to failure score of '10 or greater' indicated that the participant estimated that 10 or more repetitions could be completed, while a '0' is where the participant estimated no additional repetitions could be completed (momentary failure reached).

Table 3. Actual repetitions to failure for exercises during sessions 1 and 2

Data are mean ± SD and range

*Significantly different to session 1 ($p<0.05$)

Table 1. Category-ratio rating of perceived exertion scale.

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

Note: The verbal anchors have been changed slightly (e.g., light becomes easy; strong or severe becomes hard). The participants were shown this scale at the conclusion of the exercise set and asked ""how would you rate your effort for the set?"

Table 2. Estimated repetitions to failure scale.

Estimated Repetitions to Failure
10 or greater
9
8
7
6
5
4
3
2
1
0

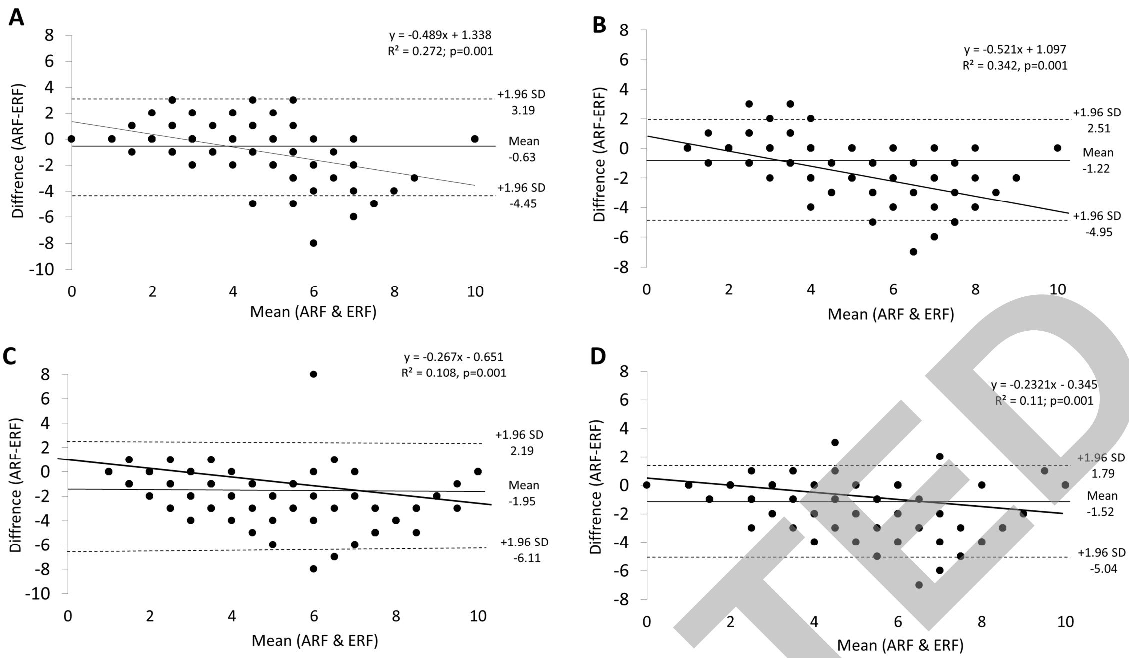
Participants were shown this scale at the conclusion of the exercise set and asked "how many additional repetitions can you perform?" An estimated repetitions to failure score of '10 or greater' indicated that the participant estimated that 10 or more repetitions could be completed, while a '0' is where the participant estimated no additional repetitions could be completed (momentary failure reached).

