Title of the article: The Autoregulation Rest Redistribution Training method mitigates sex differences in neuromuscular and perceived fatigue during resistance training

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Abstract

Purpose: To examine the sex differences in performance and perceived fatigue during resistance training prescribed using traditional (TRA) and autoregulation rest redistribution training (ARRT) approaches. ***Methods:*** Twelve resistance-trained males and twelve females completed two sessions including the bench press exercise matched for load (75% of 1-repetition maximum), volume (24 repetitions), and total rest (240 s). Sessions were performed in a counterbalanced randomized design with TRA consisting of 3 sets of 8 repetitions with 120 s interset rest and ARRT employing a personalized combination of clusters, repetitions per cluster, and between-cluster rest regulated with a 20% velocity loss threshold. The effects of TRA and ARRT on velocity loss, unilateral isometric peak force and rating of fatigue (ROF) were compared between sexes. ***Results:*** The velocity loss was generally lower during ARRT compared to TRA (-0.47 ± 0.11%) with velocity loss being mitigated by ARRT to a greater extent among males compared to females (-0.37 ± 0.15%). A smaller unilateral isometric peak force decline was observed after ARRT than TRA among males compared to females (-38.4 ± 8.4N). Lower ROF after ARRT than TRA were found among males compared to females (-1.97 ± 0.55AU). Additionally, males reported greater ROF than females across both conditions (1.92 ± 0.53AU), and ARRT resulted in lower ROF than ARRT overall (-0.83 ± 0.39 AU). ***Conclusions:*** The ARRT approach resulted in decreased velocity loss, peak force impairment, and ROF compared to TRA in both sexes. However, male subjects exhibited more pronounced acute within-session benefits from the ARRT method.

Keywords

Autonomy; load monitoring; perception; velocity-based training; velocity loss

Introduction

Fatigue is an activity-induced psychophysiological condition that manifests during resistance training (RT). It is typically quantified as a reduction in the mechanical outputs and a concurrent increase in the subjective perception of fatigue associated with a repeated motor task.[1] Measuring fatigue is common to define the limits of human performance.[2] Though, in RT, proxies of fatigue are also used to prescribe, monitor, and regulate the neuromuscular overload necessary for inducing desired training effects.[3,4] For example, the decline in velocity – hereby referred to as "velocity loss" – observed across consecutive repetitions and sets provides actionable information on the extent of acute neuromuscular fatigue accumulating during resistance exercises.[5,6] In this regard, a specific choice of velocity loss thresholds will affect both acute and chronic responses to RT.[7] As neuromuscular fatigue impairs the contractile function during and after RT, managing neuromuscular fatigue accrual within and between sessions is practically important to maximize long-term adaptations such as muscle growth, strength, and power development.[8–10] Therefore, it is not surprising that strength and conditioning practitioners constantly seek to develop training practices that effectively manage fatigue levels and maximize the benefits of RT.

One such approach is the Autoregulation Cluster Training (ACT) method,[11] which integrates two evidence-based concepts, autoregulation and cluster-set training, into one programming strategy, overcoming some of the shortcomings of traditional RT practices. The latter rely on guidelines instructing training prescription in the form of fixed structures and constituent training variables (e.g., a pre-determined number of sets and repetitions and duration of between-set rest intervals), thus failing to account for the variability of day-to-day performance.[12] For instance, RT performance (e.g., the number of repetitions that can be completed against a given load and the associated velocity outputs) may fluctuate on a day due to neuromuscular and perceived fatigue, or randomly due to other daily stressors such as chronic sleep deprivation, or inadequate dietary regimens.[13–15] Therefore, prescribing RT based on rigid structures may lead to a disparity between the prescribed dose and the observed response. An appropriate training dose is crucial for maintaining an optimal equilibrium between training stimuli and recovery, essential for eliciting favorable adaptations. In pursuit of this goal, modifications to traditional RT methodologies such as combination loading (i.e., alternating heavy and light loads across exercises or training sessions), alternative set configurations (e.g., cluster sets and redistributing rest intervals within sets), and adjusting rest periods, can be implemented to fine-tune the ideal volume load and training intensity for each individual.[16,17] Conceptually, ACT is a personalized method that allows the modification of RT structures by dynamically accommodating changes to cluster-set configurations based upon one's own autoregulation target (e.g., velocity loss threshold) iteratively during the ongoing training session. As such, ACT facilitates greater flexibility in training, and in the study of Dello Iacono et al[11] was found superior to traditional (TRA) and fixed cluster-set training configurations in mitigating velocity loss and perceived fatigue in RT sessions consisting of the bench press and back squat exercises loaded with 75% of 1 repetition maximum (1RM).

