Effects of Different Strength Training Frequencies During Reduced Training Period on Strength and Muscle Cross-Sectional Area

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Introduction

This study investigates how much resistance training frequency is necessary to maintain muscle size and strength.

Conclusions

Muscle size and strength increases with resistance training 2-3 times week, for 3-4 sets, between 6-12 repetitions.

Muscle size and strength decreases with no training stimulus (ceasing training).

Muscle size and strength is maintained at half original volume to gain muscle size and strength, as well as training only once a week.

Amendments

Study Design & Additional Information

33 untrained men were split into three groups. All groups started out with an 8 week, supervised training program with the aim to increase muscular strength and muscle size. Muscle size and strength was assessed at the beginning of the study (pre-training) and then again at the 8 week mark (post-training). Two groups continued training for another 8 weeks (for a total of 16 weeks). RST1: This group continued training at half the volume (total weight lifted) once a week for the following 8 weeks; RST2: This groups continued training at half the volume, but twice a week (still same volume as RST1) for the following 8 weeks; CT: This group ceased all training after the initial 8 weeks. Muscle size and strength was re-evaluated a third time after the full 16 weeks had passed. Strength testing was done via half squat on a smith machine and muscle size was determined by dual absorbance

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ORIGINAL ARTICLE

Effects of different strength training frequencies during reduced training period on strength and muscle cross-sectional area

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Abstract
This study investigated the effects of different reduced strength training (RST) frequencies on half-squat 1 RM and quadriceps cross-sectional area (QCSA). Thirty-three untrained males (24.7 ± 3.9 years; 1.73 ± 0.08 m; 74.6 ± 8.4 kg) underwent a 16-week experimental period (i.e. eight weeks of strength training [ST] followed by additional eight weeks of RST). During the ST period, the participants performed 3–4 sets of 6–12 RM, three sessions/week in half-squat and knee extension exercises. Following ST, the participants were randomly allocated to one of three groups: reduced strength training with one (RST1) or two sessions per week (RST2), and ceased training (CT). Both RST1 and RST2 groups had their training frequency and total training volume-load (i.e. RST1 = 50.3% and RST2 = 57.1%) reduced, while the CT group stopped training completely. Half-squat 1 RM (RST1 = 27.9%; RST2 = 26.7%; and CT = 28.4%) and QCSA (RST1 = 6.1%; RST2 = 6.9%; and CT = 5.8%) increased significantly ($p < .05$) in all groups after eight weeks of ST. No significant changes were observed in 1 RM and QCSA for RST1 and RST2 groups after the RST period, while the CT group demonstrated a decrease in half-squat 1 RM (22.6%) and QCSA (5.4%) when compared to the ST period ($p < .05$). In conclusion, different RST frequencies applied were able to maintain muscle mass and strength performance obtained over the regular ST period. Thus, it appears that RST frequency does not affect the maintenance of muscle mass and strength in untrained males, as long as volume-load is equated between frequencies.

Keywords: Ceased training, hypertrophy, reduced volume-load, volume-matched

Highlights
- It appears that one session per week is enough to maintain previous strength training induced adaptations.
- Strength training volume but not frequency is more important to maintain previous training induced adaptations.

Introduction

Strength training (ST) programmes incorporate different loading schemes in order to optimize ST-induced adaptations, such as increased muscle cross-sectional area (CSA) and maximum strength (de Souza, Ugrinowitsch et al., 2014; Fleck, 1994; Fonseca et al., 2014; Wernbom, Augustsson, & Thomee, 2007). In this context, volume, intensity and frequency are important variables of ST and they can be manipulated to enhance or maintain training-induced adaptations (Bickel, Cross, & Bamman, 2011; Izquierdo et al., 2007; Ronnestad, Hansen, & Raastad, 2010; Schoenfeld et al., 2014; Trappe, Williamson, & Godard, 2002). In addition, ST programmes might encompass periods of reduced training load due to competitions or changes in individuals' daily routine. Usually, reduced strength training (RST) is a strategy in

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which both training volume-load and frequency are decreased but intensity is maintained. Thus, different RST schemes may be organized as an attempt to avoid detraining effects (e.g. muscle atrophy and strength losses) and to maintain previously acquired training adaptations (Bosquet et al., 2013; Fleck, 1994; Graves et al., 1988; Harris, DeBeliso, Adams, Irmischer, & Spitzer Gibson, 2007; Mujika & Padilla, 2000; Ogasawara, Yasuda, Sakamaki, Ozaki, & Abe, 2011).

