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Original Article

Accuracy in predicting repetitions in reserve during resistance training: Differences Across load intensities, distance from muscular failure, sexes, and exercises

NUNO CASANOVA[1], DIANA GOMES[2], FILIPE RUSSO[3], JOANA MATEUS[4], ANDRÉ VIEIRA[5], GONÇALO MALCATA[6], PAULO TENFEN[7], DENISE SOARES[8], FÁBIO FLÔRES[9]
[1,2,3] Insight: Piaget Research Center for Ecological Human Development, Instituto Piaget, PORTUGAL.
[4,5,6,7] Instituto Superior de Estudos Interculturais e Transdisciplinares de Almada, Instituto Piaget, PORTUGAL
[8] Liberal Arts Department, American University of the Middle East, 54200, Egaila, KUWAIT
[9] Escola de Ciências Sociais, Universidade de Évora, PORTUGAL
[9] Centro de Investigação em Educação e Psicologia (CIEP), Universidade de Évora, PORTUGAL
[9] Comprehensive Health Research Centre (CHRC), Universidade de Évora, PORTUGAL

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Abstract
Resistance training adaptations depend not only on external load but also on the accurate regulation of effort, particularly the ability to estimate proximity to muscular concentric failure. The Repetitions in Reserve (RIR) scale has emerged as a practical tool to quantify relative intensity, but evidence suggests that several factors may influence the ability for individuals to accurately report RIR. This study investigates the influence of load intensity, distance from muscular concentric failure, sex, and exercise type on the accuracy of predicting RIR during resistance training. Thirty-four healthy young adults aged 21.76 ± 2.35 years old with at least 6 months of resistance training experience participated in the study. Participants performed exercises at 50% and 75% of their one-repetition maximum (1RM), reporting perceived RIR at 3RIR and 1RIR. Results indicated higher accuracy in RIR reporting at 1RIR compared to 3RIR (all $p \leq 0.001$, except for the lying leg curl, $p = 0.097$) and at 75% of 1RM compared to 50% (all $p < 0.001$). Sex did not impact RIR accuracy except for the cable triceps pushdown (3RIR at 50% of 1RM), and minor differences were observed between exercises in which more accuracy was observed during the lying leg curl. The findings highlight the importance of educating individuals on the intensity of effort and relative intensity ratio (RIR) for effective training intensity regulation. Practitioners should consider these factors, particularly load intensity and distance from muscular concentric failure when prescribing resistance training programs to optimize training outcomes and support the achievement of fitness and performance goals.
Keywords: Effort regulation; exercise intensity; rating of perceived exertion; strength training.

Introduction

Resistance training offers numerous benefits, ranging from increased muscular strength, endurance, and hypertrophy to promoting metabolic health and functional capacity (Maestroni et al., 2020; Westcott, 2012). Central to the attainment of muscular adaptations, particularly skeletal muscle hypertrophy, is the strategic modulation of training intensity, wherein proximity to muscular concentric failure (i.e., intensity of effort) emerges as an essential determinant (Grgic et al., 2022; Refalo et al., 2023; Vieira et al., 2021). However, evidence suggests that skeletal muscle hypertrophy can be achieved through training without requiring absolute muscular concentric failure with each set (Refalo et al., 2023; Vieira et al., 2021). Nevertheless, to effectively train with a margin of repetitions left in reserve, individuals must possess the ability to recognize muscular concentric failure accurately. An inability to do so may result in less effort and potentially reduce the magnitude of adaptations. For instance, Lasevicius et al. (2022) observed that achieving muscular concentric failure may be more important to promote skeletal muscle hypertrophy for low-loads (~34.4 repetitions per set) in comparison to high-loads (~12.4 repetitions per set) (Lasevicius et al., 2022). This has important implications, as an individual's inability to accurately assess the intensity of effort may lead to suboptimal muscular adaptations. Therefore, the precise evaluation of effort intensity is paramount.