The current evidence supports the use of ACT in practice, though these findings are limited to males. Considering the potential sex differences in fatigability,[18] it is important to investigate how ACT influences RT performance and whether it mitigates motor performance and perceived fatigue in females to a similar extent as in males. While the evidence about sex differences in isometric fatiguing contractions and the contributory mechanisms is available,[19] it does not directly translate into actionable insights for prescribing RT with dynamic movements.[19] Moreover, knowledge about sex differences in fatigability during dynamic RT tasks is still limited,[19] with only a few studies investigating the effects of autoregulation RT practices on sex differences in fatigability.[4,20] In this regard, Walker et al.[20] found that the sex differences in neuromuscular fatigability observed in the Smith-machine back squat exercise across consecutive sets terminated upon exceeding a velocity loss of 40% were considerably reduced when a lower autoregulation target of 20% velocity loss was used. Furthermore, Dello Iacono et al[21] also discovered that individuals experiencing greater velocity loss in the TRA condition tended to derive more benefit from the ACT condition, indicating a pronounced mitigating effect on neuromuscular fatigue. Given this supporting evidence and the common observation that males typically incur greater velocity loss than females in the TRA condition,[22] one could hypothesize that prescribing RT using personalized, autoregulated methods, compared to TRA set configurations, and anchoring the autoregulation target at a more distant rather than proximate proximity-to-failure point (20% vs. 40% velocity loss) may mitigate the sex differences in acute fatigability often observed in traditional RT.

Therefore, the aim of this study was to examine the sex differences in motor performance and perceived fatigue among resistance-trained females and males during RT sessions prescribed using TRA and ACT approaches. To note, ACT in its nature, aligns more closely with a rest redistribution configuration rather than a cluster-set configuration.[7] In fact, total rest is dynamically redistributed across clusters without additional extra rest time. Therefore, throughout this manuscript, we will use the term autoregulation rest redistribution training (ARRT) instead of ACT. In line with the current literature, we expected motor performance and perceived fatigue to be lower overall under ARRT compared with the TRA approach. Moreover, considering the personalized nature and the fixed autoregulation anchor (i.e., 20% velocity loss) characterizing ARRT, we hypothesized that the latter would be more effective in mitigating fatigue in males compared to females.

Methods

Sample Size

A convenient sample of twenty-four subjects was chosen based on a few pragmatic considerations. First, recruiting a larger sample was not feasible given the time, resource and staff constraints required for the data collection. Second, the chosen sample size is greater than in most published studies investigating the comparative effects between traditional and cluster-set RT configurations on acute fatigue using similar research designs.[23] Third, we encountered challenges in determining either the smallest effect size of interest or an expected effect size from theoretical predictions, given the absence of previous studies investigating the effects of TRA and ARRT approaches between sexes. Despite this limitation, our objective was to detect a small effect size (Cohen's $f < 0.25$). Given our study design, with a Type-1 error rate (i.e., α level) < 0.05, a total sample size of 22 subjects from two subgroups (males and females), two measurements (pre- and post-experimental condition), and a correlation among repeated measures of ≥ 0.7, the statistical power to detect a significant effect was calculated at 0.82.

