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Biological sex differences in fatigue in resistance-trained individuals: A scoping review

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Females may experience less neuromuscular fatigue and improved recovery following resistance training than males, however, it is unclear whether this applies to resistance-trained individuals. A systematic scoping review was performed to map the evidence on sex differences in fatigue during and following resistance training in trained participants. PubMed, CINAHL and SPORTDiscus were searched following PRISMA-ScR guidelines. The protocol was prospectively registered. 4020 identified articles, 34 were included. These studies assessed sex differences in fatigue using various measures during single and multiple RT sets, performance relative to baseline at various time points (0-5 min, 1-6 h, 24 h, and 48-96 h after RT), and metabolic responses. Substantial heterogeneity in study design and results were observed. Together, most studies found minor-to-no sex differences in neuromuscular fatigue, but some evidence of greater fatigability in males during or immediately following RT were found when i) more complex free-weight exercises were performed with moderate loads, ii) rest periods were shorter, and iii) males were substantially stronger than females in relative terms, among others. Future investigations should explore the impact of training variables and habitual training on fatigue in males and females of comparable relative strength and technical proficiency.

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Abstract

Females may experience less neuromuscular fatigue and improved recovery following resistance training than males, however, it is unclear whether this applies to resistance-trained individuals. A systematic scoping review was performed to map the evidence on sex differences in fatigue during and following resistance training in trained participants. PubMed, CINAHL and SPORTDiscus were searched following PRISMA-ScR guidelines. The protocol was prospectively registered. 4020 identified articles, 34 was included. These studies assessed sex differences in fatigue using various measures during single and multiple RT sets, performance relative to baseline at various time points (0-5 min, 1-6 h, 24 h, and 48-96 h after RT), and metabolic responses. Substantial heterogeneity in study design and results were observed. Together, most studies found minor-to-no sex differences in neuromuscular fatigue, but some evidence of greater fatigability in males during or immediately following RT were found when i) more complex free-weight exercises were performed with moderate loads, ii) rest periods were shorter, and iii) males were substantially stronger than females in relative terms, among others. Future investigations should explore the impact of training variables and habitual training on fatigue in males and females of comparable relative strength and technical proficiency.

Key words: female, male, fatigability, recovery

Introduction

Resistance training (RT) stimulates physiological adaptations including improved muscular strength and skeletal muscle hypertrophy [1]. In the short-term, RT also induces neuromuscular fatigue, defined as a reversible decrease in neuromuscular performance [2,3] due to i) perturbations in intramuscular metabolite concentration, ultrastructural changes in the muscle (i.e., muscle damage), or energy depletion that impair excitation-contraction coupling (peripheral fatigue) [4,5], and/or ii) the reduced neural drive and excitation of muscle fibres (central fatigue) [2]. When excessive, neuromuscular fatigue can impair the maximal load and/or volume load (sets x repetitions x load) that an individual can lift or accumulate on a given day [6–8], preventing maximal RT performance. Therefore, an improved understanding of the factors that influence neuromuscular fatigue, and potential differences in neuromuscular fatigability between individuals, could inform the fatigue management strategies of coaches and athletes.

Females are suggested to be less fatigable and capable of recovering sooner than males following RT [9,10], particularly during isometric and slow-moderate velocity concentric contractions [11]. Sex differences in fatigability may stem from distinct hormonal milieus and subsequent physiological differences in females compared to males, such as the larger proportional type-I muscle fiber areas, higher relative muscle capillarisation and perfusion, lower mechanical arterial compression, lower dependency on glycogen during exercise, higher lipid oxidation, and satellite cell activation in females versus males [9,10,12]. Females also on average lift lower absolute loads during RT than males [13] which, along with the aforementioned physiological factors, may lead to less accumulated neuromuscular fatigue over multiple RT sets, and/or a quicker dissipation of fatigue in-between RT sets and following RT sessions [9,10,14].

It is suggested that participants' training status and/or habitual training style may impact the presence, magnitude and directionality of observed sex differences in fatigue [15]. Stronger individuals have been observed to be more fatigable, regardless of sex [14], and if the imposed training stress is expressed relative to their maximum, individuals who possess different abilities in expressing their maximal strength will end up training at differing relative intensities [12]. Considering females are on average less physically active, engage less in RT, and may have distinct preferences regarding RT (e.g. males may be more inclined to perform RT with higher relative loads) [13,16,17], it is likely that observed differences in fatigue between males and females may not exclusively be a result of biological sex. For example, females demonstrate higher fatigue resistance than males during low-intensity isometric training (i.e., lower % of maximum voluntary isometric contraction [MVIC]), particularly when comparing stronger males to weaker females [11,18]. However, no such difference is apparent when relative strength are similar between sexes [18]. This suggests that strength levels and habitual training practices may play a role in biological sex differences in neuromuscular fatigue during RT, questioning the generalisability of fatigue-related studies in untrained individuals to resistance-trained individuals and athletes. Overall, this understanding highlights the importance of exploring potential sex differences in neuromuscular fatigue during RT in resistance-trained individuals and the potential contributing factors.

The primary objective of this scoping review was therefore to explore the influence of biological sex on neuromuscular fatigue during and following RT by investigating changes in neuromuscular function and the associated time course of recovery. Due to the large heterogeneity in the literature and number of possible moderators of sex differences in neuromuscular fatigue, a scoping review was chosen to map the evidence and identify critical research gaps. Secondary objectives of the scoping review were to: i) explore the influence of potential confounding factors (e.g., relative strength, type of RT protocol) on biological sex differences in neuromuscular fatigue, and ii) highlight the critical research gaps to inform future research exploring biological sex differences in neuromuscular fatigue.

Methods

The protocol for this scoping review was registered with Open Science Framework on May 10th 2022, and followed the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews) guidelines [19]. Considering the heterogeneous nature of original research studies on the role of biological sex on neuromuscular fatigue with RT, a scoping review was chosen as a means of mapping the evidence within the available literature. A scoping review allows for the navigation of multiple nuanced themes where a systematic review is inappropriate, providing a robust and transparent overview of the literature whilst identifying research gaps [20]. A population, concept, and context (PCC) framework [21] was therefore used to develop the following research question for this scoping review: *"Does biological sex influence neuromuscular fatigue during and following resistance training in resistance-trained individuals, and what are the potential moderating factors and key gaps in the literature to be addressed in future research?"*

Literature searches were conducted of the PubMed, SCOPUS and SPORTDiscus databases from their inception to April 2023 using the following search terms for each individual database:

1. "resistance training" OR "resistance exercise" OR "strength training" OR "resistance loading"
2. "sex" OR "gender" OR "women" OR "woman" OR "female"
3. "recovery" OR "fatigue" OR "fatigability"

Forward citation tracking was performed through Google Scholar for the included studies along with search alerts, to include any suitable studies published later. The article identification process was completed independently by two authors with any disagreement resolved by mutual discussion. Studies were included if: 1) participants were apparently healthy adults (18-40 years of age) that had participated in RT for a minimum of six months, corresponding to at least an intermediate level of RT experience [22], 2) participants were randomised to experimental groups, when applicable, 3) the experimental comparison involved males and females performing a similar bout(s) of RT where RT variables were attempted to be matched (e.g., exercise selection and sets/repetitions/load prescriptions), and 4) outcome measures of neuromuscular performance included either, a) mechanical (e.g., jump height, lifting velocity, power, dynamic or isometric strength) or b) metabolic (e.g., blood lactate or blood ammonia) markers of neuromuscular fatigue. Only original research articles in peer reviewed journals were included. Data charting was carried out by the principal investigator to capture key study information in a table format.

Results

Our systematic search yielded 4020 results and after duplicates were removed, 2641 articles were eligible for title and abstract screening. Subsequently, 115 articles were selected for full-text review, with 85 articles being excluded due to i) inadequate RT experience of participants, ii) absence of statistical or descriptive comparison between males and females, iii) irrelevant outcome measures, iv) incorrect study design, and v) article full text not accessible. Therefore, 30 articles and another six from secondary searches were included in this scoping review, three of which reported data from the same study [23], leaving 34 unique studies (**Figure 1**). Differences in neuromuscular fatigue herein are described as median (range), when applicable, in comparison to the opposite sex (e.g., if it is stated that "greater fatigue was found in males", this would be compared to females) with positive values indicating greater fatigue in males.

Study Characteristics

A total of 777 resistance-trained participants were included across all studies, comprising 407 males and 370 females. The sample sizes for comparator groups ranged from six to 31 participants (median = 10.5). On average, males were stronger than females relative to body mass, with a median sex difference of 37% (range: -6% to 128%). All studies examined adult females (18-40 years), except for one that did not report participant age [24], indicating samples of primarily premenopausal women. Only eleven of the included studies mentioned menstrual cycle factors in their female participants [25–35]. Of these, some did not control for menstrual cycle status [28,32,35], one included only females using hormonal contraception [34], and others tested participants at least one week away from menses [33], during the early follicular phase [25,26,30], or during the luteal phase [27,29,31], while if participants were amenorrhoeic or using hormonal contraception, testing was conducted at any time [25,27,30]. No study clearly stated how hormonal status was verified.

Fifteen studies explored sex differences in the ability to resist neuromuscular fatigue (i.e., maintain performance) during a single RT-set. This was primarily assessed the number of repetitions performed to 'set failure' (RTF) with a given relative load (median = 70% 1RM, range: 40-90% 1RM) [23,25–27,36–40]. The remaining studies assessed either time-to-task failure [28] or within-set performance decreases, measured by the decline in isokinetic peak torque [29,41] or concentric lifting velocity [15,25,30,42].

Fifteen studies explored sex differences in the ability to resist neuromuscular fatigue during multiple (two or more) RT-sets of a single exercise [24–27,31,32,36–38,42–47], or multiple exercises [31,46,47]. Three studies examined how different inter-set rest durations [31,42,46] influenced sex differences in fatigability, while the effects of exercise order [31] and proximity-to-failure [25] were each investigated by one study. Fatigability across multiple RT sets was commonly quantified as the performance decline from the first to the last set using metrics such as drop in RTF at a fixed relative load [25–27,31,36–38,45,46], absolute load at a fixed number of repetitions [43,44], MVIC [27,43,44], isokinetic peak torque [24,32], or average concentric lifting velocity [25,42]. One study assessed time-to-completion for a fixed volume-load [47].

Nineteen studies examined sex differences in recovery kinetics (i.e., the ability to rapidly recover neuromuscular performance), evaluating neuromuscular performance before and after fatiguing protocols at various recovery intervals: immediately after (0–5 min) [15,25–27,30,32–34,43,44,48–53], 1-6 hours post-exercise [32,33,35,43–45,50,54] or 24-96 hours post-exercise [15,25,32,35,43–45,48,54,55]. Neuromuscular performance measures included maximal voluntary [26,27,32–35,43,44,48,49,52,53,55] and superimposed [32,48,52] isometric contractions, concentric and eccentric isokinetic contractions [32,35,51], countermovement jump height (CMJ) [35,48,55], concentric lifting velocity [15,25,48], or repetition-maximum (RM) testing [45,54,55].

Lastly, eight studies investigated sex differences in metabolic responses to RT, measuring blood lactate [26,42–44,47,48,50] or muscle oxygenation parameters [32]. An comprehensive summary of studies can be found in **Supplementary Tables 1-6.**

Sex Differences in Neuromuscular Fatigue

Sex Differences in Fatigability During a Single Resistance Training Set

The evidence for a fatigability sex difference during a single RT-set was equivocal. On average, both males and females performed a median of 12.6 repetitions per set (range: males = 5 to 21 repetitions, females = 6 to 24 repetitions), resulting in a median sex difference of 1.4 repetitions in favour of females (range: -3.1 to 10.4 repetitions). Only during lighter load (≤70% of 1RM) lower-body exercise did average between-group differences consistently favour females (median = 2.0 repetitions, range: 0.6 to 10.4 repetitions) [23,26,36–38].

In terms of intra-set performance declines, one study found males to be more fatigable [29], while five studies reported no sex differences across a single RT set [15,25,30,41,42], with a median sex difference of -2.0% favouring males across 12 comparisons (range: -9.1% to 8.0%). However, Benitez and colleagues [28] observed a nonsignificant sex difference in time-to-task failure of 12.7 seconds (95% CI: -4.1, 29.2) during low-intensity (50% MVIC) isometric leg extensions, corresponding to approximately 16.9% greater fatigue resistance in females.