Traditionally, the intensity of effort during exercise has been assessed using the Rating of Perceived Exertion (RPE) scale, which provides a subjective rating of perceived exertion before, during, and after exercise (Borg, 1970; Foster, Rodriguez-Marroyo, & de Koning, 2017). However, in the context of resistance training, a novel scale has emerged, the Repetitions in Reserve (RIR) scale (Hackett et al., 2012; Zourdos et al., 2016). This scale offers individuals a means to quantify their proximity to muscular concentric failure during resistance exercises in an objective manner (through the quantification of repetitions before achieving muscular failure), thereby allowing for more accurate manipulation of training variables. Importantly, RIR-based RPE seems to

Corresponding Author: DENISE SOARES, E-mail: denise.soares@aum.edu.kw

have more utility during resistance training than the traditional Borg RPE scale, as data have demonstrated submaximal ratings on the Borg scale during resistance training even when a set has been taken to muscular failure (Hackett et al., 2012). While traditional RPE scales provide subjective ratings of perceived exertion, the RIR scale offers a more objective and precise means of assessing the intensity of effort. By providing a numerical representation of the number of repetitions remaining until muscular failure is achieved, the RIR scale offers a practical and objective method for individuals to gauge and adjust their intensity of effort during resistance training sessions. This distinction highlights the potential superiority of the RIR scale over traditional RPE methods, particularly in the context of resistance training, where the RIR scale has been shown to have greater sensitivity in assessing momentary failure (Hackett, Cobley, & Halaki, 2018).

Several studies have sought to assess the accuracy of individuals in utilizing the RIR scale during resistance training, revealing a considerable degree of variability in its application (Halperin et al., 2022; Remmert, Laurson, & Zourdos, 2023; Steele et al., 2017; Zourdos et al., 2021; Zourdos et al., 2016). This variability highlights the intricate interplay of factors that can impact the accuracy of RIR ratings. One such factor is the percentage of one-repetition maximum (1RM) used during resistance exercises, with evidence suggesting that using lower intensities (i.e., a lower rate of 1RM) may be associated with greater difficulty in accurately estimating proximity to muscular failure (Halperin et al., 2022). Furthermore, the distance from muscular failure (e.g., reporting 5RIR, 3RIR, or 1RIR) may impact the accuracy of RIR ratings, with previous research highlighting a higher degree of inaccuracy when participants reported 5RIR compared to 3RIR or 1RIR (Remmert, Laurson, & Zourdos, 2023; Zourdos et al., 2021). Additionally, variables such as the type of exercise, specific body parts targeted (Halperin et al., 2022), and sex (Hackett et al., 2017; Martins Dos Santos et al., 2020) may also influence the accuracy of assessing muscular concentric failure. However, the full extent of their impact remains to be fully comprehended (Halperin et al., 2022). Understanding these influencing factors is essential for elucidating the determinants of RIR accuracy and refining its application in resistance training.

Despite the increasing use of RIR-based prescription across athletic, recreational, and clinical settings, important gaps remain in the current literature. Previous studies have typically examined single variables in isolation, such as load intensity, sex, or exercise choice, making it difficult to determine their combined or comparative influence on an individual's ability to accurately estimate proximity to muscular concentric failure. Moreover, most available evidence is derived from either low-load or high-load protocols, from only one type of exercise, or from samples lacking diversity in sex or training experience. This fragmented evidence limits the practical utility of RIR as a tool for autoregulated training. A deeper understanding of how accuracy varies across load intensities, distances from muscular failure, and exercise characteristics is crucial, as misjudging repetitions in reserve, even by one or two repetitions, can meaningfully alter the actual training stimulus. Inaccurate perception of effort may result in consistently under-reaching target intensities, thereby diminishing strength and hypertrophy outcomes, or conversely, unintentionally approaching failure when not programmed. Given the widespread adoption of RIR-based strategies by coaches, athletes, and practitioners to individualize and regulate training intensity, establishing when and under what conditions individuals can accurately predict their RIR carries significant practical relevance. Identifying the contexts in which accuracy is higher or lower can inform exercise selection, load prescription, educational strategies, and expectations for different populations, ultimately supporting more effective and evidence-based programming. To address these gaps, the present study systematically examined RIR accuracy across multiple relevant training variables (load intensity, distance from muscular concentric failure, sex, and exercise type) within a controlled design.

By directly comparing these factors within the same participants and protocol, this study provides a comprehensive evaluation of the conditions that influence an individual's ability to accurately estimate repetitions in reserve during resistance training. Accordingly, the primary aim of the present study was to investigate the influence of intensity of load (training at 50% or 75% of 1RM), distance from muscular failure (reporting at 3RIR and 1RIR), sex, and type of exercise (single-joint vs. multi-joint, or upper-body vs. lower-body) on the accuracy of assessing proximity to muscular failure during resistance training. We hypothesized that participants would estimate their repetitions in reserve more accurately when lifting heavier loads (75 % 1RM), and when nearer to muscular concentric failure (1 RIR vs 3 RIR), with sex and exercise type potentially moderating this accuracy.