Subjects

Subjects' characteristics are presented in Table 1. Twelve males and twelve females volunteered to participate in the study upon confirmation of the following inclusion criteria: be healthy; be between the ages of 18 and 40 years; have at least one year of RT experience and routinely perform the bench press exercise and; be able to lift 1RM loads ≥ 1 and ≥ 0.8 of one own's body weight among males and females, respectively. Although the effects of menstrual cycle on RT performance are deemed trivial,[24] female subjects completed their experimental trials throughout the early follicular phase of their menstrual cycle, which was verbally confirmed relying upon self-reported logs. Females who were amenorrhoeic ($n = 4$) were permitted to start their experimental trials at any time. If menstrual symptoms ensued during the study period and they were perceived to affect the RT performance, the visits were rescheduled as necessary. Written informed consent was obtained from all subjects. All procedures were conducted in accordance with the Helsinki Declaration and approved by the Institution's Ethics Committee (Application number: 16819).

***** Table 1 around here *****

Design

A randomized cross-over study design was used to examine the sex differences in neuromuscular and perceived fatigue during TRA and ARRT RT sessions. Subjects reported to the laboratory on three occasions within a 7-day period. In the first session, they familiarized themselves with the study procedures and then completed a load-velocity relationship assessment in the bench press exercise. In the following two sessions, they performed the bench press exercise using either the TRA or the ARRT method. Acute neuromuscular fatigue was measured before and immediately after each training session by means of a unilateral isometric chest press test. Moreover, barbell velocity was collected during each repetition, and ratings of fatigue (ROF)[25] were reported prior to and upon completion of each session. RT sessions were performed at least 72 hours of rest apart.

Methodology

Load-velocity relationship assessment

In the first session, the individual load-velocity relationship was assessed after a general warm-up, which consisted of 5 min of running at a self-selected pace, dynamic stretching, upper limbs mobilization, and 1 set of 10 repetitions of the touch-and-go bench press exercise with an external load of 15 and 20 kg for females and males, respectively. Specifically, the subjects initiated the task holding the barbell with their arms fully extended. Then, they were asked to perform the eccentric phase by lowering the barbell until touching the chest and to initiate the concentric phase immediately without a pause. Finally, the concentric phase ended when the subjects' arms were fully extended. Subjects were strongly encouraged to perform all repetitions with maximal intent and to move the barbell as fast as possible during both phases. After 3 min of passive rest, the load-velocity relationship was assessed using an incremental loading test, consisting in 2 progressive loads equivalent to approximately 45%1RM (3 repetitions), and 90%1RM (2 repetitions) of estimated individually self-reported 1RMs. The rest interval between the consecutive loads was 3 min. The mean propulsive velocity was measured during the bench press exercise using a linear encoder sampling at 1000 Hz (Chronojump, Barcelona, Spain).[26] The reliability and validity of this device have been previously confirmed.[27] The 2-point method was used for the modeling of the individualized load-velocity relationships, and a general minimal 1RM velocity of 0.17 $m \cdot s^{-1}$ used to estimate the 1RM for each subject.[28,29]

Resistance training sessions

In the experimental sessions, subjects completed two RT workouts consisting of the bench exercise, matched for the load (75% 1RM), volume (24 repetitions) and total rest (240 s), which were performed using two structures:

- TRA: 3 sets of 8 repetitions with 2 min of rest between sets.
- ARRT: a personalized structure of clusters, repetitions, and rest intervals iteratively regulated according to a 20% velocity loss until completion of the total volume of 24

repetitions. A full description of the ARRT method and its operational elements was described by Dello Iacono et al.[11]