Sex Differences in Fatigability across Multiple Resistance Training Sets

Incurred fatigue across multiple RT-sets is generally similar between males and females; however, in some circumstances, females have been observed to be less fatigable. A total of 44 comparisons between resistance-trained males and females were found across fifteen studies [24–27,31,32,36–38,42–47], with a median sex difference of 4.1% favouring females (range: -30.3 to 37.0%). Sex differences in fatigability across multiple RT-sets were influenced by relative strength differences, exercise selection, inter-set rest intervals and proximity-to-failure. Males were found to be more fatigable with reduced inter-set rest intervals [31,42,46], when approaching 'set failure' [25], and in some, but not all [31,36] studies using biceps curls [27,45], back squats at 70% of 1RM [37,43], and bench press at ≥75% of 1RM [25,36,46]. Additionally, males required more time to complete 75 reps of the squat, bench press, and deadlift at 75% of 1RM compared to females (30.7 min vs. 35.9 min, respectively) when instructed to complete the task as quickly as possible [47]. Conversely, males were not more fatigable when squats were performed at heavier relative loads [36,37,44], bench presses at lighter relative loads [36,37], or simpler exercises (e.g., leg extension, machine squat, DB shoulder press etc.) at various relative-loads [24,26,31,32,38,45,46]. Males may even exhibit greater fatigue-resistance when relative strength differences between sexes are smaller (<10% [median = -4.3%, range: -30.3 to 10.8%]) compared to when differences are larger (>10% [median = 5.3%, range: -15.6 to 37%]).

Sex Differences in Neuromuscular Fatigue and Recovery Kinetics, Relative to Baseline

The evidence for sex differences in recovery kinetics suggests that males may, in some circumstances, experience a larger force decrement relative to baseline immediately after resistance training (0-5 min post-exercise), but no clear sex differences are observed in performance recovery hours or days after training. The median sex difference in performance decrement relative to baseline after a fatiguing protocol was 3.6% (range: -6.0% to 21.7%, 51 observations, k = 15) after 0–5 minutes [15,25–27,30,32–34,43,44,48,49,51–53], 1.7% (range: -3.0% to 3.5%, 6 observations, k = 4) after 5–45 minutes [27,33,34,51], 1.8% (range: -8.0% to 12.5%, 14 observations, k = 7) after

1–6 hours [32,33,35,43–45,54], 0.5% (range: -15.0% to 19.5%, 45 observations, k = 10) after 24 hours [15,25,32,35,43–45,48,54,55], -0.7% (range: -25.0% to 16.0%, 19 observations, k = 9) after 48 hours [15,25,32,35,43–45,54,55], and -2.2% (range: -15.0% to 8.0%, 9 observations, k = 3) after 72–96 hours [15,35,55], with positive values indicating more fatigue in males. Sex differences in neuromuscular performance and recovery kinetics, relative to baseline, were influenced by factors such as participants' training before the fatiguing protocol, exercise selection/execution, relative load, and proximity to failure. Males experienced more fatigue immediately following RT when i) sets were taken closer to 'set failure' [25,48], ii) when training was performed isometrically [34], and iii) in studies using back squat protocols at 70–80% of 1RM [15,43,49]. Conversely, no clear sex differences were observed when i) participants had undergone the same 8-week training program before testing (median [range]: before training = 7.6% [0.0 to 16.0%] vs. after training = 1.0% [-6.0 to 8.2%]) [48], despite all participants being trained prior to study commencement, ii) squatting at 85–100% of 1RM [15,44], or iii) performing leg presses or Smith machine squats at 70–80% of 1RM [48,49]. The presence, magnitude and directionality of sex differences in fatigue also varied by neuromuscular performance assessment. Raeder et al. [55] found 3.3–4.7% more fatigue in males during RM testing or CMJ, while females showed 8% more fatigue in MVIC. Davies et al. [35] reported females as 10–15% more fatigable in CMJ, concentric, and isometric strength, with no differences in eccentric strength. Marshall et al. [32] observed greater fatigue in males with superimposed isometric contractions, but no sex difference in voluntary contractions.

Sex Differences in Metabolic Response to Resistance Training

All studies examining light-to-moderate load RT observed a larger metabolic response in males, whereas the study using heavier loads found no difference. No sex differences in blood lactate were observed after 20 single repetition sets of back squat with a 1RM load [44]. However, larger increases and decreases were found for blood lactate [26,42,43,47,48,50] and muscle oxygenation [32], respectively, in males after lower and full body training at 40-75% of 1RM.

Discussion

This scoping review aimed to provide a comprehensive overview of the existing literature on biological sex differences in neuromuscular fatigue during and following RT in resistance-trained males and females. Additionally, we aimed to identify potential moderating factors and highlight research gaps for future exploration. The examination of 34 studies in this scoping review indicated that fatigability and recovery kinetics in general are similar between resistance-trained males and females during and after RT. However, males may experience greater neuromuscular fatigue immediately after RT in specific contexts (i.e., when performing more complex free-weight exercises at moderate relative loads, and when inter-set rest intervals are shortened, isometric contractions are performed, sets are taken closer to momentary muscular failure, or relative strength, and prior training between sexes is unmatched).

Previous research suggests that females may perform a higher number of repetitions at a given relative load compared to males, particularly at lower relative loads [56]. Within the studies included in this scoping review, females lifted 3.2-10.4 more repetitions in the back squat at 70-83% of 1RM [36], 4 more repetitions in the bench press at 75% of 1RM [25], 3 more repetitions in leg extension at 40% of 1RM [26], 2 more repetitions in calf raises at 75% of 1RM [38], and biceps curl at 50% of 1RM [27]. However, these findings did not consistently replicate in the remaining studies employing back squats and bench presses at 70-90% of 1RM [23,36,37,39], where sex differences were <2 reps. Based on the findings from this scoping review, we found little evidence to support a consistent sex difference in RTF-performance. This notion aligns with recent meta-analytical data that identified no clear interaction of sex on the number of reps performed at a given relative load [57].

Although most studies included in this scoping review found minor to no sex differences in neuromuscular fatigue during and following RT, females may be less fatigable than males in specific circumstances immediately after multiple sets of RT. These include when: i) more complex free-weight exercises (e.g., back squat and bench press) with moderate loads (≈70-83% of 1RM), or isolated elbow flexor exercises are performed, ii) isometric training is the fatiguing stimulus, iii) rest periods are shortened, iv) sets are taken closer to 'momentary muscular failure', v) males have substantially greater relative strength than females, and vi) participants' training before study commencement was not matched. It is unclear why complex free-weight, but not simpler machine-based exercises at moderate relative loads might incur more fatigue in males. It is plausible that relatively stronger individuals, regardless of sex, may experience more fatigue during complex exercises like the back squat or bench press. Higher relative strength levels could imply better technical, neural, and psychological abilities, enabling athletes to push closer to momentary muscular failure in complex exercises without technical failure, ultimately incurring more neuromuscular fatigue that might not be observed in less complex exercises. Our findings of larger performance decrements in males when reducing rest [31,42,46], along with the minimal sex differences in the ability to maintain performance during one RT-set, suggest it is not the incurred fatigue during a set that differs between sexes, but rather the time it takes to recover between sets. In line with this notion, females exhibit more substantial inter-set recovery of lifting velocity (i.e., the change in lifting velocity from the last repetition of the preceding set to the first repetition of the subsequent set), while no sex differences are seen in intra-set velocity loss (i.e., the change in lifting velocity from the first to the last repetition in one set) [42]. Lastly, recognising the impact of task specificity on fatigue is crucial. In agreement with others [11], we found males accumulated more acute fatigue following isometric, but not isotonic, contractions [34]. Additionally, the method of assessing fatigue influenced the existence, magnitude and directionality of sex differences in neuromuscular fatigue in multiple studies [32,35,48,52,55]. As such, we urge researchers and practitioners to be mindful of the fatiguing stimulus employed and assessment used to measure fatigue and whether it captures the outcome of interest. Taken as a whole, we found that certain circumstances lead to greater neuromuscular fatigue in males versus females during and following RT, however, this finding was not consistent across most studies in our scoping review.

Our scoping review also investigated metabolic response to RT such as blood lactate and deoxygenated haemoglobin, which are closely associated with perception of effort, central output [58–60], and time-to-task failure [60]. In this review, higher increases in blood lactate and deoxygenated haemoglobin were observed in males versus females at moderate relative loads. This discrepancy is likely attributed to females' greater proportional area of type I muscle fibers [12,61] and higher capillary density [9,12]. Consequently, males exhibit greater glycolytic capacity and lower whole-muscle oxidative capacity [12], making them more susceptible to metabolite accumulation and in turn, experiencing higher levels of both peripheral and central fatigue [2]. However, the equivocal changes in neuromuscular fatigue between sexes, as measured by superimposed twitch and the dissociated response to voluntary force production [32,52], raise uncertainty about the practical implications of these metabolic responses to RT.

Current Research Limitations

The included studies featured a small number of participants (median = 10.5 per group, range 6-31), and there was notable heterogeneity in interventions and measurement outcomes. Consequently, the findings should be interpreted with caution. While a meta-analytic approach could offer more robust evidence on the existence or absence of sex differences in fatigue, the extensive variation in relative strength sex differences (median = 32%, range: -6 to +128%), training experience, RT-prescriptions, and outcome measures, coupled with the limited number of studies for subgroup analysis, led to the decision to conduct a scoping review. This approach was deemed more suitable to summarise the available literature and facilitate a comprehensive discussion of its nuances.

All studies were conducted on adult, likely premenopausal, females, with most studies not accounting for menstrual or contraceptive status in female participants. Those studies that did report menstrual or contraceptive status, did not specify how hormonal status was verified. As such, our findings cannot be generalised to postmenopausal females, nor can we draw any conclusion regarding the impact of hormonal fluctuations on fatigue and recovery. Prior reviews suggest that menstrual and contraceptive status may influence recovery [62,63] though effects on fatigability remain equivocal [64]. However, most studies have focused on non-resistance-trained participants, and recent research has questioned whether menstrual cycle phase or hormonal contraception meaningfully affects recovery in trained females [65–68]. While this suggests that menstrual and contraceptive status may not substantially affect our overall conclusions, it may explain some of the observed heterogeneity in our results. Future research should consider adopting stricter methodological controls and explore their potential effects on fatigue and recovery in strength-trained individuals.

Additionally, it is essential to acknowledge that most studies on sex differences in fatigue only assessed fatigue after a single bout of RT, with no prior exposure to that specific training stimulus. This poses a challenge, as males and females may have distinct training preferences [13] and, consequently, be accustomed to different training practices. Additionally, the level of incurred fatigue after training diminishes with repeated exposure to the same training protocol [48,69]. More crucially, sex differences in fatigue and even metabolic response are mitigated in males and females after undergoing the same 8-week RT intervention [48]. These results have major implications for research on sex differences in fatigue, suggesting that observed differences may not be solely influenced by sex but also by specific characteristics (e.g., duration and type of exposure) of participants' training practices before study initiation.

Conclusion

This scoping review summarised the available literature on biological sex differences in neuromuscular fatigue and recovery following RT in resistance-trained individuals. Against the common notion that females are less fatigable and recover quicker than males, most studies in resistance trained individuals suggest that sex differences in fatigability and recovery kinetics are minor. However, males may experience larger neuromuscular performance decrement during and immediately after multiple sets of RT (with negligible sex differences hours and days after RT) when i) more complex free-weight exercises (e.g., back squat and bench press) were performed with moderate loads (≈70-83% of 1RM) or isolated elbow flexor exercises, ii) isometric training was performed, iii) rest periods were shorter, iv) sets were terminated closer to momentary muscular failure, v) males were substantially stronger than females in relative terms, and vi) participants' training before study commencement was not matched. Further, males show larger increases in blood lactate and decreases in muscle oxygenation during moderate-load RT versus females, likely due to their dependency on anaerobic glycolysis and their lower muscle perfusion. Overall, the results indicate that biological sex has little impact on recovery hours and days after RT, but females and/or less proficient lifters may in certain context incur less acute fatigue, which may allow them to reduce inter-set rest intervals without compromising completed volume-load and/or complete higher volume-loads with the same rest intervals. Considering the heterogeneity in RT protocols used across studies, performance assessments, differences in RT variables and prior training exposure likely influenced the findings observed and further research is required to elucidate the influence of biological sex on neuromuscular fatigue.

Recommendations for future research

To better understand the impact of biological sex on neuromuscular fatigue and recovery, it is important to note that many variables may influence short-term responses to RT. As a result, factors such as RT experience and skill level, the measure of neuromuscular performance chosen, and the manipulation of programming variables (e.g., exercise selection, relative load, proximity-to-failure, and rest periods) may all have an impact on the magnitude of sex differences on accumulated fatigue with RT. We therefore urge future research to focus on understanding the effects of specific training and non-training variables on sex differences in fatigue. Specifically, more research is needed to understand sex differences in RTF-performance, intra-set fatigability and inter-set recovery. These studies could manipulate exercise selection, relative load, proximity-to-failure, and rest periods in equally strength trained individuals to better understand possible sex differences in fatigue accumulation and recovery following RT. Further, with most research in lower body exercises, especially knee extensors, more work is needed investigating upper body exercises and those engaging the posterior chain muscles (e.g., hamstrings, glutes, erector spinae etc.). With no general consensus on how to best match strength between sexes [70], researchers are encouraged to describe the characteristics of participant skill level in greater detail [e.g., strength relative to body mass/fat free mass, or GLP] and provide qualitative data regarding their type of RT experience (e.g., bodybuilding, powerlifting, CrossFit, etc.), and familiarity with the type of training they will be exposed to (i.e., exercise, relative-load, proximity-to-failure etc.). This will allow readers to interpret the results with more context and nuance and better inform specific practical recommendations for fatigue management.

