Comparison of Two Equated Resistance Training Weekly Volume Routines Using Different Frequencies on Body Composition and Performance in Trained Males

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Abstract

The present study compared the effects of two weekly-equalized volume and relative load interventions on body composition, strength and power. Based on individual baseline maximal strength values, eighteen recreationally trained men were pair-matched and consequently randomly assigned to one of the following experimental groups: a low volume per session with a high frequency (LV-HF, n = 9) group who trained 4-days (Mondays, Tuesdays, Thursdays and Fridays) or a high volume per session and low frequency (HV-LF, n = 9) group who trained 2-days (Mondays and Thursdays). Both groups performed two different routines over 6 weeks. Participants were tested pre- and post- intervention for maximal strength, upper body power, fat-free mass, limb circumferences and muscle thickness. Compared to baseline values, both groups increased their fat-free mass (HV-LF +1.19 ± 1.94; LV-HF +1.36 ± 1.06 kg, $p<0.05$) and vastus medialis thickness (HV-LF +2.18±1.88, $p<0.01$; LV-HF +1.82±2.43 mm, $p<0.05$), but only the HV-LF group enhanced arm circumference (1.08±1.47cm, $p<0.05$), elbow flexors thickness (2.21±2.81 mm, $P<0.01$) values and decreased their fat mass (-2.41 ± 1.10, $P<0.01$). Both groups improved ($p<0.01$) the maximal loads lifted in the bench press (LV-HF +0.14 ± 0.01; HV-LF +0.14 ± 0.01 $kg \cdot body\ mass^{-1}$) and the squat (LV-HF +0.14 ± 0.06; HV-LF 0.17 ± 0.01 $kg \cdot body\ mass^{-1}$) exercises as well as in upper body power (LV-HF +0.22 ± 0.25; HV-LF +0.27 ± 0.22 $watts \cdot body\ mass^{-1}$) Although both training strategies improved performance and lower body muscle mass, only the HV-LF protocol increased upper body hypertrophy and improved body composition.

Keywords: Strength, power, muscle thickness, hypertrophy, workout design

Introduction

Resistance training (RT) is recommended as one of the most effective methods to improve muscle mass, strength and power (Kraemer et al. 2002; Panton et al. 2000). An appropriate control of training variables, such as intensity, volume, and frequency is considered essential to optimize post-exercise muscular adaptations (Kraemer and Ratamess 2004). One of these essential variables, the frequency of training, refers to the number of sessions performed in a given period of time (Wernbom et al. 2007). With respect to inducing muscle hypertrophic effects, the frequency of training is often considered as the number of times a muscle group is trained and it is generally associated with a one-week training duration (Schoenfeld et al. 2015).

In their position statement, the American College of Sports Medicine (ACSM, 2009) recommends a RT frequency of 4 (intermediate training) to 6 days (advanced training) per week using upper/lower body split routines. However, individuals targeting muscular hypertrophy commonly train each muscle every 5 to 7 days using one to maximally three muscle groups per session. Compared to the ACSM (2009) recommendations, this results in a relative higher session training volume (Gentil et al. 2017; Kerksick et al. 2009; Ostrowski et al. 1997). The strategy is based on suggestions that a muscle which is subjected to a greater session training volume, is consequently also exposure to a higher level of intramuscular metabolic stress (Gotshalk et al. 1997; Schoenfeld 2010). To elicit an enhanced hypertrophic effect, this stress response in turn requires several days to recover (Ferreira et al. 2017; Schoenfeld et al. 2016). Along these lines, relevant research also indicates that multiple-set programs (i.e. a higher volume per training session) are generally associated with greater strength (Krieger 2009) and hypertrophy (Krieger 2010) gains in both, trained and untrained individuals. Moreover, recent data have shown that the training volume is a substantial contributor to muscle hypertrophic effects, which occurs independently of training load when the total volume per session is equated (Klemp et al. 2016). However, twice (Schoenfeld et al. 2016) or higher (Dankel et al., 2017) weekly training frequencies have recently been suggested to promote superior hypertrophic outcomes, considering a volume-equated program is performed. Nonetheless, it is important to highlight that even though increasing the number of weekly sessions may provide greater muscle growth, it may be difficult to increase the training frequency without an appropriate adjustment of training volume and length of training program (Dankel et al. 2017).

