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ARTICLE

# The effects of pre-exhaustion, exercise order, and rest intervals in a full-body resistance training intervention

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**Abstract:** Pre-exhaustion (PreEx) training is advocated on the principle that immediately preceding a compound exercise with an isolation exercise can target stronger muscles to *pre-exhaust* them to obtain greater adaptations in strength and size. However, research considering PreEx training method is limited. The present study looked to examine the effects of a PreEx training programme. Thirty-nine trained participants (male = 9, female = 30) completed 12 weeks of resistance training in 1 of 3 groups: a group that performed PreEx training ($n$ = 14), a group that performed the same exercise order with a rest interval between exercises ($n$ = 17), and a control group ($n$ = 8) that performed the same exercises in a different order (compound exercises prior to isolation). No significant between-group effects were found for strength in chest press, leg press, or pull-down exercises, or for body composition changes. Magnitude of change was examined for outcomes also using effect size (ES). ESs for strength changes were considered large for each group for every exercise (ranging 1.15 to 1.62). In conclusion, PreEx training offers no greater benefit to performing the same exercises with rest between them compared with exercises performed in an order that prioritises compound movements.

*Key words:* strength, muscle, lean mass, body fat.

**Résumé :** Un entraînement physique qui fatigue le muscle au préalable (PreEx) est préconisé selon le principe qu'un exercice isolé précédant immédiatement une chaîne d'exercices permet de cibler des muscles plus forts et de les fatiguer au préalable pour susciter des adaptations supérieures sur le plan de la force et de la grosseur. Toutefois, il y a peu d'études traitant d'entraînement PreEx. Cette étude se propose d'examiner l'effet d'un programme d'entraînement PreEx; trente-neuf sujets dont 9 hommes participent à 12 semaines d'entraînement contre résistance dans l'un des trois groupes : un groupe d'entraînement PreEx ($n$ = 14), un groupe effectuant la série d'exercices selon la même séquence, mais avec un intervalle de repos entre les exercices ($n$ = 17) et un groupe de contrôle ($n$ = 8) effectuant les mêmes exercices, mais selon une séquence différente (la chaîne d'exercices précédant l'exercice isolé). On n'observe pas de différence significative entre les groupes sur le plan de la force au développé couché, au développé des jambes, à la traction vers le bas et de la modification de la masse corporelle. On analyse en outre l'importance du changement par la statistique de l'ampleur de l'effet (« ES »). Les ES de la modification de la force musculaire sont très marquées dans chaque groupe d'exercices (1,15 à 1,62). En conclusion, le programme PreEx ne procure pas plus d'avantages que les mêmes exercices présentés avec un intervalle ou effectués selon une séquence priorisant la chaîne d'exercices. [Traduit par la Redaction]

*Mots-clés :* force musculaire, muscle, masse maigre, gras corporel.

## Introduction

Pre-exhaustion (PreEx) training is an advanced resistance training (RT) method where 2 or more sequential exercises are performed in immediate succession. Whilst Jones (1970) is often credited for the hypothesis and application of PreEx RT, he suggests that the original concept existed prior to his description. The PreEx method is based upon the hypothesis that a point of momentary muscular failure (MMF) in a compound exercise occurs when the weakest muscles involved are no longer able to apply the required force to continue the exercise (Jones 1970). As such the "target" muscles can be "pre-exhausted" with an isolation exercise before moving immediately to a compound exercise. For example, the biceps might be the "weak-link" in a pulling exercise though the target might be to train the latissimus muscles. With this in mind, it is suggested to pre-exhaust the target muscles using an isolation exercise immediately prior to a compound exercise. It is hypothesised that this provides greater stimulation to the target muscles. Jones (1970) notes that "during the brief period while your weak-link muscles are actually stronger than your target muscles, you can take advantage of that momentary condition to use the strength of the weak-link muscles to train the target muscles much harder than would otherwise be possible."[1] Since evidence suggests training to MMF maximally recruits motor units and produces greatest gains in muscular strength (Fisher et al. 2011) and hypertrophy (Fisher et al. 2013*a*), the notion of attaining a greater fatigue to maximise adaptation appears logical.