In order to avoid detraining effects and maintain training adaptations, several studies that have investigated RST used a low training frequency (e.g. once or twice a week) associated with a reduction of ~30–60% in training volume-load (Bickel et al., 2011; Izquierdo et al., 2007; Trappe et al., 2002). For example, Bickel et al. (2011) conducted a study in which training volume was reduced by 30% for 32 weeks following a 16-week ST programme. They observed that strength performance and the quadriceps cross-sectional area (QCSA) were preserved in the RST group, whereas the muscle adaptations in the detraining group were reversed to the initial status. In another study, Izquierdo et al. (2007) examined physically active men for four weeks of RST (two sessions/week) with a reduction of ~50% in training volume-load following 16 weeks of regular ST. Curiously, they observed a significant increase in half-squat 1 RM performance after the RST period while the detraining group lost their adaptations and returned to the pre-training levels. Although different RST schemes have demonstrated efficacy in preserving muscular adaptations, no study has examined the effects of RST on muscle strength and CSA when reduced training volume-load is performed at different training frequencies (i.e. one or two sessions/week). This concept is supported by data showing that regular ST programmes induce similar adaptations on strength and muscle mass with different training frequencies, as long as volume-load is matched over the training period (Arazi & Asadi, 2011; Candow & Burke, 2007; Gentil, Fischer, Martorelli, Lima, & Bottaro, 2015; McLester, Bishop, & Guilliams, 2000).

In light of these observations, it is necessary to understand how different RST schemes affect previously acquired ST-induced adaptations. Therefore, the purpose of this study was to compare the effects of RST schemes with different frequencies and volume-load matched on maximum strength performance and muscle CSA in untrained males. We hypothesized that RST schemes with one or two sessions per week but with total volume matched would not affect differently maximum strength and muscle CSA maintenance in untrained individuals following a regular ST period whereas the ceased training (CT) group will demonstrate significant losses in strength and CSA.

Methods

Experimental procedures

We used a between-subject design in which, initially, all participants performed a standardized ST programme aiming to increase maximum strength and muscle CSA. They performed half-squats and knee extension exercises, three sessions/week for eight weeks. Following the ST programme, an additional eight weeks of RST was conducted, with all participants being randomly allocated into three groups: reduced strength training performed once (RST1) or twice (RST2) a week, and CT. In both RST1 and RST2 groups, the training volume-load was reduced by ~50% from the previous ST programme. The subjects in the CT group stopped training during the RST period. QCSA and half-squat maximum dynamic strength (1 RM) were assessed at baseline, after eight weeks (end of the ST programme) and following 16 weeks (end of the RST period) for all groups.

Participants

Thirty-three untrained males volunteered to participate in the present study. The participants were not engaged in any regular strength or endurance training for at least six months prior to the commencement of the study. They were free from neuromuscular disorders that could affect their ability to complete the training programme. Participants were instructed to refrain from performing additional exercises during the experimental period and they were also instructed to maintain their normal diet, as well as to abstain taking nutritional supplements throughout the study. After the standardized ST period, participants were classified into quartiles according to their QCSA and half-squat 1 RM. Participants from each quartile were then randomly assigned to the experimental groups (RST1: $n = 11$, 22.7 ± 3.7 years; 1.73 ± 0.05 m; 77.1 ± 11.9 kg. RST2: $n = 11$, 23.1 ± 2.8 years; 1.73 ± 0.06 m; 71.9 ± 6.2 kg. CT: $n = 11$, 24.5 ± 4.9 years; 1.73 ± 0.07 m; 75.4 ± 10.2 kg). This study was approved by the local Ethics Committee and all subjects were informed of the inherent risks and benefits prior to signing an informed consent form.