In novice individuals, similar outcomes were obtained from single and split body routines using a volume equalized weekly training (Arazi and Asadi 2011; Candow and Burke 2007; Gentil et al. 2015). In contrast, experienced weight lifters have demonstrated to obtain superior improvements in body composition and strength gains using multiple (i.e. 3 sessions) compared to a single weekly volume equated training session (McLester et al. 2000). It should be noted that the total weekly volume used by McLester and colleagues was lower (i.e. 3 sets per muscle group) than the typical routine employed in bodybuilding, which commonly involves between 6 to 12 sets per muscle group performed in a single session together with a greater than once a week training frequency (Schoenfeld et al. 2016).

The purpose of the present study, therefore was to compare the effects of two weekly-equalized volume and relative load interventions on body composition, strength and power gains using two different protocol designs whereby one group trained twice weekly (low frequency) with a high volume per session and a second group performed four weekly training sessions (high frequency) with a low session volume.

Methods

Experimental Design

The study utilized a two-parallel group randomized controlled trial design. Participants were randomly allocated into two intervention groups: 1) Low Training Volume and High Weekly Frequency group (LV-HF; n = 9) and 2) High Training Volume and Low Weekly Frequency group (HV-LF, n = 9). Before and after the intervention period, measurements of body composition, muscle thickness, strength and power performance were assessed. Both groups trained for a total 6 weeks, which were equated for total training weekly volume and relative load, whereby the only difference comprised the weekly training frequency (2 vs. 4) and the session volume (high vs. low).

Participants

Presented as mean (SD) the final group characteristics were as follows: LV-HF: age 21 (3.2) years, height: 180.40 (4.8) cm, and body mass: 76.63 (14.72) kg; 1 repetition maximum (1RM) squat: 103 (25.65) kg; 1RM bench press 77 (25.79) kg; RT experience 3.0 (0.5) years. HV-LF: age 28 (7.9) years, height: 178.6 (6.7) cm, and body mass: 79.38 (14.22) kg; 1RM squat: 115 (31.7) kg; 1RM bench press 71 (15.57) kg; RT experience 2.9 (0.4) years. No significant differences were observed between treatments at baseline.

To be eligible, participants had to be free of injury in the last three months prior to the intervention. They were furthermore required to train regularly between 2 to 3 times per week, using a whole-body routine including squat and bench press exercises for a minimum of two and a maximum of 5 years before the start of the present study. Only recreationally trained individuals with no regular participation in other sports, including bodybuilding, power or weight lifting were recruited. Additionally, only individuals not having ingested ergogenic aids or any type of nutritional supplements affecting muscular performance 12 weeks or longer prior to the start of the study were eligible. Participants were instructed not to change their nutritional habits, and if any relevant change had been detected (i.e. becoming a vegetarian, restricting calories, taking nutritional supplements, etc.) participants' data would have been excluded from the analysis. The University Research Ethics Committee approved the study (no. UREC/15/3/5/16). All procedures were in accordance with the Helsinki declaration. Prior to providing written informed consent, participants were fully informed of the nature and risks of the study.

Procedures

Familiarization period: Before the start of the intervention and over a one-week period, participants performed 3 sessions of familiarization where the correct execution of the main training exercises (e.g. bench press and squat) and testing procedures was explained, demonstrated and strictly controlled. After the familiarization but within a one-week period strength and body composition tests were performed. Thereafter, the participants were assigned to one of the two interventions by block randomization, using a block size of two.

Assessments: Participants refrained from heavy exercise in the 48 h prior to all pre- and post-intervention tests. Baseline and post intervention values of all relevant variables were tested within one day and in the following order 1) body composition 2) limb circumferences 3) muscular thickness measurements 4) 1RM bench press 5) 1RM parallel squat, 6) bench press power at 50% of the previously determined 1RM. Fifteen minutes of rest was allowed between the performance assessments.