Methods

Subjects

For the determination of sample size, G*Power (v 3.1.9.7) (Faul et al., 2007) was used, with a significance level set at $\alpha = 0.05$ and a desired power of 0.80. Based on an effect size of 0.75 reported in a prior study (Zourdos et al., 2021), a sample size of 16 participants was calculated to enable comparisons using paired t-tests. However, to accommodate additional comparisons between sexes, a total of 34 healthy young adults (19 males and 15 females) aged 21.76 ± 2.35 years, with at least 6 months of experience in resistance training, were recruited to participate in the present study. Participants were required to abstain from engaging in any form of exercise for a minimum of 72 hours before testing to mitigate the potential effects of fatigue. Additionally, they refrained from taking any medication or supplements that could potentially influence the study's outcomes. Prior to inclusion, participants underwent a screening session during which a qualified trainer assessed their exercise technique for the three exercises performed in the study. Only participants demonstrating satisfactory exercise techniques were included in the study. Exclusion criteria encompassed any contraindications to exercise, such as cardiovascular diseases or significant musculoskeletal disorders.

Procedures and instruments

Participants attended a single session at the university's laboratory for data collection. Before the commencement of study procedures, all eligible participants attended an initial session held on a separate day from data collection. During this session, the entire research protocol was thoroughly explained, and participants provided written informed consent after being informed about the study's aims, potential risks, and data confidentiality. A comprehensive explanation of the RIR scale was also provided during this initial session to ensure that participants fully understood the concept before the testing phase. All data collection sessions were conducted in the morning during the same period for each participant to minimize potential circadian influences. To ensure that participants understood the concept and application of the scale, a practical demonstration was conducted using visual aids and verbal instructions. Feedback and clarification were provided as needed to address any questions or uncertainties regarding the use of the RIR scale. This approach aimed to enhance participants' comprehension and confidence in accurately reporting RIR during the subsequent exercise session, thereby minimizing potential sources of variability and ensuring consistent data collection. Following this, anthropometric measurements, including height and total body mass, were obtained. Subsequently, participants completed a five-minute standardized dynamic warm-up before performing a 1RM test for the following exercises: cable triceps pushdown, cable horizontal row with a neutral shoulder-width grip, and lying leg curl. The selected exercises were selected due to their ease of technique standardization and control. Additionally, they target distinct muscle groups and include both single- and multi-joint movements, allowing for broader comparisons across exercise types. After 10 minutes of resting, each exercise was performed at two different percentage loads of the participants' 1RM (50% and 75%). During each set, participants verbally reported when they perceived they were at 3RIR and 1RIR. Participants were instructed to perform each set to volitional concentric muscular failure, with supervised oversight from trained research assistants. To maintain consistency and minimize potential sources of variability, standardization procedures were implemented across all aspects of the study protocol. Instructions provided to participants were scripted to ensure uniformity and clarity, reducing the likelihood of misinterpretation or confusion, particularly with the usage of the RIR scale. The same research assistants conducted all testing sessions, delivering standardized verbal cues and encouragement during exercise sessions, using predetermined phrases and a consistent tone of voice to provide support to participants. Additionally, the technique for each exercise was assessed during the screening session, and corrective feedback was provided as needed to ensure proper execution.

Randomization for both exercise order and percentage of 1RM conditions was implemented using computer-generated randomization. Before the study's initiation, the research team conducted all randomization procedures and finalized the randomization sequence to ensure unbiased allocation of participants to different experimental conditions. This approach minimized the risk of selection bias and maintained the integrity of the randomization process throughout the study. The research received approval from the University Ethics Committee (Approval code: P02-S09-27042022), and the study protocol adhered to the guidelines stipulated by the Declaration of Helsinki ("World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects," 2014).

Anthropometric measurements

Participants' body mass and height were assessed using a digital scale (SECA 761, Bacelar & Irmão Lda, Portugal) and a stadiometer (SECA 213, Bacelar & Irmão Lda, Portugal), respectively. These measurements were conducted with participants wearing minimal clothing and barefoot to ensure accuracy. Body mass index (BMI) was then calculated using the formula: BMI (kg/m^2) = body mass (kg) / height $(m)^2$

One repetition maximum test

Before testing, participants engaged in a standardized warm-up routine consisting of dynamic movements and the same exercises as those included in the study, performed with reduced resistance to prepare for the upcoming tasks. Following the warm-up, participants underwent a progressive loading protocol to determine their 1RM for each exercise. This protocol involved starting with five repetitions at 20% of their estimated 1RM, followed by three repetitions at 50% of their estimated 1RM, two repetitions at 70%, one repetition at 80%, and one repetition at 90% of their 1RM. Subsequent increases in 1RM attempts were made at the investigator's discretion, with RPE collected after each attempt to assist in selecting the next load. A rest period of five to seven minutes was allowed between each 1RM attempt. Importantly, the order of exercises and the determination of 1RM were randomized for each participant, and each exercise's 1RM was tested separately, with sufficient rest provided between attempts.