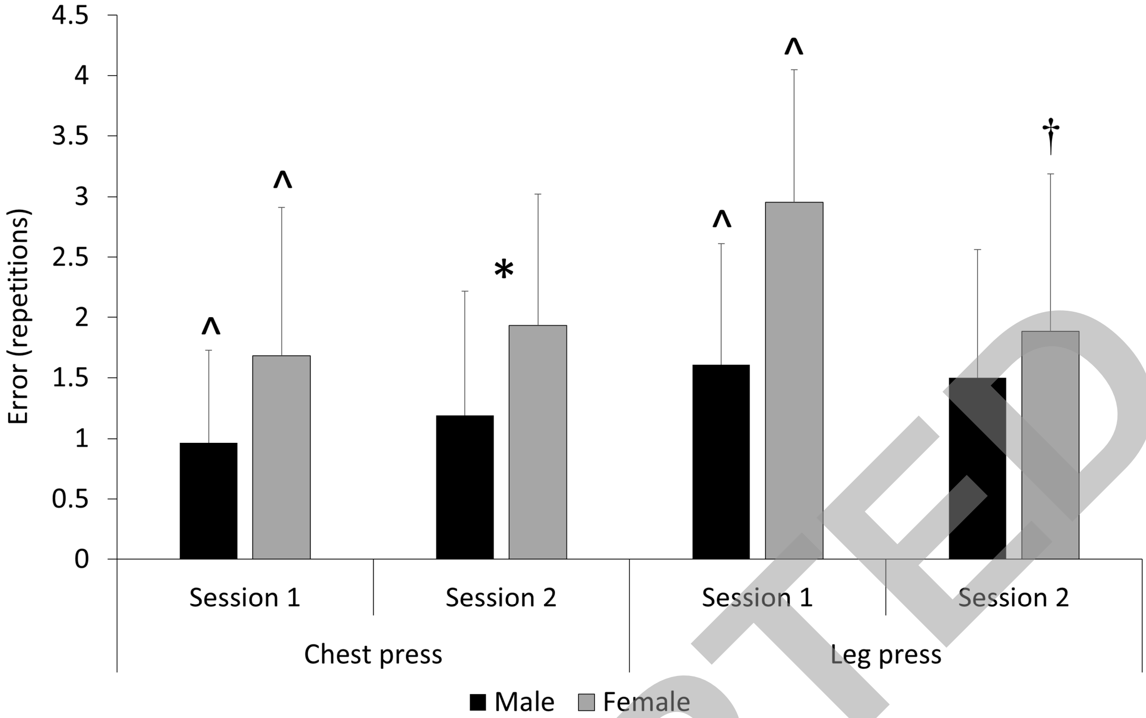
Table 3. Actual repetitions to failure for exercises during sessions 1 and 2.

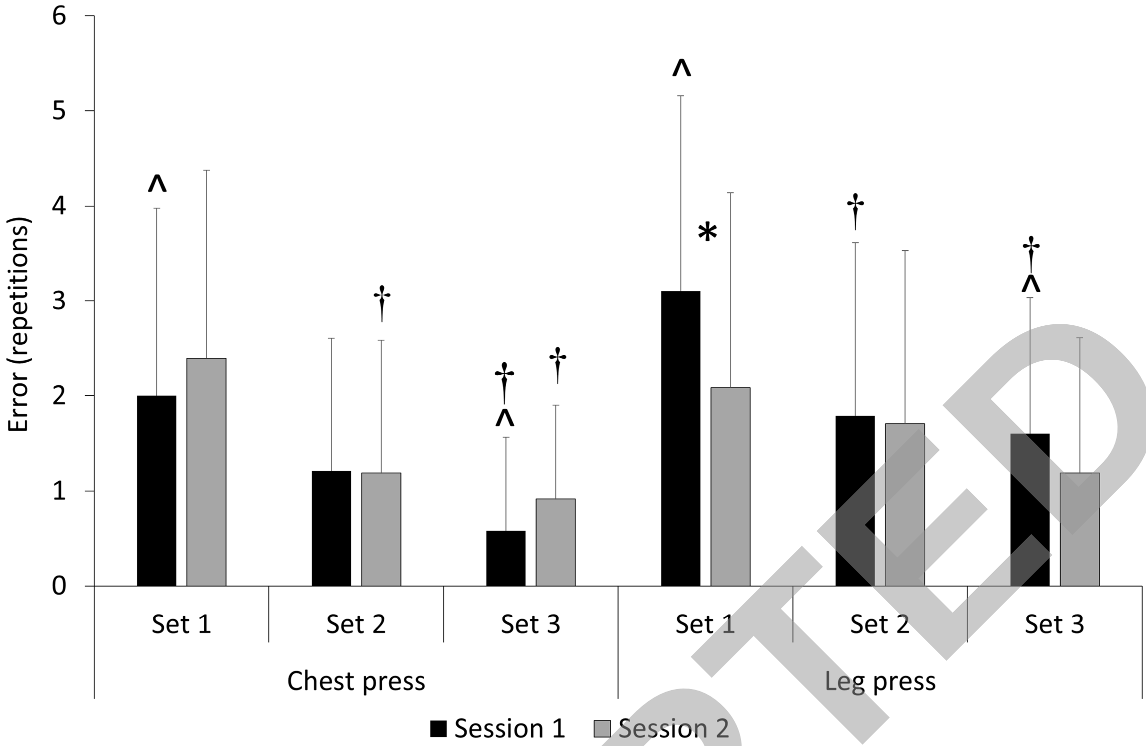
		Session 1			Session 2		
	Set	Actual Repetitions to Failure	SD	range	Actual Repetitions to Failure	SD	range
Chest press							
	1	6.2	2.7	[1 - 10]	6.6	3.0	[1 - 10]
	2	3.8	2.7	[0 - 10]	4.5	3.0	[1 - 10]
	3	3.0	1.6	[1 - 7]	4.1*	2.0	[1 - 10]
Leg press							
	1	7.5	2.8	[1 - 10]	6.8	3.0	[1 - 10]
	2	5.4	3.0	[1 - 10]	5.8	3.1	[0 - 10]
	3	4.7	2.9	[1 - 10]	4.9	2.8	[1 - 10]