The order of the two sessions was randomized (www.random.org). Sessions were conducted by the same two researchers at approximately the same time of the day (2pm-6pm). Verbal encouragement was provided to ensure that subjects performed the upward phase of the exercise with maximal intended velocity. During the sessions, if the velocity of the first repetition deviated (± 0.06 $m \cdot s^{-1}$) from the value observed during the other condition, subjects were instructed to terminate the ongoing set immediately. Researchers then promptly recalculated and adjusted the load to accommodate the initial velocity before the session could be resumed.[30] Across the total of 48 sessions completed in this study, this occurred 3 times among 3 different subjects. However, the difference in loads equated to approximately a 1% 1RM difference between the two sessions, which would likely imply a trivial session volume load difference, thus unlikely affecting RT performance and perceived fatigue. Subjects were asked to refrain from training targeting muscles involved in the bench press exercise for at least 48 h prior to the sessions, to avoid confounding effects due to residual fatigue and soreness. Also, to ensure performance was not influenced by sub-optimal recovery and nutritional status, subjects were asked to sleep ≥ 8 hours and replicate their nutritional intake at least the day before each study visit, which was confirmed by all subjects verbally upon reporting to the laboratory.

Unilateral isometric chest press test

The unilateral isometric chest press test was performed in a seated position on a folding weight bench (Figure 1). A full description of the test setup, data collection and processing procedures is provided in Supplementary File 1: https://osf.io/tzk5s/. Briefly, subjects completed three trials (within-subject coefficient of variation: 2.1 ± 3.6%, 95% CI [0.66, 3.54]) at baseline after the warm-up of the RT sessions with 2 min rest between trials. The same measurements were taken within approximately 3 min after the completion of the RT sessions, but only one trial was performed.

***** Figure 1 around here *****

Bar velocity data processing

Mean propulsive velocity outputs were collected using the same linear encoder used for the load-velocity relationship assessments. Data collection and processing followed the procedures described elsewhere using the customary software provided by the manufacturer.[31] Data was then exported into a Microsoft® Excel spreadsheet (Microsoft, Redmond, WA, USA) to: (i) calculate velocity loss (%) using the velocity of the first absolute repetition as reference (Table 2). Accordingly, velocity loss values were calculated from the 2nd to the 24th repetition; (ii) explore individual cluster-set configurations completed during ARRT.

Rating of fatigue

The single-item 11-point ROF scale was used to assess perceived fatigue.[25] The scale ranges from 0 (“not fatigued at all”) to 10 (“total fatigue”). The question “How fatigued are you at the moment?” was presented at the top of the scale. Subjects were asked to report their ROF before and immediately after the completion of each session.

Statistical analysis

For exploratory analysis, the magnitude of the relationships between relative 1RM bench press strength and both number of clusters in the ARRT condition and velocity loss in the TRA and ARRT separate for females and males were assessed using Pearson's correlation coefficients. To examine the effects of sex and RT structure on velocity loss, we fitted the following linear mixed-effects model:

$$Outcome_{in} = b_{0in} + b_{1\text{-}2}\textit{training structure} * b_{4\text{-}5}sex_{in} * b_{6\text{-}28}repetition_{in} + \varepsilon_i$$

Velocity loss (%) represented the repeated-measures *outcome* for the subject$_{in}$ whereas *training structure* (categorical variable with 2 levels [TRA, ARRT]), *sex* (categorical variable with 2 levels [females, males]) and repetition (numerical variable [2nd to 24th repetition]), their pairwise interactions, and the triple interaction were modelled as fixed effects. Moreover, random effects were assumed for *subjects*, with random intercepts and slopes (for the categorical variable *training structure*) introduced in the model given that their addition did not result in a convergence error.
To examine the effects of sex and RT structure on peak force and ROF, we fitted two similar linear mixed-effects models:

$$Outcome_{in} = b_{0in} + \text{baseline} + b_{1\text{-}2}\textit{training structure} * b_{4\text{-}5}sex_{in} + \varepsilon_i$$

Peak force and ROF measured after the RT sessions represented the repeated-measures *outcome* for the subject$_{in}$ whereas *training structure* (categorical variable with 2 levels [TRA, ARRT]), *sex* (categorical variable with 2 levels [females, males]), and their interactions were modelled as fixed effects. Baseline scores were included in the model as a continuous covariate to account for the baseline differences between females and males. Moreover, random effects were assumed for *subjects*, with random intercepts only introduced in the model.