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Figure Legends

Figure 1 PRISMA flowchart [19].

Supplementary materials. Biological sex differences in fatigue in resistance-trained individuals: A scoping review

Supplementary Table 1. Summary of data extraction: Studies exploring sex differences in fatigability and recovery during and after training. Values have been extracted from the text or tables within in each article, or if necessary, from figures using WebPlotDigitizer (from automeris.io). NMF, neuromuscular fatigue; RM, repetition maximum; e1RM, estimated 1RM from multiple rep RM-test; MF, muscular failure; MVIC, maximal voluntary isometric contraction; MVCC, maximal voluntary concentric isokinetic contraction; MVEC, maximal voluntary eccentric isokinetic contraction; RFD, rate of force development; RTD, rate of torque development; BM, body mass; CMJ, countermovement jump; RTF, repetitions to failure; MV, mean concentric lifting velocity; NHST, null-hypothesis significance testing.

Study	**Participants**	**Resistance training protocol**	**Relative strength** (positive values = M > F)	**Outcome measure**	**Key findings**
Gabriel (1991)	Males: 24 ± 2 y *n* = 11 Females: 22 ± 2 y *n* = 11 RT experience: ≥1 y	Exercise/s: Knee extension, chest press Prescription: 1 set x 20 reps à Maximal effort against hydraulic resistance	Males: 2.65kg / BM Females: 1.93kg / BM à All exercises combined Sex difference: +37.3%	Mechanical measures of NMF: Δ peak torque (1st to 20th rep)	Knee extension: Males = -21% vs. Females = -23% Chest press: Males = -28% vs. Females = -30% *NB: No NHST performed.*
Häkkinen (1992)	Males: 29 ± 5 y *n* = 9 Females: 29 ± 4 y *n* = 10 RT experience: 2-8 y	Exercise/s: Leg press, back squat Prescription: 4 sets x 5-6 reps à 70-80% 1RM	Males: 48.7N / BM Females: 41.8N / BM Knee extensor MVIC Sex difference: +16.5%	Mechanical measures of NMF: MVIC (+0 min post-RT)	Leg press: Males = -3.6% vs. Females = -4.9% ($P > 0.05$) Back squat: Males = -8.5% vs. Females = -2.7% ($P < 0.05$)

Häkkinen (1993)	Males: 29 ± 8 y n = 10 Females: 28 ± 8 y n = 9 RT experience: 3-8 y	Exercise/s: Back Squat Prescription: 20 sets x 1 rep à 100% 1RM 3min rest between sets.	Males = 2.12 kg / BM. Females = 1.26 kg / BM. 1RM back squat. Sex difference: +68.3%	Mechanical measures of NMF: Δ absolute load (1st to 20th set). MVIC (+0 min, +1 h, +2 h, +24 h, +48h post-RT). Metabolic measures of NMF: Blood lactate (+0 min post-RT).	Absolute load: Males = -10% vs. Females = -10%. MVIC: +0 min: Males = -24.1% vs. Females = -20.5% ($P > 0.05$). +1 h: Males = -19% vs. Females = -9% ($P < 0.05$). +2 h: Males = -17% vs. Females = -11% ($P > 0.05$). +24 h: Males = -5% vs. Females = -7% ($P > 0.05$). +48 h: Males = -3% vs. Females = -2% ($P > 0.05$). Blood lactate: Males = +84% vs. Females = +67% ($P > 0.05$). *NB: No NHST performed for load.*
Häkkinen (1994)	Males: 29 ± 8 y n = 10 Females: 28 ± 8 y n = 9 RT experience: 3-8 y	Exercise/s: Back Squat Prescription: 10 sets x 10 reps à 70% 1RM 3min rest between sets.	Males = 2.12 kg / BM Females = 1.26 kg / BM 1RM back squat. Sex difference: +68.3%	Mechanical measures of NMF: Absolute load (1st to 10th set). MVIC (+0 min, +1 h, +2 h, +24 h, +48h). Metabolic measures of NMF: Blood lactate (+0 min).	Absolute load: Males = -27% vs. Females = -15%. MVIC: +0 min: Males = -47.1% vs. Females = -29.4% ($P < 0.01$). +1 h: Males = -32% vs. Females = -23% ($P > 0.05$). +2 h: Males = -33% vs. Females = -18% ($P > 0.05$). +24 h: Males = -9% vs. Females = -4% ($P > 0.05$). +48 h: Males = -1% vs. Females = +8% ($P > 0.05$). Blood lactate: Males = +971% vs. Females = +329% ($P < 0.001$). *NB: No NHST performed for load.*
Pullinen et al. (2002)	Males: 29 ± 8 y n = 6 Females: 28 ± 3 y n = 6 RT experience: ≥2 y	Exercise/s: Knee Extension Prescription: 5 sets x 10 reps + 2 sets to MF à 40% 1RM 40 sec rest between sets to 1 to 5, and 3 min between sets 6 and 7.	Males: 2.00 kg / BM Females: 1.57 kg / BM 1RM Knee extension Sex difference: +27.4%	Mechanical measures of NMF: RTF (6th set, Δ from 6th to 7th set). MVIC (+2 min post-RT). Metabolic measures of NMF: Blood lactate (+0 min, +5 min, +8 min post-RT).	RTF: 6th set: Males = 21 reps vs. Females = 24 reps ($P > 0.05$). 6th to 7th set: Males = -19% vs. Females = -17%. MVIC: Males = -25% vs. Females = -25% ($P > 0.05$). Blood lactate: Males = +550% vs. Females = +656%.

					NB: No NHST performed for lactate and data were reported as a sum across time points.
Judge and Burke (2010)	Males: 23 ± 3 y n = 10 Females: 24 ± 4 y n = 10 RT experience: 4-7 y for the athlete group. 1-4 y for the recreationally trained control group.	Exercise/s: Bench Press Prescription: 5 sets x 10, 5, 4 and 2 reps with the last to MF à 50-100% of perceived 5RM 3 min rest between sets.	Male athletes: 1.31 kg / BM Female athletes: 0.80 kg / BM Male controls: 0.93 kg / BM Female controls: 0.51 kg / BM 5RM bench press. Sex difference: Athletes: +63.8% Controls: +82.4%	Mechanical measures of NMF: e1RM (+4 h, +24 h, + 48 h post-RT).	e1RM: +4 h: Male athletes = -2% vs. Female athletes = 0% vs. Male controls = -3% vs. Female controls = -1% ($P > 0.05$). +24 h: Male athletes = -4% vs. Female athletes = 0% vs. Male controls = -5% vs. Female controls = -1% ($P > 0.05$). +48 h: Male athletes = 0% vs. Female athletes = 0% vs. Male controls = 0% vs. Female controls = +1% ($P > 0.05$).
Ratamess et al. (2012)	Males: 23 ± 7 y n = 11 Females: 21 ± 5 y n = 11 RT experience: ≥1 y	Exercise/s: Bench Press, Incline Bench Press, Shoulder Press, Barbell Row. Prescription: 3 sets x ≤10 reps à 75% of 1RM Either 1, 2 or 3 min rest between bench press sets. 2 min rest between sets of incline bench press, shoulder press and barbell row.	Males: 1.3 kg / BM Females: 0.57 kg / BM 1RM bench press. Sex difference: +128.1%	Mechanical measures of NMF: Completed repetitions (Δ from 1st to 3rd set for all exercises).	RTF from 1st to 3rd set: Bench Press 1 min rest: Males = -60% vs. Females = -23%. 2 min rest: Males = -40% vs. Females = -10.1%. 3 min rest: Males = -23% vs. Females = -4%. Incline Bench Press: 1 min rest: Males = -2.2% vs. Females = -21.4%. 2 min rest: Males = -2.2% reps vs. Females = -18.4%. 3 min rest: Males = -32.7% reps vs. Females = -28.9%. Shoulder Press: 1 min rest: Males = -3.6% vs. Females = -15.6%. 2 min rest: Males = -18.3% vs. Females = -10.2%. 3 min rest: Males = -10.2% vs. Females = -4.4%. Barbell Row: 1 min rest: Males = -7.0% vs. Females = -1.0%. 2 min rest: Males = -4.1% vs. Females = -2.1%. 3 min rest: Males = -9.2% vs. Females = -4.1%. *NB: No NHST performed for decrease in reps over*

					sets.
Heavens et al (2014)	Males: 24 ± 2 y n = 9 Females: 25 ± 2 y n = 9 RT experience: ≥0.5 y	Exercise/s: Back Squat, Bench Press, Deadlift. Prescription: 10 sets x 10, 9, 8, … 1 reps à 75% of 1RM As little rest as possible.	Males: 4.8 kg / BM Males: 3.3 kg / BM 1RM total (back squat, bench press and deadlift) Sex difference: +45.5%	Metabolic measures of NMF: Blood lactate (+0 min, +15 min, +60 min post-RT).	Blood Lactate: +0 min: Males = 17.3 mmol/L vs. Females = 13.8 mmol/L ($P < 0.05$). +15 min: Males = 14.2 mmol/L vs. Females = 9.1 mmol/L ($P < 0.05$). +60 min: ($P > 0.05$ [*specific data not reported*]).
Hooper et al. (2014)	Males: 24 ± 4 y n = 12 Females: 25 ± 4 y n = 13 RT experience: ≥0.5 y	Exercise/s: Back Squat, Bench Press, Deadlift. Prescription: 10 sets x 10, 9, 8, … 1 reps à 75% of 1RM As little rest as possible.	Not reported	Mechanical measures of NMF: Time to completion. Metabolic measures of NMF: Blood lactate (+0 min post-RT).	Time to completion: Males = 35.9 min vs. Females = 30.7 min. Blood lactate: Males = 14.21 vs. Females = 10.07. *NB: No NHST performed.*
Flanagan et al. (2014)	Males: 25 ± 1 y n = 10 Females: 25 ± 2 y n = 10 RT experience: ≥0.5 y	Exercise/s: Bench Press, Back Squat. Prescription: 1 set x RTF performed either concentric-only, eccentric-only or combined (eccentric and concentric). à 85% of 1RM	Not reported	Mechanical measures of NMF: RTF @85% of 1RM.	Back Squat: CON: Males = 5.5 reps vs. Females 5.3 ($P > 0.05$). ECC: Males = 12.9 reps vs. Females = 13.7 reps ($P > 0.05$). TRAD: Males = 9.2 reps vs. Females = 7.7 reps ($P > 0.05$). Bench Press: CON: Males = 3.3 reps vs. Females 4.1 ($P < 0.05$). ECC: Males = 10.5 reps vs. Females = 13.9 reps ($P < 0.05$). TRAD: Males = 6.6 reps vs. Females = 6.2 reps ($P < 0.05$).
Vilaça-Alves et al. (2014)	Males: 27 ± 3 y n = 8 Females: 29 ± 4 y n = 11 RT experience: ≥0.5 y	Exercise/s: Lat Pulldown w/ narrow or wide grip, performed fresh or preceded by biceps curls. Prescription: Lat Pulldown: 1 set x RTF performed Biceps curl: 3 sets x 10 reps	Males: 1.01 kg / BM. Females: 0.79 kg / BM. 1RM lat pulldown (grips combined) Sex difference: +27.8%	Mechanical measures of NMF: RTF @70% of 1RM.	RTF: Wide-Grip LPD w/o Pre-Exhaust: Males = 13.6 reps vs. Females = 12.2 reps. Wide-Grip LPD w/ Pre-Exhaust: Males = 10.8 reps vs. Females = 9.9 reps. Narrow-Grip LPD w/o Pre-Exhaust: Males = 14.5 reps vs. Females = 11.4 reps. Narrow-Grip LPD w/ Pre-Exhaust: Males = 9.4 reps vs. Females = 8.1 reps.