However, PreEx research is limited to acute studies with methodological limitations. Augustsson et al. (2003) compared the acute effects of pre-exhausting the quadriceps with a knee extension exercise prior to completing a leg press exercise against completing the leg press exercise alone. They reported significantly fewer repetitions and lower rectus femoris and vastus lateralis muscle activation for the leg press following the PreEx. However, Carpinelli

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[1]This quotation has been amended from *arms* to *weak-link*, and *latissimus* to *target* to highlight application of the general principle.

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(2010) has noted that whilst statistically significant, completing 7.9 ± 1.4 and 9.3 ± 2.3 repetitions for the PreEx and non-PreEx conditions, respectively, is unlikely to be *practically* significant. Additionally, that repetition duration was not controlled further invalidates these results.

Carpinelli (2010, 2013) also suggests Jones (1970) and Augustsson et al. (2003) were incorrect in the use of a knee extension exercise to pre-exhaust the quadriceps prior to performing the leg press. This is because the quadriceps may be the weak-link in a leg press exercise and instead the stronger hip extensors should be pre-exhausted. However, which muscles are indeed the weak-links in many compound exercises is largely speculative. Whilst Jones' (1970) original definition considered pre-exhausting the stronger muscles, we might consider PreEx as utilised upon specific target muscles. For example, many persons might be more interested in adaptations in their quadriceps over their hip extensors. As such, pre-exhausting the quadriceps by performing a knee extension exercise immediately prior to a compound exercise now seems appropriate. This might allow other muscles to assist the target quadriceps muscles to be trained "harder than would otherwise be possible", as per Jones' (1970) description. This amendment to our understanding of PreEx training now accommodates both Jones (1970) and Darden (1983) in their respective examples: barbell curls immediately followed by close grip pull-ups, and triceps extensions immediately followed by a dip exercise.

Gentil et al. (2007) and Brennecke et al. (2009) considered the acute effects of performing an isolation exercise for the pectorals prior to completion of a compound chest exercise. Both studies reported significantly greater number of repetitions for the compound exercise when not preceded by the isolation exercise. In addition, both studies also reported significantly higher activation of triceps muscles during the compound exercise when preceded by the isolation exercise. This suggests chest press performance required greater triceps contribution when the pectorals were pre-exhausted, but not that the pectorals themselves were any more activated. Gentil et al. (2007) also stated that the exercises were performed in sequence with an interval of less than 20 s, whilst Brennecke et al. (2009) state that the "mean time for exercise exchange" was 11.29 (±0.67) s. However, as clarified by Jones (1970) and Carpinelli (2010), the aim should be to move from the isolation exercise to the compound exercise as quickly as possible. Jones used the term "INSTANTLY" in uppercase to emphasise this point and noted separately times of 2–3 s between exercises. As such, the time between exercises was likely too large to truly test the PreEx method as originally proposed. It should be noted, however, that without the use of specialised equipment[2] designed for this purpose it is logistically difficult, if not impossible, to safely move from 1 exercise to another. As such the recommendation of ≤2–3 s seems impractical to recommend or test. Thus a further amendment to our understanding of PreEx might also be to accommodate as little rest as possible.

PreEx training is often recommended for advanced trainees to break plateaus (Darden 2004; Baechle and Earle 2008) and as such, since our literature search produced no chronic studies considering PreEx training, it is important that the efficacy of this method be examined. Thus the aim of the present study was to determine the effects of a 12-week PreEx training intervention upon muscular strength and body composition, comparing chronic adaptations between 3 groups: a PreEx group, a group performing the same exercises in the same order with moderate rest intervals between exercises, and a group performing the same exercises in a different order. This allows consideration of whether PreEx training enhances muscular performance beyond that of more conventional exercise routines.