Repetitions to failure exercise protocol

After a 10-minute rest period following the determination of their 1RM, participants proceeded to perform repetitions until reaching volitional failure at both 50% and 75% of their respective 1RM loads. Volitional failure was defined as the point at which the participant was unable to complete a repetition or when both the participant and the investigator agreed that no further repetitions could be performed. During each set taken to muscular failure, participants verbally indicated when they believed they were at 3RIR and 1RIR. Both the predicted (using the RIR scale) and actual repetitions to failure were recorded, and the difference was calculated for each level (i.e., 3RIR and 1RIR), providing insight into the accuracy in reporting repetitions to failure during the set (RIRDIFF). In this calculation, negative values represent an underestimation of participants' maximum ability. For instance, if a participant reported 1RIR at repetition number 10 (i.e., would be able to perform 11 total repetitions) and performed 14 total repetitions, RIRDIFF would be equal to -3. This would indicate that this participant would have a margin of error of 3 repetitions when aiming to report the intensity of effort accurately. The order of the percentage of 1RM used was randomized. However, the exercise order mirrored that of the 1RM testing session, and sufficient rest (5 minutes) was given to ensure recovery between each set.

Statistical analysis

Data analysis was performed using SPSS software version 28 (IBM Corp., Armonk, New York). The data were assessed for normality using the Shapiro-Wilk test, and homogeneity of variances was examined using Levene's test. As these assumptions were not met for the variables under investigation, non-parametric statistical tests were employed for data analysis. For comparisons between independent groups (e.g., males vs. females), the Mann-Whitney U test was utilized. For comparisons within the same group but under different conditions (e.g., 50% vs. 75% of 1RM; 3RIR vs. 1RIR), the Wilcoxon signed-rank test was used. Moreover, to assess the differences between the three exercises, the Friedman test was applied. In the event of significant differences, post-hoc analyses were conducted using Wilcoxon signed-rank tests (with Bonferroni adjustments; p-value: 0.05 / 3 = 0.017 as three exercises were used in the present study) to determine specific pairwise differences between the exercises. Lastly, to assess whether each participant would have a similar level of accuracy independently of the intensity of load (50% or 75% of 1RM), distance from muscular concentric failure (1RIR or 3RIR), and exercise, Spearman Correlations were calculated. Correlation coefficients <0.30 were considered weak, those between 0.30 and 0.70 were considered moderate, and coefficients >0.70 were considered strong (Field, 2005). Data is presented as mean ± standard deviation, and statistical significance was set at $p < 0.05$.

Result

Descriptive characteristics for the entire sample, along with sex-based differences, are presented in Table 1. As can be observed, males demonstrated higher body mass and height values compared to females, but no significant differences were observed in terms of age or BMI.

Table 1 – Descriptive characteristics for the whole sample and differences between males and females.

Variable	Total (n=34)	Male (n=19)	Female (n=15)	P-value
Age (years)	21.76 ± 2.35	21.89 ± 2.54	21.60 ± 2.16	0.694
Body mass (kg)	65.04 ± 8.68	69.47 ± 5.30	59.43 ± 9.01	<0.001 *
Height (m)	1.66 ± 0.30	1.76 ± 0.05	1.65 ± 0.06	<0.001 *
BMI (kg/m^2)	22.23 ± 3.32	22.49 ± 1.92	21.89 ± 2.78	0.477

BMI – Body mass index. * Statistically significant differences between males and females.

Table 2 displays the 1RM values, loads utilized at each percentage of 1RM, and the total number of repetitions performed for the entire sample, as well as differences between males and females. As can be observed, males exhibited higher values for 1RM and utilized higher loads for each percentage of 1RM in comparison to females. Regarding the total number of repetitions, there were no statistically significant differences between sexes, except for the exercise lying leg curl at 50% of 1RM, where males performed a greater number of total repetitions than females.