Body Composition: Standard measurements were performed in accordance with the recommendations for anthropometric assessment (Ross and Marfell-Jones 1991). To eliminate inter-observer variability only one investigator consistently performed all measurements. Height was measured in a stretched stature to the nearest 0.01m using a wall mounted stadiometer (Seca GmbH, Hamburg, Germany) and body mass was weighted to the nearest 0.1 kg using a digital scale (Seca GmbH, Hamburg, Germany).

Fat mass and fat-free mass was estimated from the whole body densitometry using air displacement via the Bod Pod® (Life Measurements, Concord, CA) and followed the manufacturer’s instructions as detailed elsewhere (Dempster and Aitkens 1995). Briefly, the participants were tested wearing only tight-fitting clothing (swimsuit or undergarments) and an acrylic swim cap. Volunteers wore the exact same clothing for all body composition tests. The thoracic gas volume was estimated using a predictive equation integral to the Bod Pod® software. To estimate body composition, the calculated value for body density was taken from the Siri equation (Siri 1961). A complete body composition measurement was performed twice. If the percentage of body fat was within 0.05%, the two tests were averaged. If the two tests were not within that agreement, a third test was performed and the average of the three trials was used for all body composition variables.

Limb Circumferences: The circumferences of the right arm and thigh were measured using a constant tension tape measure during maximal elbow extension or standing position respectively. Three measurements were made for both arm and thigh circumference. Averaging was performed to obtain mean values for both circumferences. Mid arm circumference was measured midway between the tip of the acromion and the olecranon process (Heymsfield et al. 1982) and the thigh circumference was determined at a point situated two thirds between the edge of the iliac crest and the proximal border of the patella (upper knee) (Bielemann et al. 2016).

Muscle thickness: A real time B-mode ultrasound system (Dynamic Imaging, Livingston, Scotland UK) was used to capture cross-sectional images at three sites (dominant side) of the body: (i) elbow flexors, comprising biceps brachii and brachialis, (ii) anterior deltoids, and (iii) vastus medialis. A trained independent blinded researcher performed all the measurements in a standardized manner and according to the protocol described by (Bradley and O'Donnell 2002). Each participant was placed in a semi-recumbent and relaxed position with knees fully extended and arms held straight alongside the torso with a supination position of the lower arms. The measurement sites were accurately located and marked at 60% distal to the lateral humerus epicondyle from the scapular acromial process for brachii and brachialis muscles; at the acromion anterolateral edge for the anterior deltoid muscle; and at a distance of 80% distal from the greater trochanter to the lateral femur condyle for the vastus medialis muscle. A 7.5-MHz linear transducer together with water-soluble transmission gel (Aquasonic 100 Ultrasound Transmission gel), which provided acoustic contact without depressing the dermal surface, was placed in the transversal plane perpendicular to the skin surface at each of the marked sites. Distortion of tissue due to excessive compression was eliminated by resting the transducer lightly on the skin surface, by visually monitoring the image on the ultrasound screen and by asking participants to provide verbal feedback on the amount of skin pressure experienced. The interfaces between subcutaneous adipose tissue and muscle and between muscle and bone were identified from the ultrasonic image and the distance from the adipose tissue-muscle interface to the muscle-bone interface was measured as representative of muscle thickness.

The location of the probe was recorded onto acetate paper and pre- and post-intervention images were compared during the measurements to ensure that the location was the same based on identifiable markings (moles and small angiomas) viewed in the muscle fascicles as reference points. This was done to increase the reliability of repeated measures. Three images of each location were obtained and the average of the measurements was calculated. Furthermore, to ensure the intra-observer reliability of the muscle thickness, the same researcher evaluated all participants. Images were obtained at least 48 hours before and after the training intervention to avoid any intra-muscle swelling. The intra-rater reliability of muscle thickness measurements performed by the trained investigator on the same scans in a preparatory study was excellent, with an intra-class correlation coefficient of >0.980 (95% confidence intervals of 0.986 to 0.995). Therefore, the thickness measurements on the three analyzed muscles at pre- and post- intervention could be compared confidently.