		à 70% of 1RM			*Condition-specific p-values unreported, but males performed more reps across all conditions (P = 0.023).*
Raeder et al. (2016)	Males: 24 ± 2 y n = 14 Females: 25 ± 2 y n = 9 RT experience: ≥3 y ≥1.2x or 0.8x BM 1RM back squat for males and females, respectively.	Exercise/s: Back Squat. Prescription: 11 sessions over 6 days 1-4 sets x 6 reps à 40-100% of 1RM using traditional, drop set, eccentric overload and flywheel protocols. 3 min rest between sets.	1.49 kg/ BM 1RM back squat. NB: Sexes combined, due to lack of sex-specific data.	Mechanical measures of NMF: e1RM and MVIC (+24 h and +96 h post-RT). CMJ (+24 h, +48 h , +72 h and +96 h post-RT).	Back Squat e1RM: +24 h: Males = -8.8% vs. Females = -5.5% (*P* > 0.05). +96 h: Males = -4.5% vs. Females = -1.2% (*P* > 0.05). MVIC: +24 h: Males = -5.0% vs. Females = -13.0% (*P* > 0.05). +96 h: Males = -4.5% vs. Females = -9.2% (*P* > 0.05). CMJ: +24 h: Males = -8.2% vs. Females = -3.5% (*P* > 0.05). +48 h: Males = -5.7% vs. Females = -4.6% (*P* > 0.05) +72 h: Males = -6.8% vs. Females = -2.1% (*P* > 0.05). +96 h: Males = -2.1% vs. Females = +0.3% (*P* > 0.05).
Gentil et al. (2017)	Males: 22 ± 2 y n = 17 Females: 28 ± 6 y n = 17 RT experience: ≥0.5 y	Exercise/s: Isokinetic Elbow Flexions. Prescription: 1 set x 30 reps à maximal effort at 180º/s.	Males: 0.87 Nm / BM. Females: 0.63 Nm / BM. Elbow flexor torque. Sex difference: +38.1%	Mechanical measures of NMF: Δ peak torque (1st to last rep).	Peak torque: Males = -45.9% vs. Females = -37.9% (*P* < 0.05).
Tinsley et al. (2017)	Males: 22 ± 2 y n = 17 Females: 28 ± 6 y n = 17 RT experience:	Exercise/s: Isokinetic Machine Squats. Prescription: 5 sets x 6 reps à maximal effort. 2 min rest between sets.	Males: 19.4 N / BM Females: 20.6 N / BM Peak concentric isokinetic squat force. Sex difference: -5.8%	Mechanical measures of NMF: Δ concentric and eccentric force output (1st to 5th set).	CON: Males = 0% vs. Females = 0% (*P* > 0.05). ECC: Males = -11.8% vs. Females = -1.0% (*P* > 0.05). *NB: Only placebo group data is extracted.*

	≥0.5 y				
Davies et al. (2018)	Males: 23 ± 3 y n = 11 Females: 24 ± 4 y n = 8 RT experience: ≥0.5 y ≥1.25x BM 1RM back squat.	Exercise/s: Back Squat. Prescription: 5 sets x 5 reps, 1 set x MF à 80% of 1RM 1.5 min rest between sets	Males: 1.42 kg / BM Females: 1.24 kg / BM 1RM back squat. Sex difference: +14.5%	Mechanical measures of NMF: CMJ, MVIC, MVCC and MVEC (+4 h, +24 h, +48 h and +72 h post-RT).	CMJ: +4 h: Males = -14% vs. Females = -22% (*P* = 0.048). +24 h: Males = -10% vs. Females = -20% (*P* = 0.037). +48 h: Males = -6% vs. Females = -25% (*P* < 0.001). +72 h: Males = -3% vs. Females = -13% (*P* = 0.051). MVCC: +4 h: Males = -13% vs. Females = -13% (*P* > 0.05). +24 h: Males = -10% vs. Females = -25% (*P* = 0.06). +48 h: Males = -2% vs. Females = -27% (*P* = 0.003). +72 h: Males = 0% vs. Females = -14% (*P* = 0.042). MVEC: +4 h: Males = -16% vs. Females = -14% (*P* > 0.05). +24 h: Males = -21% vs. Females = -21% (*P* > 0.05). +48 h: Males = -13% vs. Females = -18% (*P* > 0.05). +72 h: Males = -7% vs. Females = -8% (*P* > 0.05). MVIC: +4 h: Males = -10% vs. Females = -15% (*P* > 0.05). +24 h: Males = -7% vs. Females = -21% (*P* > 0.05). +48 h: Males = -3% vs. Females = -20% (*P* > 0.05). +72 h: Males = 0% vs. Females = -15% (*P* > 0.05).
Latella et al. (2018)	Males: 25 ± 4 y n = 12 Females: 26 ± 3 y n = 11 RT experience: ≥0.5 y	Exercise/s: Unilateral Knee Extension. Prescription: 3 sets x 12 reps à 67% of 1RM 1 min rest between sets	Males: 2.90 Nm / BM Females: 3.01 Nm / BM Knee extensor MVIC. Sex difference: -3.7%	Mechanical measures of NMF: MVIC (+0 min, +30 min, +1 h and +6 h post-RT).	MVIC: +0 min: Males = -14.2% vs. Females = -14.2% (*P* > 0.05). +30 min: Males = -13.3% vs. Females = -11.2% (*P* > 0.05). +1 h: Males = -12.5% vs. Females = -10.2% (*P* > 0.05). +6 h: Males = -1.7% vs. Females = -2.5% (*P* > 0.05).

Mackey et al. (2018)	Males: 22 ± 3 y n = 14 Females: 22 ± 1 y n = 16 RT experience: ≥0.5 y	Exercise/s: Back Squat. Prescription: Power-Endurance protocol: 5 sets x 16 reps à 40% of 1RM 2 min rest between sets Hypertrophy protocol: 5 sets x 8 reps à 80% of 1RM 2 min rest between sets	Males: 1.71 kg / BM Females: 1.37 kg / BM 1RM back squat. Sex difference: +24.8%	Mechanical measures of NMF: MVCC at 500°/s (+0 min, +7 min, +15 min and +30 min).	MVCC: Power-endurance: +0 min: Males = -2% vs. Females = -2% ($P > 0.05$). +7 min: Males = -3% vs. Females = -1% ($P > 0.05$). +15 min: Males = -3% vs. Females = -1% ($P > 0.05$). +30 min: Males = -2% vs. Females = -1% ($P > 0.05$). Hypertrophy: +0 min: Males = -6% vs. Females = -3% ($P > 0.05$). +7 min: Males = -2% vs. Females = -2% ($P > 0.05$). +15 min: Males = -4% vs. Females = -1% ($P > 0.05$). +30 min: Males = -4% vs. Females = -2% ($P > 0.05$).
Metcalf et al. (2019)	Males: 26 ± 5 y n = 8 Females: 25 ± 3 y n = 8 RT experience: ≥3 y	Exercise/s: Unilateral leg extension. Prescription: 9 sets x 2-10 reps, last sets to MF. à 60-90% of 1RM 1.5-2 min rest between sets	Males: 0.52 kg / BM Females: 0.31 kg / BM 1RM unilateral Knee Extension. Sex difference: +67.7%	Mechanical measures of NMF: MVIC and RTD, incl. superimposed (+0 min).	Voluntary: Males = -26.6% vs. Females = -25.9% ($P > 0.05$). Superimposed at 10Hz: Males = -60.4% vs. Females = -46.2% ($P < 0.05$). Superimposed at 100Hz: Males = -45.9% vs. Females = -25.3% ($P < 0.05$). RTD: 0-25ms: Males = -14.6% vs. Females = +2.8% ($P > 0.05$). 0-50ms: Males = -20.6% vs. Females = +2.3% ($P < 0.05$). 0-75ms: Males = -19.0% vs. Females = +2.5% ($P < 0.05$). 0-100ms: Males = -13.3% vs. Females = +1.6% ($P < 0.05$). Max: Males = -19.5% vs. Females = +2.2% ($P < 0.05$).
Monteiro et al. (2019)	Males: 26 ± 4 y n = 16 Females: 25 ± 3 y n = 12	Exercise/s: Alternating sets of Leg Press and Bench Press, counterbalanced order. Prescription: 4 sets to MF	Specific numbers unreported. Sex difference: ≈ +8.5%	Mechanical measures of NMF: RTF (Δ 1st to 4th set).	Leg Press: Bench Press first: 0 min rest: Males = - 53.8% vs. Females = - 72.2% ($P < 0.05$). 3 min rest: Males = -44.5% vs. Females = -63.2% ($P < 0.05$).

	RT experience: ≥1 y	à 100% of 10RM Either 0 or 3 min rest between sets.			Leg Press first: 0 min rest: Males = - 59.4% vs. Females = - 52.7% (P < 0.05). 3 min rest: Males = -33.8% vs. Females = - 52.1% (P < 0.05). Bench Press: Bench Press first: 0 min rest: Males = -53.4% vs. Females = -60.1% (P < 0.05). 3 min rest: Males = -45.8% vs. Females = -56.2% (P < 0.05). Leg Press first: 0 min rest: Males = -67.1% vs. Females = -69.7% (P > 0.05). 3 min rest: Males = -30.9% vs. Females = -61.2% (P < 0.05).
Marshall et al. (2020)	Males: 26 ± 6 y n = 8 Females: 26 ± 6 y n = 8 RT experience: ≥3 y	Exercise/s: Rack Pulls, Barbell Row, Bench Press of Pins, Hang Cleans, DB Snatch. Prescription: 4 sets x 6 reps per exercise. à Submaximal as no rep slowdown was allowed, but no exact load is reported. 50% of BM for cleans, while 25% and 20% of BM were used by males and females for snatch, respectively. 1.5 min rest between sets	Males: 2.94 Nm / BM Females: 2.71 Nm / BM Knee extensor MVIC. Sex difference: +8.5%	Mechanical measures of NMF: MVCC torque (Δ first three repetitions of 1st set to the last five reps of the 2nd set, at +0 min, +1 h, +24 h and +48 h post-RT). MVIC and RTD, incl. superimposed (+0 min, +1 h, +24 h and +48 h post-RT). Metabolic measures of NMF: Muscle oxygenation parameters via NIRS (+0min, +1 h, +24 h and +48 h post-RT).	MVCC torque decrease: +0 min: Males = -17% vs. Females = -17% (P > 0.05). +1 h: Males = -12% vs. Females = -18% (P > 0.05). +24 h: Males = -23% vs. Females = -13% (P = 0.048). +48 h: Males = -13% vs. Females = -14% (P > 0.05). MVIC: +0 min: Males = -13% vs. Females = -13% (P > 0.05). +1 h: Males = -6% vs. Females = -10% (P > 0.05). +24 h: Males = -8% vs. Females = -9% (P > 0.05). +48 h: Males = -2% vs. Females = -4% (P > 0.05). Superimposed: +0 min: Males = -20% vs. Females = -20% (P > 0.05). +1 h: Males = -16% vs. Females = -19% (P > 0.05). +24 h: Males = 0% vs. Females = -10% (P = 0.003). +48 h: Males = -2% vs. Females = -9% (P > 0.05). RTD: +0 min: Males = -6.0% vs. Females = -16.7% (P > 0.05). +1 h: Males = -12.2% vs. Females = -13.7% (P >

					0.05). +24 h: Males = -5.2% vs. Females = -8.0% ($P >$ 0.05). +48 h: Males = -7.2% vs. Females = -11.9% ($P >$ 0.05). Muscle oxygen tissue saturation: +0 min: Males = -21% vs. Females = -7% ($P <$ 0.05). +1 h: Males = -18% vs. Females = -6% ($P < 0.05$). +24 h: Males = -18% vs. Females = -7% ($P < 0.05$). +48 h: Males = -19% vs. Females = -7% ($P < 0.05$). Deoxygenated haemoglobin: +0 min: Males = +90% vs. Females = +25% ($P <$ 0.05). +1 h: Males = +68% vs. Females = +14% ($P <$ 0.05). +24 h: Males = +78% vs. Females = +14% ($P <$ 0.05). +48 h: Males = +74% vs. Females = +24% ($P <$ 0.05).
Orssatto et al. (2020)	Males: 26 ± 6 y n = 8 Females: 26 ± 6 y n = 8 RT experience: ≥2 y	Exercise/s: Calf Raises. Prescription: 6 sets x RTF à 12RM 2 min rest between sets	Males: 1.18 kg / BM Females: 1.12 kg / BM 12RM calf raise. Sex difference: +5.4%	Mechanical measures of NMF: RTF (1st set, decrease from 1st to 6th set).	First RTF: Males = 12 reps vs. Females = 14 reps ($P < 0.05$). RTF performance decrease: Males = -51.0% vs. Females = -45.4% ($P > 0.05$).
Emanuel et al. (2020)	Males: 30 ± 4 y n = 10 Females: 29 ± 4 y n = 10 RT experience: ≥1 y ≥1.2x and 0.7x BM 1RM Bench Press and 1.2x and 1.0x BM Back Squat for	Exercise/s: Back Squat, Bench Press Prescription: 2 sets x RTF à Either 70% or 83% of 1RM 6 min rest between sets and exercises	Males: 1.44 kg/ BM Females: 0.95 kg / BM 1RM back squat and bench press combined. Sex difference: +51.6%	Mechanical measures of NMF: RTF (1st set, Δ 1st to 2nd set).	RTF performance (set 1): BP 70%: Males = 13.1 reps vs. Females = 14.6 reps. BP 83%: Males = 7.2 reps vs. Females = 7.4 reps. BSq 70%: Males = 13.2 reps vs. Females = 23.6 reps. BSq 83%: Males = 7.0 reps vs. Females = 10.2 reps. RTF performance Δ:

	males and females, respectively.				BP 70%: Males = -14.5% vs. Females = -10.3%. BP 83%: Males = -9.7% vs. Females = -1.4%. BSq 70%: Males = -11.4% vs. Females = -27.0%. BSq 83%: Males = -10% vs. Females = -11.8%. *NB: No NHST performed.*
Amdi et al. (2021)	SMRT: Males: 29 ± 5 y n = 8 Females: 26 ± 4 y n = 8 RMRT: Males: 28 ± 4 y n = 8 Females: 25 ± 4 y n = 7 RT experience: ≥0.5 y ≥1x BM 1RM Back Squat	Exercise/s: Back Squat Prescription: SMRT: 5 sets x 5 reps à 80% of 1RM ≥5 min rest between sets RMRT: 5 sets x RTF à 4-6RM ≥5 min rest between sets	SMRT: Males: 1.65 kg / BM Females: 1.21 kg / BM RMRT: Males: 1.79 kg / BM Females: 1.29 kg / BM 1RM back squat. Sex difference: SMRT: +36.4% RMRT: +38.8%	Mechanical measures of NMF: MV at 80% of 1-RM (+5 min, +24 h, +48 h, +72 h post-RT). Intra-set velocity loss (best to last rep).	SMRT: +5 min: Males = -8% vs. Females = +9%, (*P* < 0.001) +24 h: Males = -7% vs. Females = +5% (*P* = 0.005). +48 h: Males = -7% vs. Females = +9% (*P* < 0.001). +72 h: Males = +2% vs. Females = +10%, (*P* = 0.061). Velocity loss: Males = 19.3% vs. Females = 21.0% (*P* > 0.05) RMRT: +5 min: Males = -11% vs. Females = -9% (*P* > 0.05). +24 h: Males = -6% vs. Females = -6% (*P* > 0.05). +48 h: Males = -3% vs. Females = -3% (*P* > 0.05). +72 h: Males = -4% vs. Females = -3% (*P* > 0.05). Velocity loss: Males = 18.8% vs. Females = 15.9% (*P* > 0.05).
Ha et al. (2021)	Males: 22 ± 2 y n = 12 Females: 21 ± 3 y n = 14 RT experience: ≥0.5 y	Exercise/s: Ankle Plantar Flexion. Prescription: Isometric protocol: 2min sustained isometric contraction à maximal effort Dynamic protocol: 120 isotonic contractions à maximal effort at 30% MVIC	Males: 2.05 N / BM Females: 1.94 N / BM Plantar flexor MVIC Sex difference: +5.7%	Mechanical measures of NMF: MVIC (+0 min, +2.5 min, +5 min and +10 min post-RT).	Isotonic protocol: +0 min: Males = -19.4% vs. Females = -13.8% (*P* = 0.216). +2.5 min: Males = -14.9% vs. Females = -16.5% (*P* > 0.05). +5 min: Males = -10.5% vs. Females = -13.8 (*P* > 0.05). +10 min: Males = -6.6% vs. Females = -10.8% (*P* > 0.05). Isometric protocol: +0 min: Males = -29.4% vs. Females = -17.0% (*P* = 0.061. +2.5 min: Males = -16.2% vs. Females = -12.8% (*P*

					> 0.05). +5 min: Males = -10.2% vs. Females = -7.8% (*P* > 0.05). +10 min: Males = -11.7% vs. Females = -6.9% (*P* > 0.05).
Emanuel et al. (2021)	Males: 28 ± 6 y n = 10 Females: 32 ± 6 y n = 10 RT experience: ≥1 y ≥1.2x and 0.7x BM 1RM Bench Press and 1.2x and 1.0x BM Back Squat for males and females, respectively.	Exercise/s: Back Squat, Bench Press Prescription: Back Squat 3 sets x RTF à Either 70% or 80% of 1RM 6 min rest between sets Bench Press 3 sets x RTF à 70% of 1RM 6 min rest between sets	Males: 1.53 kg / BM Females: 1.05 kg / BM 1RM back squat and bench press combined. Sex difference: +45.7%	Mechanical measures of NMF: RTF (1st set, Δ 1st to 3rd set).	RTF performance (set 1): BP 70%: Males = 14.1 reps vs. Females = 15.6 reps. BSq 70%: Males = 20.1 reps vs. Females = 20.7 reps. BSq 80%: Males = 13.2 reps vs. Females = 12.9 reps. RTF performance decrease: BP 70% (males = -26.2% vs. females = -25.6%. BSq 70% (males = -40.3% vs. females = -22.7%). BSq 80% (males = -31.1% vs. females = -28.7%).
Carr and Ye (2022)	Males: 27 ± 3 y n = 13 Females: 28 ± 2 y n = 7 RT experience: ≥0.5 y	Exercise/s: Isometric elbow flexion and knee extension. Prescription: 6 sets of 30 sec MVIC. 0.5 min rest between sets.	Males: 8.09 N / BM Females: 6.48 N / BM MVIC elbow knee flexion and knee extension averaged. Sex difference: +24.8%	Mechanical measures of NMF: MVIC elbow flexion and knee extension (+0 min)	MVIC: Elbow flexion: Males = -65.9% vs. Females = -49.8% Knee extension: Males = -61.0% vs. Females = -46.7% Main effect of sex, collapsed across both measures ($P = 0.042$)
Lewis et al. (2022)	Males: 24 ± 4 y n = 16 Females: 22 ± 3 y n = 12 RT experience: ≥2 y ≥3 mo experience with	Exercise/s: DB Biceps Curls, Leg Extensions. Prescription: 4 sets x RTF à 10RM 1.5 min rest between sets and exercises	Males: 0.58 kg / BM Females: 0.44 kg / BM Combined 10RM Biceps Curl and Knee Extension. Sex difference: +31.8%	Mechanical measures of NMF: Completed reps at baseline (across 4 sets). RTF, relative to baseline (+4 h, +24 h and +48h post-RT).	RTF-performance: Biceps Curls: Baseline: Males = 30.1-31.5 reps vs. Females = 34.1-35.6 reps ($P = 0.031$). +4 h: Males = -7.3% vs. Females = +1.7% (*P* > 0.05). +24 h: Males = -6.0% vs. Females = +6.2% (*P* > 0.05). +48 h: Males = +0.7% vs. Females = -0.6% (*P* > 0.05).

	DB curls and Knee Extensions.				Knee extension: Baseline: Males = 37.4-38.5 reps vs. Females = 37.8-42.0 reps (*P* > 0.05). +4 h: Males = -3.4% vs. Females = -3.8% (*P* > 0.05). +24 h: Males = +2.7% vs. Females = +7.9% (*P* > 0.05). +48 h: Males = +2.7% vs. Females = -2.7% (*P* > 0.05).
Mochizuki et al. (2022)	Males: 23 ± 3 y n = 11 Females: 21 ± 2 y n = 11 RT experience: 4.2 ± 3.2 y	Exercise/s: Back squat. Prescription: 3 sets x 10 reps á 70% of 1RM 1.5, 2.5 or 4 min rest between sets	Males: 1.78 kg / BM Females: 1.20kg / BM 1RM back squat. Sex difference: +48.3%	Mechanical measures of NMF: Drop in average set lifting velocity across sets, velocity loss per set and in total, and velocity increase from last rep of prior set to first rep of subsequent set. Metabolic measures of NMF: Blood lactate.	Average lifting velocity per set: 1.5 min: Males = -14.8% vs. Females = -2.0% (*P* = 0.03) 2.5 min: Males = -7.7% vs. Females = -2.1% (*P* = 0.12) 4 min: Males = -2.7% vs. Females = +2.3% (*P* = 0.16) Velocity loss per set: 1.5 min: Males = 16.0% vs. Females = 22.1% (*P* > 0.05) 2.5 min: Males = 21.7% vs. Females = 25.1% (*P* > 0.05) 4 min: Males = 23.3% vs. Females = 19.2% (*P* > 0.05) Velocity loss per training: 1.5 min: Males = 32.8% vs. Females = 25% (*P* > 0.05) 2.5 min: Males = 26.8% vs. Females = 25.5% (*P* > 0.05) 4 min: Males = 24.6% vs. Females = 20.8% (*P* > 0.05) Velocity increase between sets: 1.5 min: Males = 19.2% vs. Females = 24.7% 2.5 min: Males = 24.5% vs. Females = 34.4% 4 min: Males = 27.2% vs. Females = 24.4% *NHST not performed.* Blood lactate: Males > Females (*P* = 0.002)
Walker et al. (2022)	20% VL Males: 27 ± 5 y n = 11	Exercise/s: Smith Machine Squat	20% VL Males: 1.38 kg / BM	Mechanical measures of NMF: CMJ, Leg Press MVIC and RFD, Superimposed (10 and 100Hz) Knee Extension MVIC, and Back	CMJ: Before training: 20%VL: +0-5 min: Males = -20.7% vs. Females = -20.7% (*P*

	Females: 26 ± 3 y n = 9 40% VL Males: 26 ± 3 y n = 10 Females: 26 ± 3 y n = 7 RT experience: ≥1 y	Prescription: 5 sets x either 20% or 40% velocity loss à 70% of 1RM 3 min rest inter-set rest	Females: 1.07 kg / BM 40% VL Males: 1.34 kg / BM Females: 1.06 kg / BM 1RM back squat Sex difference: 20% VL: 29.0% 40% VL: 26.4%	Squat power output @60% of 1-RM (+0-5 min, +24 h post-RT). Metabolic measures of NMF: Blood lactate (+1.5 min, +10 min post-RT). *NB: Tested both before and after an 8 week training protocol.*	> 0.05), +24 h: Males = -1.5% vs. Females = -1.5% (*P* > 0.05). 40%VL: +0-5 min: Males = -28.7%vs. Females = -20.7% (*P* > 0.05). +24 h: Males = -2.5% vs. Females = +2.5% (*P* > 0.05). After training: 20%VL: +0-5 min: Males = -20.7% vs. Females = -26.7% (*P* > 0.05). +24 h: Males = +0.5% vs. Females = -7.6% (*P* > 0.05). 40%VL: +0-5 min: Males = -25.7% vs. Females = -22.7% (*P* > 0.05). +24 h: Males = -3.5% vs. Females = -2.5% (*P* > 0.05). MVIC Leg Press: Before training: 20%VL: +0-5 min: Males = -13.6% vs. Females = -11.5% (*P* > 0.05). +24 h: Males = -3.9% vs. Females = -2.9% (*P* > 0.05). 40%VL: +0-5 min: Males = -20.7% vs. Females = -17.1% (*P* > 0.05). +24 h: Males = -4.2% vs. Females = - 7.7% (*P* > 0.05). After training: 20%VL: +0-5 min: Males = -14.6% vs. Females = -13.6% (*P* > 0.05). +24 h: Males = -2.4% vs. Females = - 3.4% (*P* > 0.05). 40%VL: +0-5 min: Males = -16.6% vs. Females = -15.6% (*P* > 0.05). +24 h: Males = -5.3% vs. Females = -8.8% (*P* > 0.05). Early Force (0-100ms) Leg Press: Before training:

			20%VL: +0-5 min: Males = -6.0% vs. Females = +1.6% (*P* > 0.05). +24 h: Males = +2.8%vs. Females = +11.7% (*P* > 0.05). 40%VL: +0-5 min: Males = -29.1% vs. Females = -13.1% (*P* > 0.05). +24 h: Males = -23.8% vs. Females = -4.3% (*P* > 0.05). After training: 20%VL: +0-5 min: Males = -21.9% vs. Females = -23.8% (*P* > 0.05). +24 h: Males = -0.7% vs. Females = -4.3% (*P* > 0.05). 40%VL: +0-5 min: Males = -14.9% vs. Females = -20.2% (*P* > 0.05). +24 h: Males = +8.2% vs. Females = -7.8% (*P* > 0.05). Superimposed knee extension 10Hz: Before training: 20%VL: +0-5 min: Males = -35.1% vs. Females = -21.8% (*P* > 0.05). +24 h: Males = -1.2% vs. Females = -3.2% (*P* > 0.05). 40%VL: +0-5 min: Males = -41.3% vs. Females = -28.7% (*P* > 0.05). +24 h: Males = -6.3% vs. Females = -10.4% (*P* > 0.05). After training: 20%VL: +0-5 min: Males = -37.2% vs. Females = -31.0% (*P* > 0.05). +24 h: Males = -11.5% vs. Females = -4.3% (*P* > 0.05). 40%VL: +0-5 min: Males = -41.3% vs. Females = -33.1% (*P* > 0.05). +24 h: Males = -14.6% vs. Females = -8.4% (*P* > 0.05).

Superimposed knee extension 100Hz:
Before training:
20%VL:
+0-5 min: Males = -14.7% vs. Females = -7.2% ($P > 0.05$).
+24 h: Males = -3.6% vs. Females = +0.4% ($P > 0.05$).
40%VL:
+0-5 min: Males = -17.9% vs. Females = -5.0% ($P > 0.05$).
+24 h: Males = -0.7% vs. Females = -2.9% ($P > 0.05$).