All statistical analyses were conducted in R language and environment for statistical computing using the *emmeans*, *ggeffects, lme4*, *lmeresampler* and *lmerTest*, packages while model assumptions were checked using the *performance* package (4.0.5; R Core Team, Vienna, Austria). The raw data file is available here: https://osf.io/645hk.

Results

For descriptive purposes, outputs of the RT sessions are presented as means, SDs, and 95% CIs in Table 2. Frequency distributions of the individual training structures under the ARRT condition grouped by sex are shown in Figure 2. The median and range of clusters performed by females and males in the ARRT condition was 3 (range: 3-7) and 5 (range: 3-9), respectively. A small non-significant correlation was observed between relative 1RM bench press strength and the number of clusters in the ARRT condition (r = 0.29, 95%CI [-0.12, 0.62], *P* = .158). Small to moderate non-significant correlations were observed between relative 1RM bench press strength and velocity loss across both conditions among females (r = -0.35, [-0.77, 0.28], *P* = .263 and r = -0.21, [-0.70, 0.40], *P* = .500 for TRA and ARRT, respectively) and males (r = 0.48, [-0.12, 0.82], *P* = .110 and r = 0.04, [-0.54, 0.60], *P* = .889 for TRA and ARRT, respectively).

Results from the linear mixed-effects models are presented in Tables 3-5 as estimates ± standard errors (SE) and 95% CIs. Velocity loss outputs across the sessions grouped by sex are displayed in Figure 3. Change scores between baseline and post-sessions are also illustrated as absolute differences for peak force and ROF in Figures 4 and 5, respectively.

***** Table 2 and Figure 2 around here *****

A significant interaction between sex, condition, and repetition was found for velocity loss (*P* = .016). The decrease of velocity across successive repetitions was mitigated by ARRT to a greater extent among males compared to females. Also, there was a significant interaction between condition and repetition (*P* < .001), with a mitigated velocity loss per repetition during ARRT compared to TRA (Table 3). Analysis of the random effects indicated a strong negative correlation (r = -0.61) between intercepts and slopes nested within each subject.

***** Table 3 and Figure 3 around here *****

A significant interaction between sex and condition was found on peak force (*P* < .001). Interaction contrast analysis indicated greater force outputs in ARRT compared to TRA among males compared to females. Moreover, main effects were observed for baseline scores and condition (*P* < .001 and *P* = .011, respectively). Therefore, greater baseline scores were predictive of greater force outputs measured after both conditions, and greater force outputs were produced after ARRT compared to TRA overall.

***** Table 4 and Figure 4 around here *****

A significant interaction between sex and condition was found on ROF (*P* = .001). Interaction contrast analysis indicated that the mitigating effects of ARRT on ROF was greater among males compared to females. Moreover, main effects were observed for baseline scores (*P* = .002), sex (*P* = .001) and condition (*P* = .039). Accordingly, greater baseline scores were predictive of greater ROF measured after both conditions, males reported greater ROF than females across both conditions, and ARRT resulted in lower ROF than TRA overall.

***** Table 5 and Figure 5 around here *****

Discussion

We examined sex differences in neuromuscular and perceived fatigue during RT sessions prescribed using TRA and ARRT approaches. As hypothesized, velocity loss, peak force impairment and ROF were mitigated under ARRT compared to TRA among both females and males. Moreover, the beneficial effects of the ARRT method were greater among males compared to females.