Table 2 – Load utilized at each percentage of 1 repetition maximum and total number of repetitions performed at each load for the whole sample and differences between males and females.

Exercise	Variable	Total (n=34)	Male (n=19)	Female (n=15)	P-value
Triceps Pushdown	1RM (kg)	56.82 ± 16.89	69.21 ± 11.93	41.13 ± 4.14	<0.001 *
	50% 1RM – Load (kg)	28.41 ± 8.44	34.61 ± 5.97	20.57 ± 2.07	<0.001 *
	50% 1RM – Total Repetitions	26.15 ± 6.52	24.84 ± 6.14	27.80 ± 6.82	0.289
	75% 1RM – Load (kg)	42.60 ± 12.66	51.89 ± 8.94	30.84 ± 3.10	<0.001 *
	75% 1RM – Total Repetitions	12.03 ± 3.51	11.68 ± 2.83	12.47 ± 4.29	0.483
Cable Row	1RM (kg)	59.03 ± 17.75	72.11 ± 11.94	42.47 ± 5.78	<0.001 *
	50% 1RM – Load (kg)	29.52 ± 8.87	36.05 ± 5.97	21.25 ± 2.92	<0.001 *
	50% 1RM – Total Repetitions	19.44 ± 4.91	19.47 ± 5.17	19.40 ± 4.75	0.945
	75% 1RM – Load (kg)	44.24 ± 13.29	54.04 ± 8.88	31.82 ± 4.36	<0.001 *
	75% 1RM – Total Repetitions	9.00 ± 3.39	9.95 ± 4.02	7.80 ± 1.90	0.165
Leg Curl	1RM (kg)	52.26 ± 14.66	62.89 ± 9.90	38.80 ± 5.75	<0.001 *
	50% 1RM – Load (kg)	26.13 ± 7.33	31.45 ± 4.95	19.40 ± 2.87	<0.001 *
	50% 1RM – Total Repetitions	18.35 ± 4.66	20.26 ± 4.54	15.93 ± 3.67	0.010 *
	75% 1RM – Load (kg)	39.19 ± 11.01	47.18 ± 7.43	29.08 ± 4.33	<0.001 *
	75% 1RM – Total Repetitions	8.03 ± 3.16	8.21 ± 2.95	7.80 ± 3.49	0.636

1RM – 1 Repetition maximum. * Statistically significant differences between males and females.

The values for RIRDIFF at both 3RIR and 1RIR, categorized by exercise, percentage of 1RM, and sex, are presented in Table 3. Regarding the moment in which RIR was reported (i.e., 3RIR or 1RIR), statistically significant differences were observed across all exercises and conditions (all $p < 0.001$), except for the lying leg curl exercise performed at 75% of 1RM ($p = 0.097$). Notably, RIR reporting tended to be more accurate (i.e., values closer to zero) at 1RIR compared to 3RIR. Concerning the percentage of 1RM, significant differences in RIRDIFF were observed for all exercises and at both 3RIR and 1RIR between 50% and 75% of 1RM (all $p < 0.001$), indicating higher accuracy in RIR reporting at 75% of 1RM. Analysis of differences in RIR reporting accuracy between sexes revealed no statistically significant differences between males and females (all $p > 0.093$), except for the 3RIR reported during the cable triceps pushdown exercise at 50% of 1RM, where males demonstrated higher accuracy.

Regarding the distinctions among the three exercises, statistically significant differences were identified at 75% of 1RM for both 3RIR ($p = 0.014$) and 1RIR ($p = 0.020$) but not at 50% for either 3RIR ($p = 0.839$) or 1RIR ($p = 0.130$). Subsequent post-hoc analyses at 75% of 1RM revealed significant differences at 3RIR between the cable triceps pushdown and lying leg curl ($p = 0.012$), as well as between the cable row and lying leg curl ($p = 0.016$). In contrast, no significant difference was observed between the cable triceps pushdown and cable row ($p = 0.860$). These findings indicate that RIR reporting accuracy was higher during the lying leg curl exercise compared to both the cable triceps pushdown and cable row. Furthermore, at 1RIR, the only significant difference observed was between the lying leg curl and cable row ($p = 0.014$), with no significant differences noted between the cable triceps pushdown and cable row ($p = 0.532$) or between the cable triceps pushdown and lying leg curl ($p = 0.048$). Consequently, RIR reporting accuracy was superior during the lying leg curl exercise in comparison to the cable row. Regarding the Spearman correlations calculated between exercises and for each condition (50% or 75% of 1RM, and 1RIR or 3RIR), no statistically significant associations were observed (all $r_s \leq 0.332$; $p \geq 0.055$).