Familiarization sessions

All participants completed three familiarization sessions. During the sessions, participants performed a standardized general warm-up consisting of five minutes of running at 9 km h^{-1} on a treadmill (Movement Technology®, Brudden, Sao Paulo, Brazil) followed by three minutes of whole-body light dynamic stretching exercises. Thereafter, participants were familiarized with the half-squat exercise and 1 RM test. For the 1 RM test, measuring tapes were fixed on the Smith machine bar and on the ground to standardize subject's body position and feet placement; respectively, over testing days. In addition, a wooden seat with adjustable heights was placed behind the subject to keep the bar displacement and knee angle (~90°) constant on each half-squat attempt. All participants' positioning was recorded during the familiarization sessions and reproduced throughout the experimental period. The exercise started at complete knee extension, subjects lowered the bar until they touched the wooden seat and then returned to the initial position.

Maximum dynamic strength test (1 RM)

The procedures for maximum dynamic strength test followed the recommendations by Brown and Weir (2001). In short, after a standardized general warm-up (e.g. five minutes on treadmill at 9 km h^{-1}) plus three minutes of whole-body light dynamic stretching exercises, the participants performed a specific warm-up composed of two sets of the half-squat exercise. In the first set, they performed eight repetitions at 50% of the estimated 1 RM followed by another set of three repetitions at 70% of the estimated 1 RM in the familiarization sessions. A three minutes rest interval was granted between sets. Then, the subject had up to five attempts to achieve the 1 RM load (i.e. maximum weight that could be lifted once with a proper technique), with a three-minute rest interval between attempts. Body, feet position and bar displacement were controlled in each attempt similar to the procedures adopted during the familiarization sessions. Strong verbal encouragement was given throughout the test. CV between maximum strength familiarization and testing sessions was less than 2.8%. All testing sessions were performed at the same time of day (2– 4 p.m.).

Quadriceps muscle cross-sectional area

QCSA was measured through magnetic resonance imaging (Signa LX 9.1, GE Healthcare, Milwaukee, WI, USA). Participants were instructed to lay in a supine position with the knees extended. Velcro straps were used to restrain leg movements during image acquisition. All images were captured from both legs. An initial image was captured to determine the perpendicular distance from the greater trochanter to the inferior border of the lateral epicondyle of the femur, which was defined as thigh length. QCSA images were acquired at 50% of the segment length with 0.8 cm slices for 3 s. The pulse sequence was performed with a view field between 400 and 420 mm, time repetition of 350 ms, eco time from 9 to 11 ms, two signal acquisitions and matrix of reconstruction of 256 × 256. The images were transferred to a workstation (Advantage Workstation 4.3, GE Healthcare, Milwaukee, WI, USA) to determine QCSA. In short, the segment slice was divided into the following components: skeletal muscle, subcutaneous fat tissue, bone and residual tissue. QCSA was determined by subtracting the bone and subcutaneous fat area and assessed in duplicated by a blinded researcher. CV between measurements was less than 1.0%.

Training programme

The standardized ST programme consisted of a lower body hypertrophy-oriented protocol. The half-squat was performed on a conventional Smith machine (Cybex®, Medway, MA, USA) and knee extension was performed on a pin-load weight machine (Cybex®, Medway, MA, USA). Both exercises were performed until muscular failure with constant speed. Each repetition was performed with a two-second eccentric phase and a two-second concentric phase with a 90° range of motion at the knee joint. All subjects underwent an 8-week ST programme (e.g. two sessions/week for the first four weeks followed by three sessions/week in the last four weeks). The ST programme consisted of 3–4 sets of 6–12 maximal repetitions (RM) per exercise (Table I). During the RST period, RST1 and RST2 groups performed one and two sessions/week, respectively, with the intensity ranging from 6 to 8 RM. RST1 performed four sets on each exercise (i.e. half-squat and knee extension) and RST2 performed two sets on each exercise (Table II). The participants from the CT group did not perform any ST during the RST period. The training volume-load (sets × repetitions × mass lifted [kg]) was equalized between RST1 and RST2 groups. In addition, all training sessions were supervised by an experienced researcher and training compliance was 100% by all participants (i.e. ST + RST1 = 28 sessions, ST + RST2 = 36 sessions and ST + CT = 20 sessions). All training sessions were performed at the same time of day (2–4 p.m.).