Strength: The 1RM value for both the bench press (BP) and parallel squat (SQ) using free weights was determined according to the methodology described by McGuigan (2016) (see supplementary material for further explanation). To avoid any specific muscle group interaction, the order of BP and SQ tests was randomized. Additionally, each participant followed the same assessment order at the pre- and post- intervention time point.

Upper body power determination: The maximal upper body power value was measured for the BP exercise using 50% of the previously determined 1RM value. Participants were required to perform 5 repetitions with a maximal possible movement velocity and using a correct technique. Muscular power was determined from the repetition that produced the maximal average accelerative mechanical power (calculated from the accelerative portion of the concentric phase, during which the acceleration of the barbell was $\geq -9.81\ m.s^{-2}$.

An optical rotary encoder (Model WLEN01, Winlaborat®, Buenos Aires, Argentina,) with a minimum lower position register of 1 mm connected to the proprietary software (Real Speed Version 4.20) was used for measuring the position and for the calculation of the average mechanical power in watts achieved during the five BP repetitions. The cable of the encoder was connected to the bar in such a way that the exercise could be performed freely while it allowed the cable to move in both directions of the movement.

The test-retest reliability coefficients (ICCs), coefficient of variation (CV) and standard error of measurement (SEM) for the 1RM BP; 1RM SQ and BP power at 50% were 0.95 (2.1%; SEM 3.12) 0.92 (1.1%; SEM 2.11) and 0.90 (2.5%; SEM 23.08) respectively.

Training Intervention: The two intervention groups (LV-HF and HV-LF) underwent a 6-week RT program aimed to improve muscle strength and muscle hypertrophy. Each group performed two training routines involving 9 exercises per session. Routine 1 was designed to target pectorals, deltoids and arm flexors while routine 2 focused on back, arm extensor and lower body (Table 1).

Table 1

The LV-HF group trained 4 times per week (Mondays and Thursdays routine 1; Tuesday and Fridays routine 2) whereby the HV-LF group trained 2 times per week (Mondays routine 1 and Thursdays routine 2). Consequently, both groups completed the same number of total sets per exercise and routine per training week (Table 2). To equate the exercise effort, all participants regardless of group performed a minimum of 8 to a 12 self-determined maximum repetitions (Steele et al. 2017) per set with a load ~75% of the estimated 1RM with 2 min of rest between sets (de Salles et al. 2009). If participants became aware that they could not reach the minimum number of prescribed repetitions per set, an additional ~30 sec of rest within the set was allowed to reach the lower target number of repetitions. Conversely, a minimum amount of load (2.5kg) was added to the subsequent set if participants felt that they could perform more than 12 repetitions per set. Participants were instructed to perform the concentric phase of every exercise with the maximal possible movement velocity from the beginning of each set and during the entire session. All training sessions were supervised and instructed by a qualified research assistant. To improve the quality of supervision, a ratio of one instructor to three participants was maintained during all training sessions. All participants completed the 6 weeks of intervention with a full compliance to both training routines. All sessions were completed within ~45 minutes or ~105 for the LV-HF or HV-LF respectively.

Table 2 summarizes the volume and relative load used per training session and week for both intervention protocols.