## Materials and methods

### Study design

A randomised controlled trial design was adopted, with 3 experimental groups included. We examined the effects of 3 RT interventions in trained participants on strength and body composition. The study design was approved by the relevant ethics committee at the first author's institution.

### Participants

Participants were required to have had at least 6 months' RT experience and no medical condition for which RT is contraindicated to participate. Power analysis of research using low volume RT in trained participants (Fisher et al. 2013*b*) was conducted to determine participant numbers (*n*) using an effect size (ES), calculated using Cohen's *d* (Cohen 1992) of 1.02 for improvements in strength. Participant numbers were calculated using equations from Whitley and Ball (2002), which revealed that each group required 15 participants to meet required power of 0.8 at an $\alpha$ value of $p \leq 0.05$. Written informed consent was obtained from all participants prior to any participation.

Seventy-one persons from the present membership pool in a fitness facility in the United States (Discover Strength, Plymouth, Minn., USA) attended an initial briefing and eligibility assessment regarding the research following advertisement. Forty-one asymptomatic participants (male = 11, female = 30) were recruited. Figure 1 shows a CONSORT diagram highlighting the participant numbers for enrolment, allocation, follow-up, and analysis stages for the study. Participants were randomised using a computer randomisation programme to 1 of 3 groups; PreEx without rest between isolated and compound exercises (PE; $n$ = 14), PreEx with rest between isolated and compound exercise (PER; $n$ = 17) and a control group who performed the same exercises in a different order (CON; $n$ = 8). Participants were asked to refrain from any exercise away from the supervised sessions.