After training:
20%VL:
+0-5 min: Males = -17.9% vs. Females = -13.7% ($P > 0.05$).
+24 h: Males = -6.1% vs. Females = -2.9% ($P > 0.05$).
40%VL:
+0-5 min: Males = -16.1% vs. Females = -19.1% ($P > 0.05$).
+24 h: Males = -8.3% vs. Females = -8.3% ($P > 0.05$).

MPP back squat @60% of 1RM:
Before training:
20%VL:
+0-5 min: Males = -4.2% vs. Females = -3.2% ($P > 0.05$).
+24 h: Males = -2.2% vs. Females = +1.8% ($P > 0.05$).
40%VL:
+0-5 min: Males = -8.7% vs. Females = -4.2% ($P > 0.05$).
+24 h: Males = -0.2% vs. Females = -3.2% ($P > 0.05$).

After training:
20%VL:
+0-5 min: Males = -8.2% vs. Females = -2.7% ($P > 0.05$).
+24 h: Males = -3.2% vs. Females = -1.8% ($P > 0.05$).
40%VL:
+0-5 min: Males = -5.2% vs. Females = +0.8% ($P > 0.05$).
+24 h: Males = +0.3% vs. Females = +1.3% ($P >$

					0.05). Blood lactate: Before training: 20%VL: +1.5 min: Males = +234% vs. Females = +179% (*P* > 0.05). +10 min: Males = +178% vs. Females = +113% (*P* > 0.05). 40%VL: +1.5 min: Males = +719% vs. Females = +568% (*P* > 0.05). +10 min: Males = +549% vs. Females = +427% (*P* > 0.05). After training: 20%VL: +1.5 min: Males = +280%vs. Females = +196% (*P* > 0.05). +10 min: Males = +208% vs. Females = +137% (*P* > 0.05). 40%VL: +1.5 min: Males = +476% vs. Females = +448% (*P* > 0.05). +10 min: Males = +360% vs. Females = +391% (*P* > 0.05).
Refalo et al. (2023)	Males: 29 ± 5 y n = 12 Females: 32 ± 6 y n = 12 RT experience: ≥3 y 1RM bench press: Males: ≥1.2x BM Females: ≥0.8x BM	Exercise/s: Bench Press Prescription: 6 sets x either 3RIR, 1RIR or MF à 75% of 1RM, with 2min rest between sets	Males: 1.37 kg / BM Females: 0.88 kg / BM 1RM Bench Press Sex difference: +55.7%	Mechanical measures of NMF: RTF (1st set, Δ1st to 6th set). MV per set (Δ1st to 6th set). MV at ≈64% of 1-RM (+4 min, +24 h, +48 h post-RT). Velocity loss (per set)	RFT-performance: Males = 12 reps vs. Females = 16 reps (*P* > 0.05). Decrease in reps from 1st to 6th set: 3RIR Males = -29% vs. Females = -25% (*P* > 0.05). 1RIR Males = -43% vs. Females = -37% (*P* > 0.05). FAIL Males = -59% vs. Females = -51% (*P* > 0.05). Decrease in velocity from 1st to 6th set: 3RIR Males = -8.1% vs. Females = -1.1% 1RIR Males = -11.3% vs. Females = -10.1%. FAIL Males = -28.8% vs. Females = -19.6%.

					Overall effect of sex: *P* = 0.020. Lifting velocity, relative to baseline: 3RIR: +4 min: Males = -8% vs. Females = -8% ($P > 0.05$). +24 h: Males = +2% vs. Females = +2% ($P > 0.05$). +48 h: Males = +2% vs. Females = 0% ($P > 0.05$). 1RIR: +4 min: Males = -14% vs. Females = -14% ($P > 0.05$). +24 h: Males = -2% vs. Females = -5% ($P > 0.05$). +48 h: Males = -2% vs. Females = -2% ($P > 0.05$). FAIL: +4 min: Males = -29% vs. Females = -20% ($P = 0.007$). +24 h: Males = -3% vs. Females = -3% ($P > 0.05$). +48 h: Males = 0% vs. Females = -2% ($P > 0.05$). Intra-set velocity loss: 3RIR Males = -30.6% vs. Females = -34.3% 1RIR Males = -42.4% vs. Females = -51.5%. FAIL Males = -57.6% vs. Females = -62.5%.
Jukic et al. (2023)	Males: 18-40 y n = 31 Females: 18-40 y n = 15 RT experience: ≥0.5 y	Exercise/s: Back Squat Prescription: 3 sets x RTF à 90%, 80% and 70% of 1RM, with 10min rest between sets	Males: 1.79 kg / BM Females: 1.25 kg / BM 1RM Back Squat Sex difference: +43.2%	Mechanical measures of NMF: RTF @70, 80 and 90% of 1RM	RTF-performance: 90% of 1RM: Males = 5.0 reps vs. Females = 6.0 reps. 80% of 1RM: Males = 6.4 reps vs. Females = 7.9 reps. 70% of 1RM: Males = 8.8 reps. vs. Females = 10.0 reps. *Overall sex effect ($P = 0.011$).*
Benitez et al. (2024)	Males: 24 ± 3 y n = 10 Females: 24 ± 4 y	Exercise/s: Isometric knee extension Prescription: 1 set to failure at 50%	Males: 22.4 N / BM Females: 20.0 N / BM Knee extensor MVIC	Mechanical measures of NMF: Time to task failure	Time to task failure: Males = 75.2 sec vs. Females = 87.8 sec ($P > 0.05$)

	n = 10 RT experience: ≥1 y	MVIC (i.e., falling below 50% of MVIC)	Sex difference: +12.0%		
Iacono et al. (2024)	Males: 25 ± 5 y n = 12 Females: 22 ± 2 y n = 12 RT experience: ≥1 y	Exercise/s: Bench press Prescription: TRA: 3 sets x 8 reps @ 75% of 1RM ARRT: 24 reps @ 75% of 1RM to 20% VL using rest redistribution.	Males: 1.38 kg / BM Females: 0.98 kg / BM Bench press 1RM Sex difference: +40.8%	Mechanical measures of NMF: Unilateral chest press MVIC (+0 min), lifting velocity loss (TRA only).	MVIC: TRA: Males = -15.5% vs. Females = -9.6% ARRT: Males = -4.0% vs. Females = -2.1% *Condition x Sex interaction (P < 0.001)* Velocity loss: Males = 16.7% vs. Females = 14.3%
Voskuil et al. (2024)	Males: 22 ± 3 y n = 10 Females: 21 ± 2 y n = 10 RT experience: ≥0.5 y	Exercise/s: DB biceps curl Prescription: 4 sets x RTF à 50% of 1RM, with 2 min rest between sets	Males: 0.30 lbs / BM Females: 0.21 lbs / BM 1RM DB biceps curl Sex difference: +42.9%	Mechanical measures of NMF: RTF @50% of 1RM (first set, total, and decrement across sets), elbow flexor MVIC (+0 min, +2.5 min, +5 min, +10 min)	RTF-performance: Total reps: Males = 48.3 reps vs. Females = 64.9 reps (P < 0.001) RTF_{first}: Males = 18.6 reps vs. Females = 20.6 reps *NHST not performed* RTF $decrement_{first\ to\ last}$: Males = -56.5% vs. Females = -36.4% (P = 0.201) MVIC (time x sex interaction NS) +0 min: Males = -32.4% vs. Females = -29.7% +2.5 min: Males = -29.3% vs. Females = -26.1% +5 min: Males = -27.4% vs. Females = -26.8% +10 min: Males = -25.6% vs. Females = -22.7%

Supplementary Table 2. Study overview.

	n (M)	n (F)	Rel. Strength diff
Gabriel (1991)	11	11	37.30%
Häkkinen (1992)	9	10	16.50%
Häkkinen (1993)	10	9	68.30%
Häkkinen (1994)	10	9	68.30%
Pullinen et al. (2002)	6	6	27.40%
Judge and Burke (2010)	10	10	73%
Ratamess et al. (2012)	11	11	128.10%
Heavens et al. (2014).	9	9	45.50%
Hooper et al. (2014).	12	13	
Flanagan et al. (2014)	10	10	
Vilaca-Alves et al. (2014)	8	11	27.80%
Raeder et al. (2016)	14	9	
Gentil et al. (2017):	17	17	38.10%
Tinsley et al. (2017)	17	17	-5.80%
Davies et al. (2018)	11	8	14.50%
Latella et al. (2018)	12	11	-3.70%
Mackey et al. (2018)	14	16	24.80%
Metcalf et al. (2019)	8	8	67.70%
Monteiro et al. (2019)	16	12	8.50%
Marshall et al. (2020)	8	8	8.50%
Orssatto et al. (2020)	8	8	5.40%
Emanuel et al. (2020)	10	10	51.60%
Amdi et al. (2021)	8	8	38%
Emanuel et al. (2021)	10	10	45.70%
Ha et al. (2021)	12	14	5.70%
Carr and Ye (2022)	13	7	24.80%
Lewis et al. (2022)	16	12	31.80%
Mochizuki et al. (2022)	11	11	48.30%
Walker et al. (2022)	21	16	27.70%
Refalo et al. (2023)	12	12	55.70%
Jukic et al. (2023)	31	15	43.20%

Benitez et al. (2024)	10	10	12.00%	
Iacono et al. (2024)	12	12	40.80%	
Voskuil et al. (2024)	10	10	42.90%	
Sum	407	370		777
Median	11	10	37%	10.5
Min	6	6	-6%	6
Max	31	17	128%	31

Supplementary table 3. RTF-studies

Study	Relative strength difference	Matching category	Exercise	Relative load	Reps (M)	Reps (F)	Sex difference (+=F>M)
Emanuel et al. (2020) - Bench Press - Light	51.6%	UMM	Bench Press	70.0%	13	15	1.5
Emanuel et al. (2020) - Bench Press - Heavy	51.6%	UMM	Bench Press	83.0%	7	7	0.2
Emanuel et al. (2020) - Squat - Light	51.6%	UMM	Squat	70%	13	24	10.4
Emanuel et al. (2020) - Squat - Heavy	51.6%	UMM	Squat	83%	7	10	3.2
Emanuel et al. (2021) - Bench Press	45.7%	UMM	Bench Press	70%	14	16	1.5
Emanuel et al. (2021) - Squat	45.7%	UMM	Squat	70%	20	21	0.6
Emanuel et al. (2021) - Squat	45.7%	UMM	Squat	80%	13	13	-0.3
Flanagan et al. (2014) - Bench Press			Bench Press	85.0%	6.6	6.2	-0.4
Flanagan et al. (2014) - Squat			Squat	85.0%	9.2	7.7	-1.5
Orssatto et al. (2020)	5.4%	UMF	Calf Raise	70.0%	12.0	14.0	2.0
Vilaca-Alves et al. (2014) - Wide-Grip	27.8%	M	WG LDP	70.0%	13.6	12.2	-1.4
Vilaca-Alves et al. (2014) - Narrow-Grip	27.8%	M	NG LPD	70.0%	14.5	11.4	-3.1
Pullinen et al. (2002)	27.4%	M	Leg Ext	40.0%	21	24	3
Jukic et al. (2023) - 70%	43.2%	UMM	Squat	70.0%	8.8	10	1.2
Jukic et al. (2023) - 80%	43.2%	UMM	Squat	80.0%	6.4	7.9	1.5
Jukic et al. (2023) - 90%	43.2%	UMM	Squat	90.0%	5	6	1
Refalo et al. (2023)	55.7%	UMM	Bench Press	75.0%	12	16	4
Voskuil et al. (2024)	42.9%	NMM	Biceps curl	50.0%	18.6	20.6	2
Total (all measures)							
Median				70%	12.55	12.55	1.35

Mean	73%	11.98	13.39	1.41
Max	90%	21.00	24.00	10.40
Min	40%	5.00	6.00	-3.10
Upper body lifts				
Median	70%	13.10	12.20	0.85
Mean	75%	11.59	11.91	0.54
Max	85%	14.50	16.00	4.00
Min	70%	6.60	6.20	-3.10
Lower body lifts				
Median	75%	10.60	11.55	1.35
Mean	74%	11.59	13.70	2.11
Max	90%	21.00	24.00	10.40
Min	40%	5.00	6.00	-1.50
Heavier loads (≥80%)				
Median	83%	7.00	7.70	0.20
Mean	84%	7.80	8.33	0.53
Max	90%	13.20	12.90	3.20
Min	80%	5.00	6.00	-1.50
Lighter loads (≤70%)				
Median	70%	13.60	14.60	1.50
Mean	67%	14.49	16.23	1.77
Max	70%	21.00	24.00	10.40
Min	40%	8.80	10.00	-3.10

Lighter load lower body lifts

Median	70%	13.20	20.70	2.00
Mean	64%	15.02	18.46	3.44
Max	70%	21.00	24.00	10.40
Min	40%	8.80	10.00	0.60