In line with the evidence on intra-set rest redistribution configurations during RT, we found beneficial effects of ARRT in mitigating neuromuscular and perceived fatigue. Accordingly, we assume that the short and frequent rest intervals embedded within the ARRT structures alleviated the mechanical, metabolic, and perceptual stress induced by the repeated lifting tasks. This was evidenced by greater velocity (i.e., reduced velocity loss) and peak force outputs as well as lower ROF responses (Table 2). Therefore, our findings confirm the effectiveness of ARRT in RT practice to mitigate neuromuscular and perceived fatigue in males as initially demonstrated by Dello Iacono et al.,[11] but also suggest similar effects among females although to a lesser extent. The flexible, dynamic, and personalized nature of ARRT accounts for between-subject variability in RT performance and seems to accommodate individual neuromuscular capabilities and training patterns. The visual inspection of Figure 2 reinforces this assumption given the large range and variety of individual patterns, including clusters, number of repetitions per cluster, and between-cluster rest intervals, observed within and particularly between sexes during the ARRT condition. Not surprisingly, the ARRT structures among females consisted of fewer clusters and more repetitions per cluster compared to males. This supports previous research showing that females are less fatigable than males when performing moderately to heavily loaded lifting tasks involving dynamic muscle contractions.[18,32] Moreover, when training at the same relative intensity (e.g., 70-90% of 1RM), females can perform more repetitions before exceeding any velocity loss threshold ranging from 5% to 60%.[33,34]

The novel finding of this study is that the beneficial effects of ARRT were greater in males compared to females. Specifically, the sex differences – favoring females – observed during and after the TRA session were reversed under ARRT for velocity loss (Figure 3) and ROF (Figure 5) but not for peak force outputs (Figure 4). The further analysis of random effects in the velocity loss model, specifically examining the relationship between individual subjects' intercepts and slopes, reveals a noteworthy finding. The observed correlation coefficient ($r = -0.61$) indicates a large and consistent mitigating effect of ARRT on neuromuscular fatigue across all subjects. Moreover, this suggests that individuals with greater velocity loss in the TRA condition (i.e., higher intercept) tend to benefit more from the ARRT condition (i.e., greater negative slope). Accordingly, given the overall greater velocity loss observed among males in the TRA condition, the model outputs imply that males, regardless of their relative 1RM, experienced greater benefits from ARRT. This observation adds depth to our understanding of the impact of ARRT on neuromuscular fatigue mitigation, highlighting its effectiveness, especially in situations where higher levels of fatigue are present, as evidenced by greater velocity loss. Although investigating the underpinning mechanisms was not possible in this study, we critically elaborate on some of the morphological, physiological, and training-related factors underlying the sex differences in fatiguability, as the main reasons explaining these effects.

The reduced intramuscular occlusion of blood flow within the working muscles is one of the main explanations for the female advantage in fatigue resistance.[18,32,35] Females possess lower absolute force capacity, which induces less mechanical compression of the local vasculature when performing at the same relative work (i.e., % of 1RM) as males.[18,32,35] This, coupled with a greater intramuscular perfusion allows enhanced availability of oxygen and clearance of metabolic byproducts during RT, thereby delaying neuromuscular fatigue.[35]

The differences in fiber-type proportional area and the associated energetic substrate utilization also contribute to sex differences in fatiguability during RT. In fact, the greater dimensions and proportional area of type II fibers across several muscle groups,[36] and the predominant reliance on glycolytic pathways, expose males to exacerbated acute neuromuscular fatigue during prolonged RT tasks.[37]

Finally, the sex differences in fatiguability during RT tasks may also stem from the distinct lifting velocity levels between males and females. To illustrate, males display higher mean propulsive velocities than females in the first repetition across many RT exercises,[34] particularly in the bench press against moderate loads (i.e., ~70% 1RM). This implies a steeper repetition-velocity loss profile in males than females during fatiguing RT tasks.[22]