Statistical analysis

Results are expressed as mean ± standard variation (SD). Data normality and variance equality were

Table I. Standardized ST programme

Week	1	2	3	4	5	6	7	8
Variables								
RM	10–12	10–12	8–10	8–10	8–10	6–8	6–8	6–8
Sets	3	3	3	3	3	4	4	4
Training sessions/week	2	2	2	2	3	3	3	3

Notes: RM, repetitions maximum; training sessions/week, frequency of training sessions per week during the experimental period.

Table 1

This table simply shows the volume/work and number of training sessions that was used for all three groups for the 8 weeks of initial training (see study design section for more information).

Primary Results

- All groups trained 2-3 times a week, 3-4 sets, between 6-12 repetitions.

assessed through the Shapiro Wilk and Levene tests. A 2×3 mixed model with repeated measures was performed for each dependent variable, assuming group (RST1, RST2 and CT) and time (pre-test, post-RST and post-RST) as fixed factors, and participants as a random factor. Whenever a significant F-value was obtained, a *post hoc* test with Tukey's adjustment was performed for multiple comparison purposes. The significant level was set at $p < .05$ and all analyses were performed using statistical software package SAS 9.2 for Windows (SAS Institute Inc., Cary, NC). In addition, we presented the mean value and confidence intervals of the within-group absolute difference (CIdiff). Positive and negative confidence intervals that did not cross zero were considered significant. Finally, within-group effect sizes (ES) (pre- to post-changes) were calculated using Cohen's d (Cohen, 1988). An initial analysis revealed no significant difference between groups in the baseline values for all of the dependent variables ($p \geq .135$).

Results

Training volume-load

Training volume-load was progressively increased in all groups in the first eight weeks of standardized ST (Figure 1). Training volume was similar among groups: RST1 = 129,610.0 ± 15,369.8 kg; RST2 = 129,220.7 ± 12,430.8 kg; CT = 131,129.6 ± 14,799.0 kg ($F = 2.6$, $p = 0.10$). During the RST period (9th–16th weeks), training volume was significantly reduced in both RST groups when compared to the standardized ST programme (RST1: 63,669.4 ± 8923 kg, −50.3%; and RST2: 55,275.3 ± 7118.2 kg, −57.1%, $F = 13.8$, $p = .001$) and in similar magnitude between groups ($F = 1.4$, $p = .21$) (Figure 1).

Cut volume (total work done) in half when entering the latter 8 weeks of training.

Maximum dynamic strength

Half-squat 1 RM values increased significantly in all groups post-ST period: RST1 = 27.9% (ES: 2.8, 95%CIdiff: mean 36.2 kg, 26.2–46.2 kg, $F = 18.5$, $p = .001$); RST2 = 26.7% (ES: 1.7, 95%CIdiff: mean 35.0 kg, 25.0–45.0 kg, $F = 16.9$, $p = .001$); and CT = 28.4% (ES: 1.7, 95%CIdiff: mean 36.8 kg, 26.8–46.8 kg, $F = 12.7$, $p = .001$). Post-RST, there was a significant decrease in half-squat 1 RM (−22.6%) only in the CT group (ES: −1.6, 95%CIdiff: mean −28.4 kg, −38.4 to −18.4 kg, $F = 14.8$, $p = .001$). The half-squat 1 RM in the CT group was significantly lower than RST1 (−22.7%) and RST2 (−22.5%) groups after the RST period ($F = 15.7$, $p = .001$). There were no significant changes in half-