Table 3 – Values for the differences between reported repetitions in reserve and total number of repetitions at 3RIR and 1RIR for the whole sample and between males and females.

Exercise	RIRDIFF	Total (n=34)	Male (n=19)	Female (n=15)
Triceps Pushdown	50% 1RM - 3RIR	-4.68 ± 3.64	-3.58 ± 2.85	-6.07 ± 4.13
	50% 1RM - 1RIR	-2.44 ± 3.02	-1.58 ± 1.71	-3.53 ± 3.93
	75% 1RM - 3RIR	-1.59 ± 1.88	-1.42 ± 2.12	-1.80 ± 1.57
	75% 1RM - 1RIR	-0.50 ± 0.75	-0.32 ± 0.75	-0.73 ± 0.70
Cable Row	50% 1RM - 3RIR	-3.94 ± 2.26	-3.42 ± 2.12	-4.60 ± 2.32
	50% 1RM - 1RIR	-2.18 ± 1.93	-1.79 ± 1.65	-2.67 ± 2.19
	75% 1RM - 3RIR	-1.56 ± 1.56	-1.95 ± 1.54	-1.07 ± 1.49
	75% 1RM - 1RIR	-0.65 ± 1.04	-0.84 ± 1.12	-0.40 ± 0.91
Leg Curl	50% 1RM - 3RIR	-3.44 ± 2.11	-3.95 ± 2.32	-2.80 ± 1.66
	50% 1RM - 1RIR	-1.32 ± 2.06	-1.26 ± 2.45	-1.40 ± 1.50
	75% 1RM - 3RIR	-0.47 ± 1.64	-0.32 ± 1.49	-0.67 ± 1.84
	75% 1RM - 1RIR	-0.09 ± 0.71	-0.05 ± 0.71	-0.13 ± 0.74

1RM – 1 repetition maximum; RIR – repetitions in reserve.

Discussion

The current study aimed to investigate several factors influencing the accuracy of reporting RIR during resistance training, including sex-based differences, load intensity, exercise type, and proximity to muscular concentric failure. The findings from this study suggest that higher accuracy may be observed at higher proximity to muscular failure and higher load intensities. However, no consistent sex-related or exercise-based differences were observed.

Prior investigations have indicated that terminating each set close to muscular failure is crucial for maximizing muscular adaptations, particularly in terms of skeletal muscle hypertrophy, while leaving a few repetitions in reserve (RIR) that may yield comparable results (Refalo et al., 2023; Vieira et al., 2021). Recent evidence from a crossover design study corroborates this notion, demonstrating similar quadriceps hypertrophy outcomes between legs subjected to different exercise interventions: one reaching muscular failure and the other maintaining 1-2RIR per set (Refalo et al., 2024). Although training with RIR may produce comparable muscular adaptations, accurately assessing one's intensity of effort becomes paramount, as misreporting RIR levels can potentially result in suboptimal training outcomes. Therefore, comprehending both modifiable and non-modifiable factors influencing the precision of RIR reporting is essential. Such insights not only aid in refining training prescription and periodization but also empower professionals to optimize training efficacy.

Consistently across scientific research, two factors have emerged as significant determinants of accuracy in reporting the intensity of effort during resistance training: proximity to muscular concentric failure and the intensity of the load (Halperin et al., 2022). In the present investigation, participants demonstrated greater accuracy in reporting the intensity of effort at 1RIR compared to 3RIR, which aligns with previous findings (Halperin et al., 2022; Zourdos et al., 2021; Zourdos et al., 2016). Additionally, accuracy was more pronounced when intensity of effort was reported at 75% of 1RM compared to 50% of 1RM. These findings align with prior research, which has demonstrated greater precision in reporting RIR when closer to muscular failure and at higher percentages of 1RM. For instance, Zourdos et al. (2021) reported higher accuracy at 1RIR compared to 3RIR or 5RIR (Zourdos et al., 2021). These observations are further supported by a scoping review and exploratory meta-analysis conducted by Halperin et al. (2022). Furthermore, Halperin et al. (2022) noted that as the number of repetitions performed to task failure decreased (indicating a load at a higher percentage of 1RM), the accuracy in reporting RIR increased. Specifically, the authors found no statistically significant differences in accuracy when the total repetitions per set fell below 12, corresponding to loads exceeding ~70% of 1RM. However, discrepancies in accuracy emerged when a higher number of repetitions were performed per set despite substantial heterogeneity in the data. These results align with the data from the present study, in which accuracy was higher at 75% of 1RM (averaging 8 to 12 repetitions per set) compared to 50% of 1RM (>12 repetitions per set). While the precise mechanisms behind the observed findings warrant further investigation, it is plausible to hypothesize that individual perceptions of discomfort may influence the accuracy of RIR reporting. For instance, it has been noted that discomfort perceptions may be higher during lower-load exercises, as observed in a study in which participants performed an isolated lumber extension exercise at 80% or 50% of maximal voluntary contraction, with reported discomfort being higher during the latter condition (Stuart et al., 2018). Consequently, heightened discomfort sensations may prompt individuals to cease a set prematurely, even when they retain the physical capacity to generate mechanical force.