However, it is important to point out that the above assumptions hold true only upon a unique condition, that is, the RT task being performed in a continuous pattern towards approaching proximity to failure. Given that sex differences in fatiguability develop in a graded fashion during RT, it can be argued that the ARRT method contrasted sex differences accretion as indicated by the significant interaction between sex and condition observed for velocity loss, force outputs and ROF. Specifically, we speculate that the multiple clusters, fewer repetitions per cluster, and more frequent short rest intervals characterizing the ARRT structures among males (Figure 2) led to i) mitigated intramuscular vascular occlusion and metabolic byproducts[18,32] accumulation due to the shorter time under tension per single repetition (i.e., lower velocity loss: -0.37 ± 0.15%) and the cumulative mechanical strain,[38] and ii) reduced suppression of force production by type II muscle fibers and more efficient energy replenishment given that fewer repetitions were executed in succession; iii) lower decrease in lifting velocity as clusters were terminated at a fixed and low (i.e., 20% threshold) magnitude of velocity loss, and therefore relatively far from muscle failure.[20] The confluence of these variables appears to elucidate, at least in part, the differential efficacy of the ARRT method between sexes, with males manifesting more substantial benefits than their female counterpart.[20]

The reason peak force outputs followed a similar, albeit less pronounced, trend as velocity loss and ROF (Figures 3-5), cannot be fully ascertained from the current data. However, a plausible explanation is that the interdependence between the two attributes of fatigue – neuromuscular and perceived – is task- and contraction-specific.[18,32] Therefore, the greater mitigating effects of ARRT on ROF among males could have been paired with a corresponding mitigated decrease in motor performance (i.e., velocity loss) during the RT task but not fully reflected by a similar motor performance decrease during a different task such as the unilateral isometric chest press test. Furthermore, males usually show larger neuromuscular fatigue during single-joint isometric tasks compared to females.[18,32] This might be due to slower contractile properties requiring lower motor unit firing frequencies to reach a tetanic force output.[18,19,32] Accordingly, we argue that the contraction modality of the unilateral isometric chest press test may have in part moderated the interaction between training condition and sex, although this assumption should be verified in future studies.

This study has a few limitations. First, while we intended to match baseline strength levels between the female and male subjects, achieving complete parity in our study proved challenging. In fact, we were unable to recruit a sufficiently large sample of weaker males without violating the RT experience inclusion criteria (i.e., minimum one year). In contrast, recruiting highly trained female athletes could have introduced confounding effects related to other modifiable factors such as sporting age, athletic training age, and RT age, all known to influence neuromuscular performance beyond sex differences. Second, the RT sessions included only one exercise and load corresponding to 75% 1RM combined with a 20% velocity loss threshold. It is thus unclear if our findings generalize to other exercises, loads and velocity loss thresholds. Third, we contrasted ARRT only to a TRA structure. It may well be the case that the effectiveness of the ARRT method may vary in comparison to other autoregulation methods. Finally, we were unable to elaborate on the sites (e.g., central and/or peripheral) and underlying mechanisms of fatigue.

Practical Applications

Practitioners should consider employing the ARRT method as a personalized strategy for prescribing RT due to its positive impact on reducing acute within-session neuromuscular and perceived fatigue in both males and females. Importantly, its adoption does not necessitate extra training time in comparison to conventional TRA methods. This highlights its viability for integration into existing training regimens. However, coaches should be mindful of sex-specific differences, as males tend to benefit more from the ARRT method. By leveraging the ARRT method, practitioners can potentially optimize training outcomes by reducing variability and theoretically ensure more consistent training exposure, while tailoring protocols to individual needs, enhancing overall training efficacy.

Conclusions

The ARRT method led to reduced velocity loss, peak force impairment, and perceptual fatigue compared to TRA, for both males and females. Notably, the advantages of the ARRT method were more pronounced in males than females. These findings emphasize the effectiveness of the ARRT paradigm in improving neuromuscular outcomes and mitigating perceived fatigue during RT. Additionally, a differential response to the ARRT method between sexes underscores the importance of personalized training approaches.

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Figures captions

Figure 1. Isometric chest press test setup
Figure 2. Frequency distributions of the individual ARRT configurations grouped by sex
Figure 3. Between-sex velocity loss comparisons across training conditions
Figure 4. Between-sex peak force outputs comparisons across training conditions
Figure 5. Between-sex ROF comparisons across training conditions