Supplementary table 4. Intra-set fatigue

Study	Relative strength difference	Exercise	Outcome	Males	Females	Sex difference (+=F>M)	NHST
Gentil et al. (2017)	38.10%	Elbow flexion	Isokinetic peak torque	-46%	-38%	8%	p < 0.05
Gabriel (1991) - Chest	37.30%	Chest press	Isokinetic peak torque	-28%	-30%	-2%	N/A
Gabriel (1991) - Leg	37.30%	Leg Extention	Isokinetic peak torque	-21%	-23%	-2%	N/A
Amdi et al. (2021) - SMRT	36.40%	Back Squat	Velocity loss	-19%	-21%	-2%	p > 0.05
Amdi et al. (2021) - RMRT	38.80%	Back Squat	Velocity loss	-19%	-16%	3%	p > 0.05
Mochizuki et al. (2022) - 1.5min	48.30%	Back Squat	Velocity loss	-16%	-22%	-6%	p > 0.05
Mochizuki et al. (2022) - 2.5min	48.30%	Back Squat	Velocity loss	-22%	-25%	-3%	p > 0.05
Mochizuki et al. (2022) - 4min	48.30%	Back Squat	Velocity loss	-23%	-19%	4%	p > 0.05
Refalo et al. (2023) - 0RIR	55.70%	Bench Press	Velocity loss	-31%	-34%	-4%	N/A
Refalo et al. (2023) - 1RIR	55.70%	Bench Press	Velocity loss	-42%	-52%	-9%	N/A
Refalo et al. (2023) - 3RIR	55.70%	Bench Press	Velocity loss	-58%	-63%	-5%	N/A
Iacono et al. (2024) - TRA only	40.80%	Bench Press	Velocity loss	-17%	-14%	2%	N/A
Benitez et al. (2024)	12.00%	ISO leg extension	Time-to-task failure	75.20	87.80		N/A
Overall							
Median						-2.0%	
Min						-9.1%	
Max						8.0%	
Count						12	

Supplementary table 5. Force decrement across sets

Study	Relative strength difference	Exercise	Relative load (% of 1RM)	Outcome	Males	Females	Sex difference (+=F>M)	NHST
Häkkinen (1993) - Load	68.30%	Back Squat	100%	Decrease in Training Load	-10%	-10%	0%	N/A
Häkkinen (1993) - MVIC	68.30%	Back Squat	100%	Decrease in MVIC	-24%	-21%	4%	
Häkkinen (1994) - Load	68.30%	Back Squat	70%	Decrease in Training Load	-27%	-15%	12%	N/A
Häkkinen (1994) - MVIC	68.30%	Back Squat	70%	Decrease in MVIC	-47%	-29%	18%	
Pullinen et al. (2002)	27.40%	Leg Extention	40%	Decrease in RTF	-19%	-17%	2%	N/A
Ratamess et al. (2012) - BP - 1 min rest	128.10%	Bench Press	75%	Decrease in RTF	-60%	-23%	37%	N/A
Ratamess et al. (2012) - BP - 2 min rest	128.10%	Bench Press	75%	Decrease in RTF	-40%	-10%	30%	N/A
Ratamess et al. (2012) - BP - 3 min rest	128.10%	Bench Press	75%	Decrease in RTF	-23%	-4%	19%	N/A
Ratamess et al. (2012) - IBP	128.10%	Incline Bench Press	75%	Decrease in RTF	-12%	-23%	-11%	
Ratamess et al. (2012) - SP	128.10%	Shoulder Press	75%	Decrease in RTF	-11%	-10%	1%	
Ratamess et al. (2012) - BR	128.10%	Barbell Row	75%	Decrease in RTF	-7%	-2%	4%	
Hooper et al. (2014).		Squat, Bench Press, Deadlift	75%	Time to completion	35.90	30.70	17%	N/A
Tinsley et al. (2017) - CON	-5.80%	Machine Squat	85%	Decrease in peak force	0%	0%	0%	P > 0.05
Tinsley et al. (2017) - ECC	-5.80%	Machine Squat	85%	Decrease in peak force	-12%	-1%	11%	P > 0.05
Monteiro et al. (2019) - BP, BP first, 0 min rest	8.50%	Bench Press	75%	Decrease in RTF	-53%	-60%	-7%	P < 0.05
Monteiro et al. (2019) - BP, LP first, 0 min rest	8.50%	Bench Press	75%	Decrease in RTF	-67%	-70%	-3%	P > 0.05
Monteiro et al. (2019) - BP, BP first, 3 min rest	8.50%	Bench Press	75%	Decrease in RTF	-46%	-56%	-10%	P < 0.05
Monteiro et al. (2019) - BP, LP first, 3 min rest	8.50%	Bench Press	75%	Decrease in RTF	-31%	-61%	-30%	P < 0.05
Monteiro et al. (2019) - LP, BP first, 0 min rest	8.50%	Leg Press	75%	Decrease in RTF	-54%	-72%	-18%	P < 0.05
Monteiro et al. (2019) - LP, LP first, 0 min rest	8.50%	Leg Press	75%	Decrease in RTF	-59%	-53%	7%	P < 0.05
Monteiro et al. (2019) - LP, BP first, 3 min rest	8.50%	Leg Press	75%	Decrease in RTF	-45%	-63%	-19%	P < 0.05
Monteiro et al. (2019) - LP, LP first, 3 min rest	8.50%	Leg Press	75%	Decrease in RTF	-34%	-52%	-18%	P < 0.05
Monteiro et al. (2019) - 0 min rest mean	**8.50%**		**75%**	**Decrease in RTF**	**-58%**	**-64%**	**-5%**	
Monteiro et al. (2019) - 3 min rest	**8.50%**		**75%**	**Decrease in RTF**	**-39%**	**-58%**	**-19%**	

mean								
Monteiro et al. (2019) - Within-sex difference between rest durations					**51%**	**9%**		
Marshall et al. (2020) - +0 min	8.50%	Leg Extention	75%	Decrease in concentric torque	-17%	-17%	0%	P > 0.05
Marshall et al. (2020) - +1 h	8.50%	Leg Extention	75%	Decrease in concentric torque	-12%	-18%	-6%	P > 0.05
Marshall et al. (2020) - +24 h	8.50%	Leg Extention	75%	Decrease in concentric torque	-23%	-13%	10%	P = 0.048
Marshall et al. (2020) - +48 h	8.50%	Leg Extention	75%	Decrease in concentric torque	-13%	-14%	-1%	P > 0.05
Orssatto et al. (2020)	5.40%	Calf Raises	70%	Decrease in RTF	-51%	-45.40%	6%	P > 0.05
Emanuel et al. (2020) - Bench Press - 70%	51.60%	Bench Press	70%	Decrease in RTF	-15%	-10.30%	4%	N/A
Emanuel et al. (2020) - Bench Press - 83%	51.60%	Bench Press	83%	Decrease in RTF	-10%	-1.40%	8%	N/A
Emanuel et al. (2020) - Back Squat - 70%	51.60%	Back Squat	70%	Decrease in RTF	-11%	-27.00%	-16%	N/A
Emanuel et al. (2020) - Back Squat - 83%	51.60%	Back Squat	83%	Decrease in RTF	-10%	-11.80%	-2%	N/A
Emanuel et al. (2021) - Bench Press - 70%	45.70%	Bench Press	70%	Decrease in RTF	-26%	-25.60%	1%	N/A
Emanuel et al. (2021) - Back Squat - 70%	45.70%	Back Squat	70%	Decrease in RTF	-40%	-22.70%	18%	N/A
Emanuel et al. (2021) - Back Squat - 80%	45.70%	Back Squat	80%	Decrease in RTF	-31%	-28.70%	2%	N/A
Lewis et al. (2022) - Leg Extensions	31.80%	Leg Extention	75%	Completed reps	37.80	40.33	7%	P > 0.05
Lewis et al. (2022) - DB Curls	31.80%	DB Curls	75%	Completed reps	30.70	34.93	14%	P = 0.031
Mochizuki et al. (2022) - 1.5min	48.30%	Back Squat	70%	Decrease in mean velocity per set	-14.80%	-2.00%	13%	p = 0.03
Mochizuki et al. (2022) - 2.5min	48.30%	Back Squat	70%	Decrease in mean velocity per set	-7.70%	-2.10%	6%	p = .12
Mochizuki et al. (2022) - 4min	48.30%	Back Squat	70%	Decrease in mean velocity per set	-2.70%	2.30%	5%	p = .16
Refalo et al. (2023) - 3RIR	55.70%	Bench Press	75%	Decrease in RTF	-29%	-25%	4%	P > 0.05
Refalo et al. (2023) - 1RIR	55.70%	Bench Press	75%	Decrease in RTF	-43%	-37%	6%	P > 0.05
Refalo et al. (2023) - 0RIR	55.70%	Bench Press	75%	Decrease in RTF	-59%	-51%	8%	P > 0.05
Voskuil et al. (2024) - RTF	42.90%	DB Curls	50%	Decrease in RTF	-57%	-36%	20%	p = 0.201
Voskuil et al. (2024) - MVIC	42.90%	DB Curls	50%	Decrease in MVIC	-32%	-30%	3%	NS

Overall	
Median	4.1%
Min	-30.3%
Max	37.0%
	44
Stronger males (Relative strength difference >10%)	
Median	5.3%
Min	-15.6%
Max	37.0%
Stronger females (Relative strength difference <10%)	
Median	-4.3%
Min	-30.3%
Max	10.8%
Count	
Negative 5% and below	9
±5%	14
5% and above	17
Total	44
Lighter (≤70% of 1RM)	
Median	6%
Min	-16%
Max	20%
Heavy (>70% of 1RM)	
Median	2%

Min	-30%
Max	37%
Upper body	
Median	4%
Min	-30%
Max	37%
Lower body	
Median	3%
Min	-19%
Max	18%