Table 2

Statistical Analysis

A descriptive analysis was performed and subsequently the Kolmogorov-Smirnov and Shapiro-Wilk test were applied to assess normality. Sample characteristics at baseline were compared between groups using an independent means Student`s t-test. All pre- and post-data were summarized and reported as mean (standard deviation) unless stated otherwise. Raw changes in all outcome variables were calculated by subtracting pre minus post assessment values. Under the assumptions that both conditions would promote changes from baseline values and that the amount of change would be also dependent on each individual's enrolment performance levels, one-way Analysis of Covariance (ANCOVA) models were used to compare differences in raw change between groups, using the pre assessment values as covariates. Confidence intervals (CI) of the adjusted differences were calculated and plotted. Those CIs not crossing zero were considered statistically significant. Additionally, two-tailed one sample student's tests were used to test for a null effect hypothesis. Effect sizes of the adjusted differences between intervention groups were assessed converting eta squared from the ANCOVA effects to Cohen's d-values and compared to common benchmarks (Cohen 1988) (small $d = 0.2$-0.49; moderate $d = 0.5$-0.79; and large $d = \geq 0.8$). Significance level was set to $p < 0.05$, but p values between 0.05 and 0.1 were considered indicative of a trend. Stata (version 13.1, StataCorp, College Station, TX, USA) was used for statistical analysis.

Results

The pre- and post- values of the analyzed variables are depicted in table 3. Furthermore, the changes and the adjusted 95% CI are included for each of the intervention groups.

Table 3

Differences from the baseline

Only the HV-LF produced positive changes in body composition, as both total and relative amount of fat and fat-free mass decreased and increased respectively (Figure 1A and B), while body mass remained relatively stable. The LV-HF group demonstrated a positive change in fat-free mass only when expressed in kg (mass) but not as percentage. Although both groups significantly increased vastus, medialis thickness (Figure 1D), only the HV-LF condition showed significant increases in arm circumference (Figure 1C) and elbow flexors thickness (Figure 1D).

Different from the body composition outcomes, both groups produced similar significant improvements in the absolute and relative strength and upper body power values. (Table 3 and Figure 1E and 1F).

Figure 1

The individual responses to both RT protocols for the all analyzed variables are presented in the supplementary material.

Comparison between groups

No main significant differences were observed between groups. However, the HV-LF group showed a large effect size (>0.80) for increasing body mass and absolute 1RM bench press at post intervention (Table 3).

Discussion

The main finding of the present study indicates that both training designs using a high and a low weekly training frequency comprising the same weekly RT volume are effective in improving fat-free mass and performance in recreationally resistance trained individuals. Even though, no significant differences favoring one of the two used strategies were observed at post intervention, the HV-LF design seems to be more effective to enhance body mass ($p = 0.054$, $d= 1.08$) and upper body strength ($p = 0.067$, $d = 0.89$). Although the trend to increase 1RM bench press disappears when results are normalized by body mass, it seems that the HV-LF protocol produces a better stimulus for increasing body mass in this population. Moreover, along with a trend to increase anterior deltoids thickness the HV-LF group showed significant positive changes in the reduction of fat mass, as well as in the increase of fat-free mass (Figure 1A), arm circumference (Figure 1C), vastus medialis and elbow flexors thickness (Figure 1D) (Table 3). The analysis of the individual changes revealed that almost all participants but one allocated in the HV-LF group showed a consistent decrease in fat mass. Conversely, the participants included in the LV-HF demonstrated a more heterogeneous response with 5 decreasing fat mass, 2 increasing and 2 showing no changes. Reasons for discrepancies can be attributed to the different patterns of response in RT between individuals as well as the lack of a strict control of the diet habits. Additionally, the higher metabolic stress associated with the HV-LF protocol represent an important stimulus for adaptations within skeletal muscle necessary to create an enhanced anabolic response (Burd et al. 2010; Buresh et al. 2009). High volume routines have also been associated with greater acute post training increase of testosterone (Smilios et al. 2003) and growth hormone (Mulligan et al. 1996) concentrations. Thereby increasing the potential of facilitating muscle tissue remodeling including a higher energy demand for supporting the recovery process (Schoenfeld et al. 2016).