### Equipment

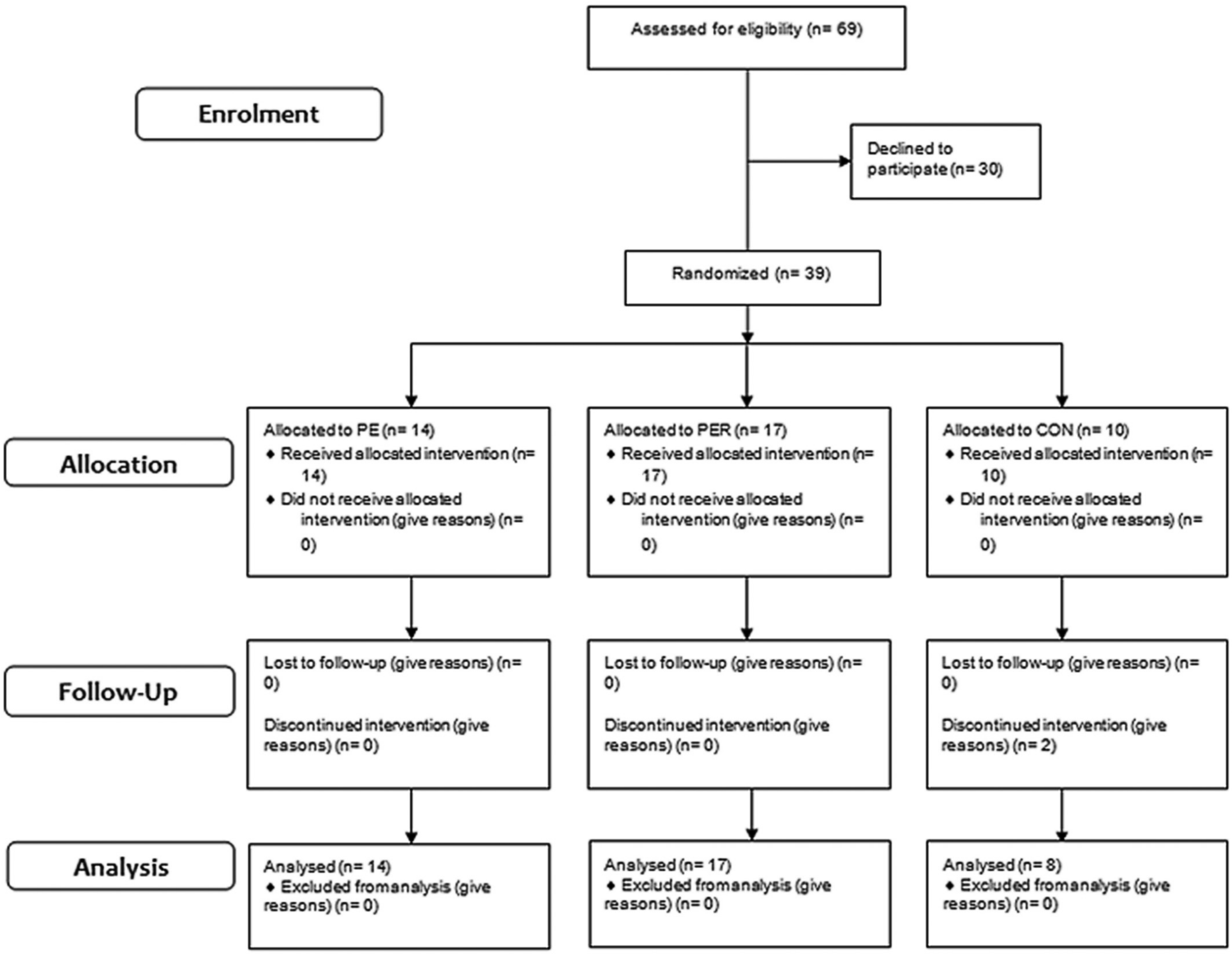
Strength was measured using chest press, leg press (MedX, Ocala, Fla., USA), and pull-down (Hammer Strength wide pull-down, Rosemont, Ill., USA) resistance machines. These were also used for the RT interventions in addition to pectoral fly (pec-fly) (Nautilus Nitro Plus, Vancouver, Wash., USA), leg extension (MedX, USA), pull-over (Nautilus 2ST, USA), abdominal flexion (MedX Core Ab Isolator, USA), and lumbar extension (MedX Core Lumbar Strength, USA) resistance machines. Procedures for strength testing are discussed below. Body composition was estimated using air displacement plethysmography (Bod Pod GS, Cosmed, USA).

### Testing procedures

Pre- and poststrength testing was performed in the following order with 120 s of rest between exercises: chest press, leg press, pull down. As participants were existing members of the facility where testing and training took place, all participants used their pre-existing training load for testing. It was estimated that this load would allow performance of 8 to 12 repetitions at the 2-s concentric, 4-s eccentric (2:4) repetition duration used for testing and training. Pre- and post-testing utilised the same absolute load allowing total volume (e.g., load × repetitions) to be calculated as has been completed in previous research (DeSouza et al. 2010). This method allows comparison of overall work output and is considered a representative method because of the direct relationship between muscular strength and the number of repeti-

[2]Nautilus (USA) previously manufactured *compound* and *double* machines to serve this exact purpose, accommodating both an isolation and compound exercise in a resistance machine. This might realistically be the only way to perform PreEx within the originally recommended time.

**Fig. 1.** CONSORT diagram. CON, control.




tions possible at a submaximal load (Carpinelli 2011). This also removes the need for potentially dangerous 1-repetition maximum testing, and provides greater ecological validity to realistic training conditions as most persons rarely test or use their maximal strength. The exercise was ceased when the participant failed during the concentric phase of a repetition or could not maintain the required repetition duration. Post-testing was performed at least 48 h following the final training session as per previous research (Fisher et al. 2014). The instructor performing the pre- and post-testing was blinded to group assignment. Details of the test procedures for estimation of body composition using air displacement plethysmography with the Bod Pod have been previously described in detail elsewhere (Dempster and Atkins 1995). Briefly, whilst wearing minimal clothing (swimsuit or tight fitting underwear) and a swim cap, participants were weighed using a calibrated digital scale. The participant was then seated in the Bod Pod for body volume measurement. From the body mass and body volume measurements, and predicted thoracic lung volumes, body density was estimated by the Bod Pod software and lean and fat mass estimations were calculated using the Siri equation.