Consistent with previous literature, our results revealed significant sex-based differences in anthropometric characteristics and strength parameters, with males exhibiting higher body mass, height, and 1RM values compared to females across all exercises, reflecting inherent disparities in muscular strength and mass between the sexes (Roberts, Nuckols, & Krieger, 2020). However, it is noteworthy that despite these differences, both sexes demonstrated similar levels of accuracy in reporting RIR, with only minor discrepancies observed in specific conditions, such as 3RIR during the cable triceps pushdown exercise at 50% of 1RM. These findings are in agreement with the results of Hackett et al. (2017), in which differences between sexes only emerged during the leg press exercise, at four or more repetitions away from muscular concentric failure, in which males reported more accurate values for RIR (Hackett et al., 2017).

Our results revealed differences in the accuracy of RIR reporting across various resistance exercises, particularly evident at 75% of 1RM. Post-hoc analyses showed a superior accuracy in reporting RIR during the lying leg curl exercise compared to both the cable triceps pushdown and cable row exercises. However, similar to findings by Halperin et al. (2022), these differences exhibited a degree of heterogeneity, with small and inconsistent variations across all conditions (Emanuel, Rozen, & Halperin, 2020). This discrepancy could stem from biomechanical differences and individual familiarity with each exercise, both of which may influence perceptions of effort. Moreover, while all exercises in our study were stable and of relatively low complexity, the extent to which similar findings would manifest in more complex movements remains uncertain. For instance, Emanuel et al. (2020) noted that apart from perceived fatigue, factors such as pain and cardiovascular strain, which contribute to set termination, were more prevalent during the squat exercise (Emanuel, Rozen, & Halperin, 2020). Thus, comparing exercises like the lying leg curl or leg extension to squats or a chest fly to a barbell bench press, with their differing loads, complexities, and physiological demands, may yield divergent accuracies in reporting RIR. It is noteworthy that Spearman correlations did not reveal any statistically significant associations between exercises and conditions. These were calculated since it could be postulated that participants exhibit consistent levels of accuracy across exercises and conditions (e.g., the same inaccuracy of 2 repetitions for the three exercises performed at 75% of 1RM). However, these results suggest that an individual's accuracy in estimating RIR could vary depending on the specific exercise, intensity of load, and proximity to muscular failure. Therefore, it is essential to assess the accuracy of each participant individually for each exercise, taking into account the variability observed across conditions.

While this study provides insights into the accuracy of predicting RIR during resistance exercise, some limitations should be acknowledged. Firstly, the study sample consisted of relatively young (18 to 31 years old) and healthy individuals with modest training experience, which may limit the generalizability of the findings to other populations, such as more experienced practitioners, older adults, or individuals with specific medical conditions. Of note, no associations were observed between age and level of accuracy in reporting RIR for any exercise or condition. Furthermore, only three exercises and two intensity loads were assessed in the current study. However, these were exercises in which the technique was simple and that are frequently used during resistance training, which reduces the influence of novelty or technique complexity. Future studies could benefit from including a more diverse participant pool and exploring how factors such as age and exercise selection influence the accuracy of RIR predictions, as well as using other intensity loads. It is noteworthy that while participants were acquainted with the traditional 0-10 RPE scale, they were not familiar with the RIR scale. This lack of familiarity with the RIR scale could have influenced the accuracy of their reporting.