Only a few controlled trials investigated the effects of RT frequency on muscular adaptations. (Candow and Burke 2007) compared the effects of frequency between 2-days and 3-days weekly volume equated training in a cohort of untrained individuals. Conversely, after 6 weeks, no differences in muscle strength or lean body mass (as assessed by DXA) were identified between conditions. The aforementioned study included a gender mixed sample of 6 men and 29 women and consequently the influence of gender on lean mass gain could have affected results. Arazi and Asadi (2011) who also used untrained individuals, found similar results after an 8-week equalized-volume intervention comparing 1-day vs. 2-days vs. 3-days weekly training volume as no significant differences amongst experimental groups on maximal strength were identified. Similarly, Gentil et al. (2015) in untrained individuals showed that after a 10-week equalized training volume, which compared a 1-day vs. 2-days weekly frequency, no differences between groups in terms of changes in muscle mass and strength were identified. In contrast and using well-trained individuals, McLester et al. (2000) demonstrated that strength gains in a low frequency condition (1-day/week) were less than 62% of that achieved by a higher frequency (3-days/week) protocol over a 12-week training period. Moreover, differences for lean body mass accretion also favored the high frequency routine (~8% for 3-days and ~1% for 1-day weekly training routines). It is likely, that the apparent discrepancies in findings between the aforementioned investigations were subject to the different training status of participants as only McLester et al. (2000) used trained individuals.

Results from the present study suggest that in recreationally resistance trained males, a twice-weekly training involving two different high-volume routines each performed once a week seems to elicit slightly superior changes in body composition. It is conceivable that early-phase adaptations in less-well trained individuals are less sensitive to alterations in frequency and that benefits reach more notable differences with a progressively higher training level. Indeed, a meta-analysis by Rhea et al. (2003) found that well-trained individuals require a greater number of weekly training sessions to maximize strength gains. Moreover, the low frequency condition implemented by McLester et al. (2000) involved only one session per week while the low frequency protocol implemented by Candow and Burke (2007) comprised two weekly training sessions. Thus, in novice or recreationally trained individuals, it could be hypothesized that a frequency of two weekly training sessions represents a threshold beyond which further increases may not yield additional benefits, without manipulating other variables, particularly the relative load or the overall weekly volume.

The present results demonstrate greater increases in upper body muscle thickness with a lower weekly RT frequency. Our findings contrast with McLester et al. (2000) who identified greater improvements with a 3-weekly training frequency. Besides the aforementioned issue of training level, the discrepancies in findings may partially be attributed by the differences in study designs. McLester et al. (2000) employed the same exercises each training session and participants were tested using the same exercises pre- and post- intervention. Furthermore, different from our study in which ultrasound measurements were conducted, McLester and colleagues estimated body composition through the use of the 3-skinfold-site Jackson and Pollock equation and limb circumferences. Our study was designed to mimic the typical split-body routines used by resistance trained enthusiasts and thus exercises for each muscle group were rotated on a session to session basis each week. Even though this strategy provides sufficient recovery and avoids fatigue accumulation throughout the weekly routines in the major muscle groups (pectorals, back and lower body), for muscles such as biceps and triceps which act as synergists during several multiple-joint exercises, the training frequency was higher e.g. 4 (two as agonist and two as synergist) and 2 (one as agonist and two as synergist) for the LV-HF and HV-LF groups respectively. Nonetheless, considering that the HV-LF group showed a more robust increase in muscle mass, the training frequency was still lower than three times per week. Moreover, McLester et al. (2000) utilized a 12-week intervention period, whereby the present study implemented a shorter, i.e. a 6-week duration.

Compared to a single set protocol, multiple sets per exercise sessions result in significantly greater metabolic stress (Gotshalk et al. 1997). Consequently, higher volume sessions can elicit a greater anabolic stimulus and hence require a longer recovery phase to enhance the hypertrophic response and adaptations to RT. While not reaching statistical significance between groups, this might have contributed to our findings of a more effective HV-LF training strategy. The suggestion that increasing the number of sets performed per session, rather than increasing the training frequency, is a more effective strategy to increase muscle size is in contrast to others (Dankel et al. 2017). Nonetheless, regardless how the weekly volume is distributed over 1 or 2 sessions, it is important to highlight that all participants in the present study regardless of the protocol, performed 6 or more than 10 sets per week involving the action of vastus medialis or elbow flexors respectively. Even though these figures are in the line with the recent recommendations of >5 to 9 (moderate) and >9 (high) weekly sets per muscle group for maximizing muscle mass increase (Schoenfeld et al. 2017), the LV-HF protocol was not effective to significantly increase elbow flexors thickness. The lack of consistent responses opens an avenue for future research that investigates whether an increased training frequency while maintaining a similar weekly volume, does indeed results in greater muscle hypertrophy or strength gains.