**Training intervention (PE, PER, CON)**

Training was performed 2 times per week (with at least 48 h between sessions) for 12 weeks. Each exercise was performed for 1 set[3] per training session at a 2:4 repetition duration until MMF (i.e., when they reached a point of concentric failure during a repetition). Once participants were able to perform more than 12 repetitions before achieving MMF, load was increased by ~5%. This is in accordance with previous recommendations and research (e.g., Ratamess et al. 2009; and Fisher et al. 2013*b*, respectively). The PE group performed isolation exercises followed by compound exercises with as little rest as logistically possible (assessed prior to the study to be ≤5 s between exercises based upon their placement in the facility). In order, the exercises were pec-fly followed by chest press, leg extension followed by leg press, and pull-over followed by pull-down. These were followed by abdominal flexion and lumbar extension exercises. The PE group rested 120 s between finishing each compound exercise and beginning the next isolation exercise (i.e., between chest press and leg extension, and between leg press and pull-over). They then rested 60 s between pull-down, abdominal flexion, and lumbar extension ex-

[3]Whilst the authors accept that volume remains a contentious issue, previous research has reported considerable strength improvements in single-set RT with trained participants (e.g. Fisher et al. 2013*b*) and it unquestionably represents the most time-efficient approach.



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ercises. The PER group performed the same exercises in the same order but rested 60 s between each exercise, removing the PreEx method whilst maintaining the same overall rest duration and exercise order. The CON group performed the same exercises in the following order, prioritising compound exercises: chest press, leg press, pull-down, pec-fly, leg extension, pull-over, abdominal flexion, and lumbar extension. They rested 60 s between each exercise. This approach retained parity between exercise completion and rest per workout. It also replicated the ideas of Jones (1970) and Darden (1983) with their brief (~23 min including rest intervals), high intensity of effort (performed to MMF), full-body workouts.

### Data analysis

Data were available from 39 participants (PE, $n = 14$; PER, $n = 17$; CON, $n = 8$). Data met assumptions of normality when examined using a Kolmogorov–Smirnov test. Baseline data were compared between groups using a one-way ANOVA to determine whether randomisation had succeeded. Between groups comparisons were performed using ANOVA, examining absolute changes in strength and body composition outcomes. Where baseline data differed significantly between groups, analysis of covariance (ANCOVA) was performed for that outcome with it input as a covariate. Significant between-group effects were examined further with post hoc Tukey testing to determine the location of significant differences. Statistical analysis was performed using IBM SPSS Statistics for Windows (version 20; IBM Corp., Armonk, N.Y., USA) and $p \leq 0.05$ set as the limit for statistical significance. Further, 95% confidence intervals (CIs) were calculated in addition to ES using Cohen's *d* (Cohen 1992) for each outcome. This allowed comparison of the magnitude of effects between groups where an ES of 0.20–0.49 was considered as small, 0.50–0.79 as moderate, and ≥0.80 as large. Because of the considerable discrepancy in gender ratio between groups in this study, the above analyses were also conducted with the males excluded. It is noted in the Results section where these results differed from the combined sex findings. The researcher who performed the data analyses was blinded to group assignment.

## Results

### Participants

Participant baseline demographics are shown in Table 1. Demographic variables did not differ between groups at baseline.

### Strength

ANOVA did not reveal any significant between group effects for baseline strength data for any exercise. Figure 2 shows mean change in strength plus 95% CIs for each group and exercise. ANOVA did not reveal any significant between-group effects for change in strength for any of the tested exercises (all $p > 0.05$). Results for ANOVA did not differ when females were examined separately. ESs for strength changes were considered large and for the PE, PER, and CON groups, respectively, were 1.32, 1.67, and 1.25 for chest press; 1.15, 1.36, and 1.89 for leg press; and 1.82, 1.49, and 1.54 for pull-down.