Table II. RST programmes

RST programmes	Week	1	2	3	4	5	6	7	8
Groups	Variables								
RST1	Training sessions/week	1	1	1	1	1	1	1	1
	RM	6–8	6–8	6–8	6–8	6–8	6–8	6–8	6–8
	Sets	4	4	4	4	4	4	4	4
RST2	Training sessions/week	2	2	2	2	2	2	2	2
	RM	6–8	6–8	6–8	6–8	6–8	6–8	6–8	6–8
	Sets	2	2	2	2	2	2	2	2

Note: RST1, reduced strength training one session/week; RST2, reduced strength training two sessions/week; RM, repetitions maximum; training sessions/week, frequency of training sessions per week.

Table 2

The researchers are showing the amount of work/training being done for each of the two post-baseline continued training. RST1: Training once a week; RST2: Training twice a week.

Primary Results

- Training once a week for 8 weeks did 4 sets at 6-8 repetitions (RST1)
- Training twice a week for 8 weeks did 2 sets at 6-8 repetitions, per workout (RST2).

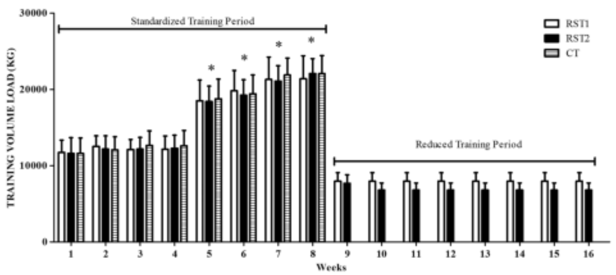

Figure 1. Training volume-load/week for the RST1, RST2, and CT groups. *Significantly greater than the RST period.

Figure 1

This graph shows the amount of total work performed (volume) per week, for each group. The initial 8 weeks, all three groups participated. In the next 8 weeks, only two groups participated, at different weekly frequencies (1 time a week - RST1, 2 times a week - RST2), while CT did not resistance train any longer (after the initial 8 weeks).

Primary Results

- All groups did the same amount of work in the initial 8 weeks of training.
- Volume decreased below baseline levels in the following 8 weeks.
- Both groups that continued training (RST1 and RST2) did the same amount of work, even with two different frequencies.

Take Away: Volume, amount of work, was equated across groups.

squat 1 RM in the RST1 (ES: −0.23, 95%CIdiff: mean 5.0 kg, −5.0 to 15.0 kg, $F = 1.42$, $p > .05$) and RST2 (ES: 0.41, CIdiff: mean 6.1 kg, −3.9 to 16.1 kg, $F = 1.42$, $p > .05$) groups post-RST period compared to post-ST period (Table III).

Quadriceps cross-sectional area

QCSA values increased significantly in all groups post-ST period: RST1 = 6.1% (ES: 0.5, 95%CIdiff: mean 591.6 mm^2, 322.1–861.2 mm^2, $F = 11.5$, $p = .001$), RST2 = 6.1% (ES: 0.61, 95%CIdiff: mean 512.5 mm^2, 243.0–782.1 mm^2, $F = 12.8$, $p = .001$) and CT 5.8% (ES: 0.6, 95%CIdiff: $F = 13.5$, $p = .001$). Following post-RST, there was a significant decrease in QCSA (−5.4%) only in the CT group (ES: −0.52, 95%CIdiff: mean −417.0 mm^2, −686.6 to −147.4 mm^2, $F = 15.9$, $p = .0001$). In addition, QCSA in the CT group was significantly smaller than RST1 (−4.8%) and RST2 (−4.7%) groups following the post-RST period ($F = 13.8$, $p = .001$). Also, QCSA in the RST1 (ES: −0.16, 95%CIdiff: mean −209.1 mm^2, −478.7–60.5 mm^2, $F = 1.35$, $p > .05$) and RST2 (ES: −0.13, 95%CIdiff: mean −120.1 mm^2, −389.7–149.5 mm^2, $F = 0.35$, $p > .05$) groups was unchanged post-RST period compared to the post-ST period (Table III).