Data are mean ± *SD* and range

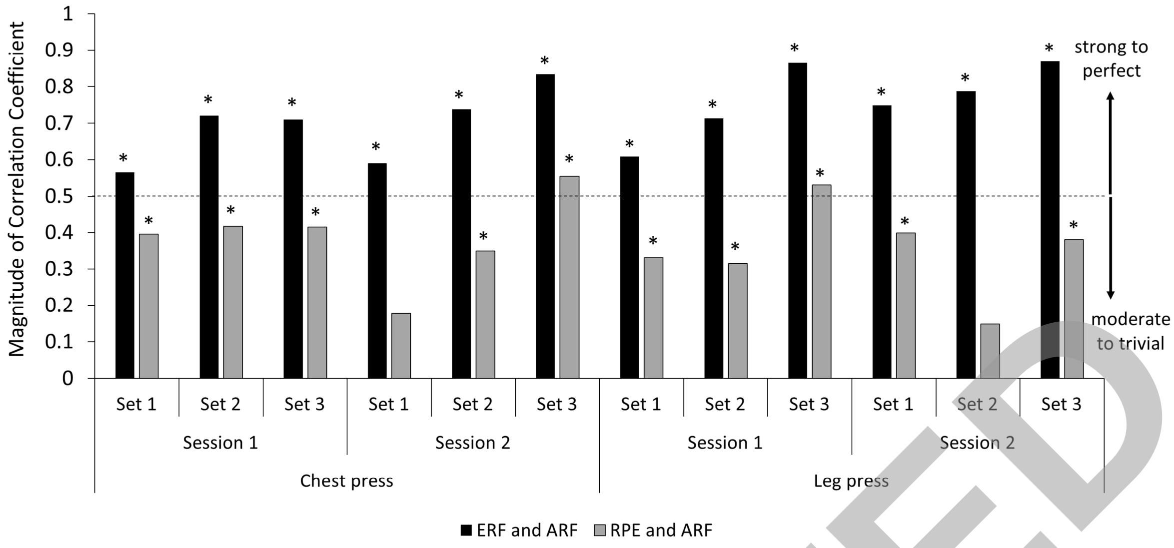
*Significantly different to session 1 ($p<0.05$)


A
y = -0.489x + 1.338
R² = 0.272; p=0.001
+1.96 SD
3.19
Mean
-0.63
+1.96 SD
-4.45
Diffrence (ARF-ERF)
Mean (ARF & ERF)
B
y = -0.521x + 1.097
R² = 0.342, p=0.001
+1.96 SD
2.51
Mean
-1.22
+1.96 SD
-4.95
Diffrence (ARF-ERF)
Mean (ARF & ERF)
C
y = -0.267x - 0.651
R² = 0.108, p=0.001
+1.96 SD
2.19
Mean
-1.95
+1.96 SD
-6.11
Diffrence (ARF-ERF)
Mean (ARF & ERF)
D
y = -0.2321x - 0.345
R² = 0.11; p=0.001
+1.96 SD
1.79
Mean
-1.52
+1.96 SD
-5.04
Diffrence (ARF-ERF)
Mean (ARF & ERF)


4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Error (repetitions)
^
^
*
^
^
†
Session 1
Session 2
Session 1
Session 2
Chest press
Leg press
Male
Female



6
5
4
3
2
1
0
Error (repetitions)
Set 1
Set 2
Set 3
Set 1
Set 2
Set 3
Chest press
Leg press
Session 1
Session 2


Magnitude of Correlation Coefficient
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
strong to perfect
moderate to trivial
Set 1
Set 2
Set 3
Session 1
Session 2
Chest press
Leg press
ERF and ARF
RPE and ARF