### Body composition

Table 2 shows mean changes and ESs for body composition outcomes. ANOVA revealed a significant between group effect at baseline for body fat percentage ($F_{[2,36]} = 4.432$, $p = 0.019$). Multiple comparisons using post hoc Tukey revealed a significant difference between PE and CON groups ($p = 0.018$). No other outcomes differed at baseline. ANCOVA did not reveal any significant between-group effects for change in any body composition outcome examined. Examination of body fat change when body fat was used as a covariate also did not reveal any between group effects. Results for ANOVA did not differ when females were examined separately.

**Table 1.** Participant baseline demographics.

| | PE | PER | CON | *p* |
|---|---|---|---|---|
| Age (y) | 49±6 | 47±12 | 47±13 | NS |
| Stature (cm) | 167.37±9.67 | 168.52±4.57 | 169.04±8.15 | NS |
| Body mass (kg) | 72.27±17.13 | 69.86±16.47 | 68.78±16.61 | NS |
| BMI | 25.7±5.3 | 24.4±4.8 | 23.9±3.9 | NS |
| Sex ratio (male:female) | 2:12 | 4:13 | 3:5 | NA |

**Note:** Results are means ± SD; BMI, body mass index; CON, control; NA, not applicable; NS, nonsignificant (analysed using ANOVA); PE, pre-exhaustion training; PER, rest interval between exercises.

## Discussion

This study examined the effects of PreEx training and also exercise order within 3 rest-equated RT programs in trained participants. Results indicated that neither PreEx or exercise order affected strength gains in a single-set, full-body RT intervention where exercises were performed to MMF. Neither pre-exhausting a target muscle through use of PreEx nor prioritisation of exercises used for testing offered any greater strength improvements in any of the exercises tested. Magnitude of strength gains for all groups and all exercises were considered large and significant from examination of ESs and 95% CIs.

Training to a point of MMF during an exercise has been argued to be the primary stimulus for strength gains irrespective of other variables such as set volume and load (Fisher et al. 2011). It is proposed that RT performed to a sufficiently high intensity of effort, such as MMF, maximally recruits available motor units facilitating adaptations (Carpinelli 2008; Fisher et al. 2011). However, is has previously been suggested that during compound exercises certain muscles may be considered to be weak-links, which reach MMF prior to other muscles. As such this might cause cessation of the exercise before maximal motor unit recruitment has been achieved for all involved muscles (Jones 1970). Thus, it has previously been hypothesised that use of PreEx, as described herein, might allow greater motor unit recruitment to facilitate adaptations.

Prior to the present study, no others had examined the use of PreEx as a training intervention and had only examined acute responses. However, acute electromyography (EMG) studies (Augustsson et al. 2003; Gentil et al. 2007; Brennecke et al. 2009) combined with our results suggest the above reasoning regarding application of PreEx may be faulty.

Gentil et al. (2007) and Brennecke et al. (2009) suggested that the proposed weak-link in the bench press, the triceps, was more active after pre-exhaustion of the pectorals using an isolation exercise (pec-deck/chest-fly). However, they reported no difference in pectoral activation over and above performing the bench press without the use of PreEx. Thus it seems this compound exercise already provided maximal pectoral recruitment and potentially greatest potential for adaptation similar to that of prioritising the bench press or performing it independently. In support, we reported no significant differences in strength gains for the chest press exercise between PreEx, PreEx with rest, and prioritisation conditions. This may be due to the fact that the muscles utilised within upper-body pressing movements, such as bench press and chest press, are already maximally active for that movement.