Discussion

The purpose of this study was to compare the effects of two volume-matched RST schemes with different training frequencies on strength performance and muscle CSA in untrained individuals. Our results support the hypothesis that RST schemes performed either once or twice a week, with a reduction of ~50% of training volume-load were able to maintain previous ST-induced muscle adaptations. However, the cessation of training led to decreases in strength and muscle CSA.

It is well established in the literature that ST programmes carried out in different frequencies (e.g. one to three sessions/week) and different training volume-load (e.g. 50.000–150.000 kg) produce positive effects on strength performance and muscle CSA in trained (Schoenfeld et al., 2014; Schoenfeld, Ratamess, Peterson, Contreras, & Tiryaki-Sonmez, 2015; Simao et al., 2012; Sooneste, Tanimoto, Kakigi, Saga, & Katamoto, 2013) and untrained males (Ahtiainen, Pakarinen, Alen, Kraemer, & Hakkinen, 2003; Burd et al., 2010; McLester et al., 2000; Radaelli et al., 2015; de Souza et al., 2013; de Souza, Tricoli et al., 2014). In accordance with previous studies, our results showed significant increases in QCSA (5.8–6.9%) and half-squat 1 RM (26.7–28.4%) after eight weeks of a ST programme. Thus, our findings demonstrated that the standardized ST period produced positive changes on morphological and functional responses.

Conversely, the positive morphological and functional adaptations to ST are reversed in any population when training ceases (Bickel et al., 2011; Bosquet et al., 2013; Mujika & Padilla, 2001). Our findings are consistent with the previous research, which demonstrated that training cessation beyond four weeks results in a significant reduction in strength performance and muscle CSA (Bickel et al., 2011; Leger et al., 2006). For instance, the observed reductions in maximum strength (~22.6%) and muscle CSA (~5.4%) in our study were similar to those reported by Leger et al. (2006)

Table III. Half-squat maximum dynamic strength (1 RM kg, mean ± SD) and QCSA (mm^2, means ± SD) for RST1, RST2 and CT groups, pre-test, post-ST and post-RST interventions

	1 RM (kg)			QCSA (mm^2)		
	Pre-test	Post-ST	Post-RST	Pre-test	Post-ST	Post-RST
RST1	129.7 ± 17.4	165.9 ± 22.3*	170.9 ± 23.3*	8582.4 ± 968.6	9174.7 ± 969.6*	8965.0 ± 970.6*
RST2	130.8 ± 20.5	165.8 ± 14.6*	171.9 ± 15.4*	8344.3 ± 935.5	8856.8 ± 966.8*	8736.7 ± 931.0*
CT	129.7 ± 20.6	166.5 ± 17.1*	138.0 ± 25.0**,***	8371.1 ± 786.9	8863.5 ± 674.2*	8446.5 ± 907.1**,***

*Significantly higher than pre-test (p = .001).
**Significantly lower than RST1 and RST2 (p = .001).
***Significantly lower than post-ST (p = .001).

which showed significant decrements in strength performance and QCSA (20% and 5%, respectively) in young untrained males after eight weeks of training cessation. Also, in line with our findings but with a smaller reduction in strength performance, Bickel et al. (2011) found significant decreases in strength (8%) and QCSA (5%) in young physically active males following 32 weeks of training cessation. Collectively, the aforementioned results demonstrated that training-induced adaptations are transitory and may be reversed even in untrained individuals.