Supplementary table 6. Recovery kinetics

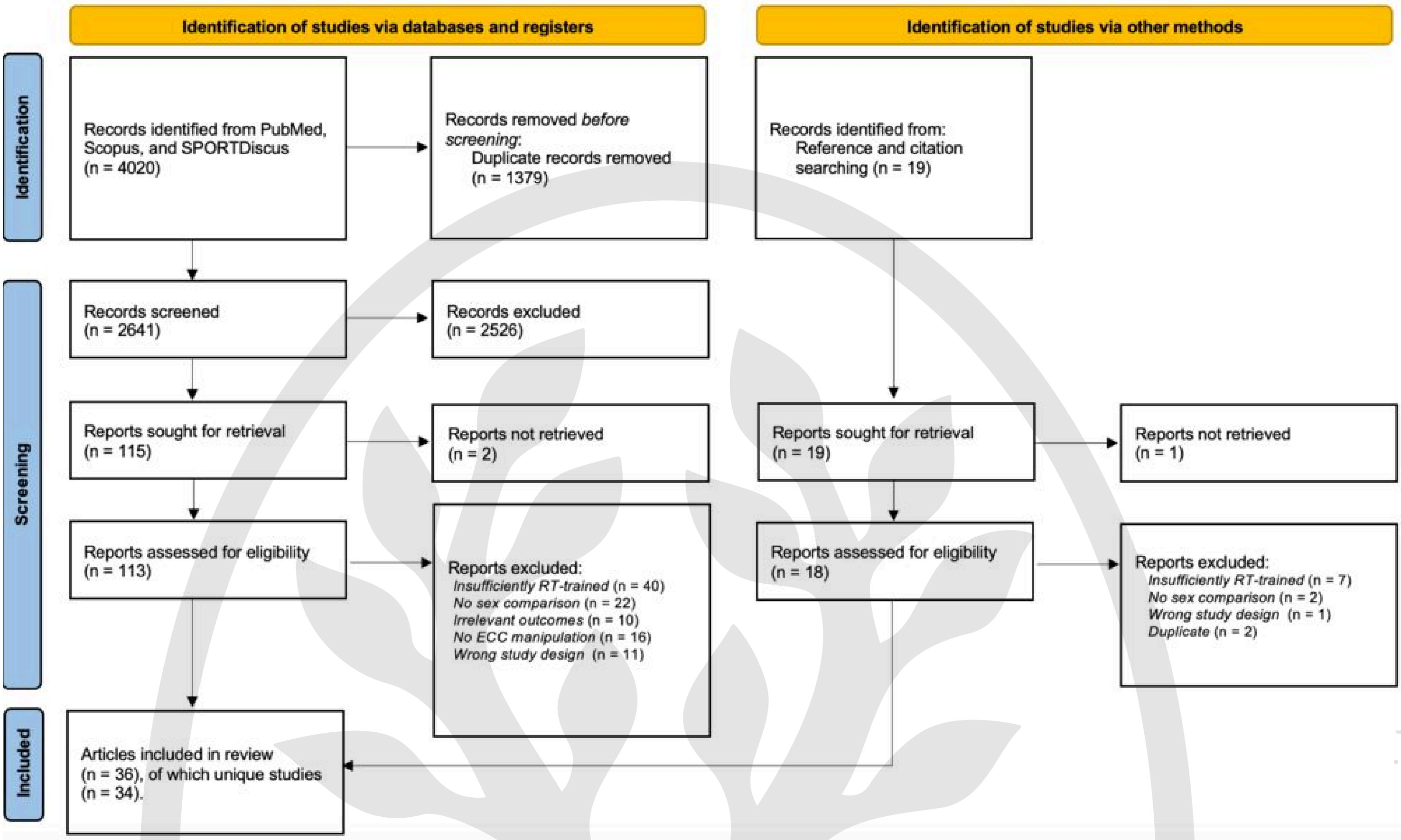
Study	Relative strength difference	Exercise	Relative load (% of 1RM)	Sex difference in fatigue - Positive values suggest less female fatigue					
				0-5min	>5min-45min	1-6h	24h	48h	72-96h
Latella et al. (2018) - MVIC	-3.70%	Knee exetnsion	67.00%	0.0%	1.1%	0.8%			
Marshall et al. (2020) - Superimposed	8.50%	Whole-body	Mixed	0.0%		3.0%	10.0%	7.0%	
Marshall et al. (2020) - RTD	8.50%	Whole-body	Mixed	10.7%		1.5%	2.8%	4.5%	
Marshall et al. (2020) - MVIC	8.50%	Whole-body	Mixed	0.0%		-4.0%	-1.0%	-2.0%	
Ha et al. (2021) - Isometric protocol - MVIC test	5.70%	Calf raises	Low	12.4%	3.5%				
Ha et al. (2021) - Isotonic protocol - MVIC test	5.70%	Calf raises	Low	5.6%	-3.0%				
Häkkinen (1992) - Leg press - MVIC	16.50%	Leg Press	70-80%	-1.3%					
Häkkinen (1992) - Squat - MVIC	16.50%	Squat	70-80%	5.8%					
Mackey et al. (2018) - PowEnd - CONC	24.80%	Squat	40.00%	0.0%	1.7%				
Mackey et al (2018) - HYP - CONC	24.80%	Squat	80.00%	3.0%	1.7%				
Pullinen et al. (2002) - MVIC	27.40%	Knee exetnsion	40.00%	0.0%					
Amdi et al. (2021) - SMRT - MV	36.40%	Squat	80.00%	17.0%			12.0%	16.0%	*8.0%*
Amdi et al. (2021) - RMRT - MV	38.80%	Squat	87.50%	2.0%			0.0%	0.0%	*1.0%*
Häkkinen (1993) - MVIC	68.30%	Squat	100.00%	3.6%		9.0%	-2.0%	1.0%	
Häkkinen (1994) - MVIC	68.30%	Squat	70.00%	17.7%		12.5 %	5.0%	9.0%	
Metcalf et al. (2019) - MVIC	67.70%	Knee exetnsion	Mixed	0.7%					
Metcalf et al. (2019) - Superimposed 10Hz	67.70%	Knee exetnsion	Mixed	14.2%					
Metcalf et al. (2019) - Superimposed 100Hz	67.70%	Knee exetnsion	Mixed	20.6%					
Metcalf et al. (2019) - RTDmax	67.70%	Knee exetnsion	Mixed	21.7%					
Davies et al. (2018) - CMJ	14.50%	Squat	80.00%			-8.0%	-10.0%	-19.0%	*-10.0%*
Davies et al. (2018) - Concentric	14.50%	Squat	80.00%			0.0%	-15.0%	-25.0%	*-14.0%*
Davies et al. (2018) - Eccentric	14.50%	Squat	80.00%			2.0%	0.0%	-5.0%	*-1.0%*
Davies et al. (2018) - MVIC	14.50%	Squat	80.00%			-5.0%	-14.0%	-17.0%	*-15.0%*
Judge and Burke (2010) - Athletes - RM	63.80%	Bench press	87.50%			2.0%	4.0%	0.0%	

Judge and Burke (2010) - Recreationally trained - RM	82.40%	Bench press	87.50%		2.0%	4.0%	1.0%	
Raeder et al. (2016) - Squat		Squat	Mixed			3.3%		*3.3%*
Raeder et al. (2016) - MVIC		Squat	Mixed			-8.0%		*-4.7%*
Raeder et al. (2016) - CMJ		Squat	Mixed			4.7%	1.1%	*3.6%*
Carr and Ye (2022) - Elbow Flexion - MVIC	24.80%	Isometric Elbow Flexion	Maximal	16.1%				
Carr and Ye (2022) - Knee Extension - MVIC	24.80%	Isometric Knee Extension	Maximal	14.3%				
Lewis et al. (2022) - Biceps Curls - RM	31.80%	Biceps curl	75.00%		9.0%	12.2%	-1.3%	
Lewis et al. (2022) - Leg Extensions - RM	31.80%	Knee exetnsion	75.00%		-0.4%	5.2%	-5.4%	
Walker et al. (2022) - 20% VL - CMJ - before	29.00%	Smith Squat	70.00%	0.0%		0.0%		
Walker et al. (2022) - 20% VL - CMJ - after	29.00%	Smith Squat	70.00%	-6.0%		-8.1%		
Walker et al. (2022) - 40% VL - CMJ - before	26.40%	Smith Squat	70.00%	8.0%		5.0%		
Walker et al. (2022) - 40% VL - CMJ - after	26.40%	Smith Squat	70.00%	3.0%		1.0%		
Walker et al. (2022) - 20% VL - Leg Press MVIC - before	29.00%	Smith Squat	70.00%	2.1%		1.0%		
Walker et al. (2022) - 20% VL - Leg Press MVIC - after	29.00%	Smith Squat	70.00%	1.0%		-1.0%		
Walker et al. (2022) - 40% VL - Leg Press MVIC - before	26.40%	Smith Squat	70.00%	3.6%		-3.5%		
Walker et al. (2022) - 40% VL - Leg Press MVIC - after	26.40%	Smith Squat	70.00%	1.0%		-3.5%		
Walker et al. (2022) - 20% VL - Leg Press MVIC 0-100ms - before	29.00%	Smith Squat	70.00%	7.6%		8.9%		
Walker et al. (2022) - 20% VL - Leg Press MVIC 0-100ms - after	29.00%	Smith Squat	70.00%	-1.9%		-3.6%		
Walker et al. (2022) - 40% VL - Leg Press MVIC 0-100ms - before	26.40%	Smith Squat	70.00%	16.0%		19.5%		
Walker et al. (2022) - 40% VL - Leg Press MVIC 0-100ms - after	26.40%	Smith Squat	70.00%	-5.3%		16.0%		
Walker et al. (2022) - 20% VL - MPP - before	29.00%	Smith Squat	70.00%	1.0%		4.0%		
Walker et al. (2022) - 20% VL - MPP - after	29.00%	Smith Squat	70.00%	5.5%		1.4%		
Walker et al. (2022) - 40-% VL - MPP - before	26.40%	Smith Squat	70.00%	4.5%		-3.0%		
Walker et al. (2022) - 40% VL - MPP - after	26.40%	Smith Squat	70.00%	-6.0%		1.0%		
Walker et al. (2022) - 20% VL - Superimposed 10Hz - before	29.00%	Smith Squat	70.00%	13.3%		-2.0%		
Walker et al. (2022) - 20% VL - Superimposed 10Hz - after	29.00%	Smith Squat	70.00%	6.2%		7.2%		

Walker et al. (2022) - 40% VL - Superimposed 10Hz - before	26.40%	Smith Squat	70.00%	12.6%			-4.1%		
Walker et al. (2022) - 40% VL - Superimposed 10Hz - after	26.40%	Smith Squat	70.00%	8.2%			6.2%		
Walker et al. (2022) - 20% VL - Superimposed 100Hz - before	29.00%	Smith Squat	70.00%	7.5%			4.0%		
Walker et al. (2022) - 20% VL - Superimposed 100Hz - after	29.00%	Smith Squat	70.00%	4.2%			3.2%		
Walker et al. (2022) - 40% VL - Superimposed 100Hz - before	26.40%	Smith Squat	70.00%	12.9%			-2.2%		
Walker et al. (2022) - 40% VL - Superimposed 100Hz - after	26.40%	Smith Squat	70.00%	-3.0%			0.0%		
Refalo et al. (2023) - 3RIR -MV	55.70%	Bench press	75.00%	0.0%			0.0%	-2.0%	
Refalo et al. (2023) - 1RIR - MV	55.70%	Bench press	75.00%	0.0%			-3.0%	0.0%	
Refalo et al. (2023) - FAIL - MV	55.70%	Bench press	75.00%	9.0%			0.0%	-2.0%	
Iacono et al. (2024) - TRA - MVIC	40.80%	Bench press	75.00%	5.9%					
Iacono et al. (2024) - ARRT - MVIC	40.80%	Bench press	75.00%	1.9%					
Voskuil et al. (2024) - MVIC	42.90%	Biceps curl	50.00%	3.4%	2.9%				
Count				**51.00**	**6.00**	**14.00**	**45.00**	**19.00**	**9.00**
Total (all measures)									
Median	29%			3.6%	1.7%	1.8%	0.5%	-0.7%	-5.5%
Mean	32.3%			5.3%	1.3%	1.7%	1.4%	-2.2%	-5.2%
Max	82.4%			21.7%	3.5%	12.5%	19.5%	16.0%	8.0%
Min	-3.7%			-6.0%	-3.0%	-8.0%	-15.0%	-25.0%	-15.0%
Walker et al. before									
Median				7.6%			0.5%		
Max				16.0%			19.5%		
Min				0.0%			-4.1%		

Walker et al. after						
Median	1.0%			1.0%		
Max	8.2%			16.0%		
Min	-6.0%			-8.1%		
Lower body						
Median	4.2%	1.7%	0.4%	0.5%	-2.5%	-1.0%
Max	21.7%	3.5%	12.5 %	19.5%	16.0%	8.0%
Min	-6.0%	-3.0%	-8.0%	-15.0%	-25.0%	-15.0%
Upper body						
Median	3.4%	2.9%	2.0%	2.0%	-0.7%	#NUMMER!
Max	0.0%	2.9%	2.0%	-3.0%	-2.0%	0.0%
Min	16.1%	2.9%	9.0%	12.2%	1.0%	0.0%
Lower load (≤70%)						
Median	3.6%	1.7%	6.6%	1.0%	9.0%	#NUMMER!
Max	-6.0%	-3.0%	0.8%	-8.1%	9.0%	0.0%
Min	17.7%	3.5%	12.5 %	19.5%	9.0%	0.0%
Higher load (>70%)						
Median	3.6%	1.7%	2.0%	0.0%	-1.7%	-5.5%
Max	-1.3%	1.7%	-8.0%	-15.0%	-25.0%	-15.0%
Min	17.0%	1.7%	9.0%	12.2%	16.0%	8.0%
Lower relative strength difference (≤20%)						
Median	2.8%	1.1%	0.4%	-1.0%	-5.0%	-12.0%

Max	-1.3%	-3.0%	-8.0%	-15.0%	-25.0%	-15.0%
Min	12.4%	3.5%	3.0%	10.0%	7.0%	-1.0%
Higher relative strength difference (>20%)						
Median	3.6%	1.7%	5.5%	1.0%	0.0%	4.5%
Max	-6.0%	1.7%	-0.4%	-8.1%	-5.4%	1.0%
Min	21.7%	2.9%	12.5 %	19.5%	16.0%	8.0%
Isometric assessment						
Median	5.7%	2.0%	1.5%	0.0%	2.8%	-9.9%
Max	-5.3%	-3.0%	-5.0%	-14.0%	-17.0%	-15.0%
Min	21.7%	3.5%	12.5 %	19.5%	9.0%	-4.7%
Dynamic assessment						
Median	2.0%	1.7%	2.0%	1.0%	-1.3%	1.0%
Max	-6.0%	1.7%	-8.0%	-15.0%	-25.0%	-14.0%
Min	17.0%	1.7%	9.0%	12.2%	16.0%	8.0%


Identification of studies via databases and registers
Identification of studies via other methods
Identification
Records identified from PubMed, Scopus, and SPORTDiscus (n = 4020)
Records removed before screening: Duplicate records removed (n = 1379)
Records identified from: Reference and citation searching (n = 19)
Screening
Records screened (n = 2641)
Records excluded (n = 2526)
Reports sought for retrieval (n = 115)
Reports not retrieved (n = 2)
Reports sought for retrieval (n = 19)
Reports not retrieved (n = 1)
Reports assessed for eligibility (n = 113)
Reports excluded: Insufficiently RT-trained (n = 40) No sex comparison (n = 22) Irrelevant outcomes (n = 10) No ECC manipulation (n = 16) Wrong study design (n = 11)
Reports assessed for eligibility (n = 18)
Reports excluded: Insufficiently RT-trained (n = 7) No sex comparison (n = 2) Wrong study design (n = 1) Duplicate (n = 2)
Included
Articles included in review (n = 36), of which unique studies (n = 34).