Previous evidence suggests that accuracy in reporting RIR may improve over successive sets (Halperin et al., 2022; Remmert, Laurson, & Zourdos, 2023; Zourdos et al., 2021). The present study involved one set per condition, which potentially limited participants' acclimatization to the RIR scale and affected the accuracy of their reports. To mitigate this limitation, the order of conditions was randomized, aiming to minimize any potential bias related to the order of performance. Moreover, the study did not investigate potential cognitive or psychological factors that may influence RIR prediction accuracy, such as attentional focus or motivation. Likewise, studies could incorporate measures of cognitive function or psychological factors to understand better their impact on the accuracy of effort estimation intensity during resistance training. Addressing these limitations and exploring these avenues for future research will enhance our understanding of how individuals perceive and regulate the intensity of effort during resistance training.

In conclusion, the present study highlights the diverse range of variables that influence RIR accuracy during resistance training. While sex-based differences in anthropometric characteristics and strength parameters were observed, they did not significantly affect an individual's ability to gauge proximity to muscular failure accurately. Notably, the intensity of load and proximity to muscular concentric failure emerged as determinants of RIR reporting accuracy, as well as exercise type, emphasizing the importance of tailored programming strategies to optimize training outcomes. Moving forward, research endeavours should explore the role of specific psychological factors, such as perceived exertion and discomfort, in conjunction with physiological parameters to provide comprehensive insights into resistance training programming. By addressing these aspects, future studies can further elucidate the nuances of RIR accuracy and contribute to refining effective training protocols.

Practical applications

The findings of this study provide practical insights for athletes, coaches, and fitness professionals involved in resistance training programs. Firstly, the importance of educating individuals on the concept of RIR is underscored, enabling them to assess the intensity of their effort during resistance exercises accurately. Understanding the proximity to muscular failure allows individuals to regulate training intensity effectively, thereby optimizing the stimulus for muscular adaptations. This is particularly relevant when prescribing lower loads, where achieving muscular failure may be more critical for optimal skeletal muscle hypertrophy (Lasevicius et al., 2022). Our findings, in alignment with prior research (Halperin et al., 2022), suggest that accurately identifying RIR may pose challenges with lower loads. Thus, practitioners should exercise caution when prescribing lower loads, as underestimation of the intensity of effort may compromise the desired muscular adaptations.

Moreover, practitioners should consider the influence of distance from muscular failure when prescribing or executing sets aimed at leaving some residual intensity range (RIR). Our study indicates that accuracy in reporting 3RIR was lower compared to closer proximity to muscular failure, consistent with previous findings (Halperin et al., 2022; Zourdos et al., 2021; Zourdos et al., 2016). Educating practitioners on absolute muscular failure can serve as an anchor for accurate RIR reporting. Understanding that a set terminated at 3RIR may have ended with five or more RIR emphasizes the need for practitioners to recalibrate their understanding of intensity thresholds. Regarding sex and exercise differences, our study suggests that these may not significantly predict RIR reporting inaccuracy. While minor differences were observed between sexes and exercises in specific conditions, overall accuracy was comparable between males and females. Similarly, no clear associations were found based on exercise type, which is consistent with prior findings (Halperin et al., 2022), although the lying leg curl exhibited superior accuracy compared to other exercises. Thus, it is essential for everyone to evaluate and calibrate their level of accuracy for each exercise under specific conditions. This study's findings provide valuable insights into the practical application of RIR concepts in resistance training programming. By educating individuals on RIR principles, tailoring training programs to individual characteristics, and promoting ongoing monitoring and adjustment of training intensity, practitioners can optimize training outcomes and support the achievement of fitness and performance goals.

Conclusions

The findings of this study suggest that trained individuals demonstrate markedly greater accuracy when estimating very low repetitions in reserve (1 RIR) compared to moderate RIR values (3 RIR), indicating that the ability to assess proximity to muscular failure becomes increasingly precise as individuals approach the point of task termination. This finding reinforces previous research while extending its applicability across different muscle groups and both single- and multi-joint exercises.

Collectively, the results suggest that although the RIR scale is a valuable autoregulation tool, its utility is constrained by the individual’s capacity to accurately judge distances from failure, which may lead to unintended reductions in training stimulus when higher RIR targets are prescribed. From a practical standpoint, these insights highlight the importance of exposure to near-failure training to refine perceptual accuracy, as well as the need for coaches and practitioners to interpret reported RIR values with caution, particularly when programming at 3–5 RIR ranges. Improving athletes’ familiarity with muscular failure, providing structured feedback, and selecting exercises that allow for clearer perception of effort may help enhance the effectiveness of RIR-based training prescriptions.

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Use of generative ai statement

During the preparation of this work the author(s) used ChatGPT
in order to Check references formatting, grammar inconsistencies and synonyms.

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