On the other hand, following the RST period (RST1 and RST2), QCSA and 1 RM gains were retained when compared to the values obtained at post-standardized ST. Total training volume-load from RST1 and RST2 groups was reduced by 50–57% when compared with the volume performed during the standardized ST protocol. Our findings are similar to other studies (Bickel et al., 2011; Izquierdo et al., 2007; Trappe et al., 2002). Bickel et al. (2011) also observed a maintenance of QCSA and 1 RM gains obtained after 32 weeks of RST with a reduction of ~30% in total volume-load used during a regular ST period. In contrast, a decrease in QCSA and 1 RM was observed in the group that CT after this period. In another study, Trappe et al. (2002) used a RST scheme during 12 weeks, once/week with a reduction of ~50% in total volume-load. The authors found maintenance in QCSA and leg extension exercise 1 RM after the RST period while a 5% reduction in QCSA and 11% in 1 RM were observed in the cessation training group. Our study along with Bickel et al. (2011) and Trappe et al. (2002) suggest that in order to maintain strength performance and muscle morphological gains following a standardized ST programme, training volume-load during RST schemes should reach a minimum threshold to preserve muscular adaptations regardless of training frequency.

In addition, studies which have applied short-term RST programmes (e.g. less or equal eight weeks) have reported similar results on strength performance compared to our findings (Coutts, Reaburn, Piva, & Murphy, 2007; Gibala, MacDougall, & Sale, 1994; Izquierdo et al., 2007). However, it should be mentioned that previous studies used RST as a tapering strategy and with different populations (e.g. highly trained athletes). For example, Izquierdo et al. (2007) observed significant improvements in half-squat 1 RM performance after four weeks of RST applied twice/week with a reduction of ~50% in total training volume-load following six weeks of standardized ST. In another study, Gibala et al. (1994) put trained athletes through 10 days of RST with two sessions/week and reduction of ~40% in total volume-load after three weeks of standardized ST and also observed maintenance of maximum isometric strength in the leg extension exercise. Similarly, Coutts et al. (2007) found the maintenance of half-squat 3 RM performance in rugby players with three sessions of RST with a reduction of ~55% in total training volume-load following six weeks of standardized ST. On the contrary, our study used RST schemes with equal duration to the standardized ST (i.e. eight weeks of ST and eight weeks of RST) and we observed similar maintenance in strength performance. Collectively, these findings indicate that the manipulation of total training volume-load might be more critical than training duration and frequency in order to preserve muscular adaptations during RST periods regardless of training status.

Finally, it is noteworthy to mention that our study has inherent limitations. A possible limitation was the lack of diet control. Previous studies have shown that supplementation or protein consumption potentiates muscle protein synthesis, hypertrophy and/or maintenance of ST-induced muscular adaptations following ST training cessation (Breen & Phillips, 2012; Phillips, 2016; Tipton & Phillips, 2013). However, other studies have shown no additional effect of protein supplementation associated to the ST regimen on muscle mass and strength, especially when the training period is less than 12 weeks (Boone, Stout, Beyer, Fukuda, & Hoffman, 2015;

Table 3

This shows the data on muscle strength (1RM) and muscle size (QCSA) in all three groups (CT: No training, RST1: Training once a week, RST2: Training twice a week). Pre-test: Prior to training for the initial 8 weeks; Post-ST: After training for the initial 8 weeks; Post-RST: After the full 16 weeks (8 weeks training + 8 weeks of training or detraining/no training).

Primary Results:
- Training for 8 weeks increased muscle size and strength.
- Ceasing training for 8 weeks reduces muscle size and strength.
- Training once or twice maintains muscle size and strength.

Take Away: Training increases muscle size and strength, and even with dramatically reduced volume (amount of work), training once a week maintains muscle size and strength, while ceasing training reduces muscle size.

Hulmi et al., 2015; Paoli et al., 2016). In addition, it should be mentioned that the effects of ST-induced muscle and strength adaptations may undergo the influence of several confounding factors (i.e. training duration, individual physiological responsiveness, training status). In our study, the participants were instructed to maintain their typical dietary habits throughout the experimental period. Thus, we acknowledge that lack of diet control might be a confounding factor.

In conclusion, our results demonstrated that different training frequencies during RST with total training volume-load matched were able to maintain the gains in QCSA and muscle strength obtained after an 8-week period of standardized ST. The findings of this present study suggest that a reduction of 50–60% in training volume-load, performed once a week, can retain the functional and morphological adaptations obtained following a regular ST programme in untrained males.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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