The present study had several limitations that must be considered when attempting to draw evidence-based inferences. Firstly, the low sample size of 9 participants included in each experimental group could increase the risk of type 2 error. Nonetheless, the presented effect size analysis reduces the risk of misinterpretation and suggests potential changes, which need to be confirmed in future studies. Furthermore, the study period lasted only 6 weeks and although this period was sufficient to achieve significant increases in muscular strength and hypertrophy for both groups, it is possible that results between groups could have diverged with a longer implemented intervention protocol. Secondly, a high degree of inter-individual variability was noted between participants, which limited the ability to detect significant differences in several outcome measures. Third, measurements of muscle thickness were obtained only at the middle portion of the muscle. Although this region is often used as a proxy of overall growth of a given muscle, research indicates that hypertrophy manifests in a regional specific manner, with greater gains sometimes seen at the proximal and/or distal aspects (Wakahara et al. 2012). Proposed mechanisms for this phenomenon include exercise specific intramuscular activation and or tissue oxygenation saturation (Miyamoto et al. 2013). The possibility therefore exists that different changes in proximal or distal muscle thickness may have occurred in one condition vs. the other, which would have gone undetected. It is also important to highlight that diet was not controlled but participants were instructed to maintain their diet habit. Although nutritional changes were consistently monitored, providing a prepared and pre-packed diet to participants during the intervention would have offered an ideal scenario to standardize and control the influence of diet on the present results.

From a practical point of view, provided that the total weekly training volume approaches a total of 9 exercises targeting 3 or 4 muscle groups (including the action of synergist muscles during multi-joint exercises) per session (= 36 per the entire training session), similar outcomes would be obtained by performing the entire training routine once a week or splitting the volume into two separate sessions over the same week. Nonetheless it is noteworthy that for recreationally resistance trained individuals using a HV-LF strategy over a short intervention period (i.e. 6 weeks) might be a better (day saving) option to induce hypertrophic effects and overall positive changes in body composition. At this point it is interesting to highlight that those who can only commit to short sessions, spreading out the volume over a LV-HF protocol might be an appropriate consideration.

In conclusion, over a 6-week period, both weekly-equalized volume protocols, HV-LF and LV-HF were similarly effective to improve performance, fat-free mass and lower body muscle mass. However, only the HV-LF group was effective for enhancing upper body hypertrophy and reducing fat mass in recreationally resistance-trained males.

Conflict of interest statement

The authors declare there are no conflicts of interest relevant to this study.

Acknowledgements

The authors would like to thank the participants for their time and effort to complete the assessments and training protocol.

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Table 1. Exercises performed in the two training routines

Training protocol 1 (chest, arm flexors and shoulders)	**Training protocol 2 (back, arm extensors and lower body)**
Bench press	Lateral pull-down
Dumbbell Fly	Dumbbell reverse fly
Chest press	Barbell pullover
Barbell curl	Barbell lying arm extension
Seated dumbbell curl	Barbell close grip press on bench
Reverse grip bent-over row	Cable pushdowns
Dumbbell deltoid raise	Parallel squat
Barbell shoulder press	Dead lift
Barbell shoulder front raise	Machine leg curl

Table 2. Acute program variables for the intervention groups

Variable	LV-HF (n= 9)	HV-LF (n= 9)
Reps per set and estimated intensity	8 to 12 (~75% 1RM)	8 to 12 (~75% 1RM)
Training sessions per week	4	2
Number of exercises per session	9	9
Sets per exercise	2	4
Total sets per training session (workout volume)	18	36
Sessions per each routine (training frequency)	2	1
Total sets per week by Exercises Routine	 4 36	 4 36