Muscular recruitment during compound exercises is likely a dynamic process and the proposal of weak-links in such exercises is premature in the absence of studies examining them. For example, during compound trunk extension the lumbar extensor musculature might be the weaker muscles compared with the larger hip extensors in terms of force production. However, there is evidence to suggest they do not in fact limit performance of such exercise and may de-recruit after a certain degree of fatigue is achieved (Steele et al. 2013). Whilst this might appear counterintuitive, it highlights the complex nature of attempting to determine weak-links for use of PreEx training. Normalised EMG data

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**Fig. 2.** Mean strength changes and 95% confidence intervals for each group and exercise. CON, control; PE, pre-exhaustion training; PER, rest interval between exercises.

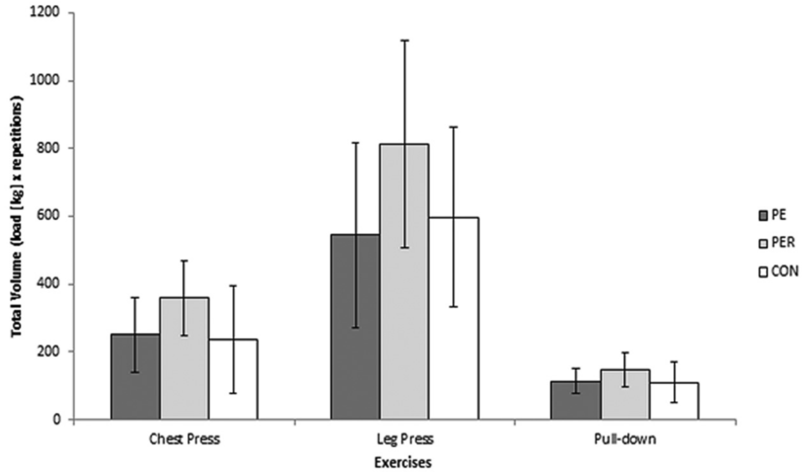


**Table 2.** Mean changes and effect sizes (ESs) for body composition outcomes.

| | PE | | | PER | | | CON | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Outcome | Change | 95% CI | ES | Change | 95% CI | ES | Change | 95% CI | ES | $p$ |
| Body mass (kg) | 0.09±0.90 | −0.43 to 0.62 | 0.10 | −0.36±1.16 | −0.96 to 0.23 | −0.31 | −0.60±1.74 | −2.06 to 0.85 | −0.35 | 0.388 |
| Body fat (%) | −0.2±1.45 | −1.04 to 0.64 | −0.14 | −0.78±1.65 | −1.63 to 0.07 | −0.47 | 0.01±2.30 | −1.91 to 1.93 | 0.01 | 0.487 |
| Lean mass (kg) | 0.41±1.08 | −0.21 to 1.03 | 0.38 | −0.34±3.37 | −2.08 to 1.39 | −0.10 | −0.40±0.60 | −0.91 to 0.10 | −0.67 | 0.620 |

**Note:** Results are means ± SD; ES was calculated using Cohen's *d*; Cohen 1992; *p* values for between group effects using ANCOVA. CI, confidence interval.

from Brennecke et al. (2009) in fact suggest that there is a similar degree of activation for pectorals, anterior deltoids, and triceps for compound upper-body pushing exercises, making determination of a weak-link difficult. Plus, assuming maximal motor unit activation is a primary driver of adaptations, the use of PreEx to target a specific muscle prior to such exercise would seem unnecessary. Indeed our results evidence this to be the case. In addition, Gentil et al. (2013) have demonstrated that gains in strength and hypertrophy for the elbow flexors and extensors are similar when performing compound upper-body exercises (bench press, pull-down) with or without single-joint exercises (elbow flexion, elbow extension). Thus it seems that for upper-body compound exercises, the majority of involved musculature may be maximally stimulated.

Whether the above reasoning is true of other compound exercises is difficult to say because of lack of evidence. The lumbar extensors appear an under-stimulated muscle group within trunk extension based exercise as evidence by their lack of adaptation from deadlift training (Fisher et al. 2013*b*). However, the inclusion of isolated lumbar extension exercise training does contribute to greater deadlift performance (Fisher et al. 2013*b*). For lower body compound pressing exercise, however, a similar situation appears to present with upper-body exercises. Using PreEx for the quadriceps through knee extension exercise prior to leg press produces similar activity in both the rectus femoris and vastus lateralis (though reported significantly different it was within EMG measurement error) and the gluteus maximus (Augustsson et al. 2003). In fact, gluteus maximus activity was similar to that of the rectus femoris, again highlighting difficulty in determining a weak-link and thus a suitable target muscle for use of PreEx. Again, we found no significant differences in strength gains for the leg-press exercise between PreEx, PreEx with rest, and prioritisation conditions.

Our results seem to suggest that for trained participants, performance of single set per exercise RT to MMF produces considerable strength gains independently of exercise order, rest intervals, or indeed application of PreEx. Previous publications have specifically suggested that exercise order is important in chronic adaptations. For example, Miranda et al. (2010) and Simão et al. (2012) reported a greater number of repetitions for exercises when performed at the beginning of a workout compared with at the end. From this they suggested that this greater volume with a given load might catalyse larger gains in strength. However, these were both acute studies, and whilst making recommendations towards chronic training intervention strategies they lack evidence to support these claims. In fact Carpinelli (2010, 2013) published extensive reviews of PreEx and exercise order, reporting that there is little evidence to support these recommendations.

The strength gains reported in this study were considered large and were similar to other studies of low-volume RT performed to MMF in trained participants (Fisher et al. 2013*b*). Body composition changes in this study, however, were minimal and likely within the measurement error (Fields et al. 2001; Collins et al. 2004). It may be that changes in body composition were not detected for this population of trained participants because of lack of control over dietary intake. However, though participants were not instructed to maintain or change their current diet we did not record this and so it is possible it may have changed spontaneously as a result of participation in the intervention. Indeed, it has been reported that active females participating in higher intensity of effort exercise may spontaneously increase energy intake (Pomerleau et al. 2004). We might also consider that as trained participants they are unlikely to have been performing an identical workout of 2 times per week for 12 weeks, without variation, prior to this programme. As such trained participants performing alternative exercises might have previously induced hypertrophic response in muscles, which did not receive sufficient stimulus from the present intervention. Marginal atrophy of these untrained muscles might equate to the degree of hypertrophy in the trained muscles thus presenting no change in body composition. This, in turn, might present evidence for regular modification of RT programmes.

The present study was conducted in trained participants and thus adds to the relatively sparse data existing on this population. However, whilst combined sex and female-only results did not differ, the small number of males in this study means it is imprudent to extrapolate these results to wider male populations.

## Conclusion

These results suggest that considerable improvements in strength are possible in trained participants when performing single set per exercise full-body RT to MMF. Further they also suggest that strength gains are not influenced by the use of PreEx, exercise order, or between-exercise rest intervals. We should acknowledge that the American College of Sports Medicine (Ratamess et al. 2009) has previously recommended larger volumes of exercise, heavier loads (and accordingly lower repetition ranges), and large inter-set/inter-exercise rest intervals for trained participants. However, the present data suggests that strength increases are possible in a far more time-efficient manner, and support alternative recommendations that have advocated a lower volume of exercise when training to MMF (Fisher et al. 2011). Studies on PreEx to date have been acute and utilised applications of this method differing from the original hypothesis. Whilst this study also differed in application from the original PreEx hypothesis, we utilised a more practical application of PreEx. In addition, this is the first chronic study to our knowledge that examined this method. However, based upon these results there appears no benefit to performing PreEx RT over and above simply performing individual exercises to MMF in a preferred order and with preferred rest between exercises.

### Conflict of interest statement

There are no conflicts of interest to declare.

## Acknowledgements

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