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SHORT COMMUNICATION

Training practices of recreationally resistance trained-women: an observational study

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Objective: The aims of this study were to: 1) quantify the weekly volume of sets prescribed for each muscle group of the lower limbs in recreationally-trained women; 2) assess the association between resistance training experience and the weekly volume.

Design and Methods: The training programs of 1019 recreationally-trained women subjects were analyzed. Data was analyzed for the following lower limb muscle groups: quadriceps femoris, knee flexors, hip adductors, gluteus medius, gluteus maximus, triceps surae, and tibialis anterior. A k-cluster analysis was performed to subdivide the weekly volume of sets into 3 groups (low, medium, and high).

Results: A significant difference in RT experience (years) and weekly frequency was observed between the 3 groups. For relative (%) weekly volume of sets, a larger number was noted for quadriceps femoris (34.29%), followed by gluteus maximus (28.57%), knee flexors (11.43%), and hip adductors, gluteus medius and triceps surae (all 8.57%). A moderate correlation was observed between RT experience and AVS (r_s = 0.56; 95% CI = 0.50 to 0.59; p = 0.001) and a strong correlation between weekly frequency and AVS (r_s = 0.73; 95% CI = 0.69 to 0.75; p = 0.001).

Conclusion: In conclusion, strength coaches usually prescribe high weekly volumes of sets for lower limb muscle groups. Additionally, a higher weekly volume of sets was prescribed for the quadriceps femoris and gluteus maximus muscles when compared to the knee flexors. This results suggest that training experience positively correlates with to the absolute weekly volume of sets.

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Key words: Resistance training ■ women ■ volume ■ training variables

INTRODUCTION

Relevant neuromuscular adaptations (e. g. muscle strength and size) are induced by distinct resistance training (RT) programs. The proper manipulation of training variables has been shown to maximize the desirable adaptations.[1] In this context, RT-volume seems to be a major determinant to be controlled in order to enhance muscular morphological outcomes.[2] Then, it is plausible to point that coaches/practitioners aiming to induce muscle size increment should adopt a strict control of this variable and periodically assess its effects on an individual basis. However, the main challenge with training volume seems to be the proper quantification method to be adopted.

The volume load (sets x repetitions x load) is currently the most common tool described in the scientific literature to quantify the total training volume.[3] Alternatively, the weekly number of sets performed by each muscle group is an easier and reliable method to quantify RT volume in experienced individuals aiming to increase muscle mass.[4,5] Furthermore, training experience must be considered when prescribing the weekly volume of sets within a RT program. Briefly, more experienced lifters seem to require a higher training dose to continuously progress over time, since they display reduced acute post-exercise elevation in muscle protein synthesis compared to their non-trained peers.[6] The understanding of the association between training volume and training experience would help strength coaches to better implement and manipulate this variable considering previous experience. In addition, the proper control of training volume may also bring relevant information regarding the work performed by distinct muscle groups, helping to prevent eventual musculoskeletal injuries and/or improving common asymmetries observed between distinct muscle groups in individuals training with aesthetics goals.

Therefore, the aims of the present study were to: 1) quantify the weekly volume of sets prescribed for each muscle groups of the lower limbs in recreationally-trained women; 2) assess the association between RT experience and the weekly vol-

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ume of sets; 3) correlate the weekly frequency and the absolute volume of sets; 4) correlate RT experience and the weekly frequency. The hypothesis was that more experienced lifters usually perform a higher weekly volume of sets per muscle group. In addition, a significant difference would be observed between weekly volume of sets performed among the muscle groups assessed, with a higher value being observed for the exercises targeting the quadriceps femoris and the gluteus maximus muscles.

METHODS

Participants

One thousand and nineteen (18-35 years) recreationally trained women (median [interquartile range]; RT experience = 1 [0.5 – 2] year; RT frequency = 2 [1 – 2] sessions per week only for lower limbs) consented to allow the analysis of their current RT programs. To be included in the analysis, all subjects should report to be regularly performing hypertrophy-oriented RT programs for at least 6 months before data collection.[7,8] In addition, subjects should also state to be free from any metabolic, cardiovascular or musculoskeletal disorders that could impair their performance in each of the prescribed training program.

All procedures were performed in eight training facilities located in the cities of Campinas, Hortolândia, Monte-Mor, and Franca (SP, Brazil). The subjects were informed of the risks and benefits of the study prior to any data collection, and then read and signed an institutionally approved informed consent document (#1.749.141).

Protocol

This was an exploratory descriptive study that aimed to establish the training prescription of recreationally-trained women. Data was analyzed for the following lower limb muscle groups: quadriceps femoris, knee flexors, hip adductors, gluteus medius, gluteus maximus, triceps surae, and tibialis anterior. The weekly volume of sets prescribed per muscle group was calculated through the following equation: number of exercises per muscle group per training session X number of sets per exercise in each training session X weekly training frequency per muscle group.[9]

Data collection was carried out by three experienced researchers, from February to June 2019. The same researcher filled out and performed the analysis of the weekly volume of sets through training spreadsheets. The strength coach responsible for each gym indicated the spreadsheets of the volunteers who fit each pre-requisite. For all spreadsheets, strength coaches of each facility prescribed RT programs and its variables (exercises, number of sets, number of repetitions/set) and each participant should fill out the load that was adopted in each of the exercises prescribed throughout a given predefined period (2-3 months). All exercises and their variations were included in each of the aforementioned muscle groups, and prime movers and agonists were considered. Thus, the list of exercises included in the analysis is presented in table 1.

Data Analysis: the absolute weekly volume of sets (AVS) was calculated as the product of the number of exercises per muscle group performed in each RT session x number of sets per exercise in each RT session x weekly RT frequency for

Table 1 Exercises included in the analysis for each muscle group.

Muscle groups	Exercises
Quadriceps femoris	Squat (all the variations) Leg press (all the variations) Deadlift (traditional and "sumo") Seated knee extension Lunges (all the variations) Hip Thrust (all the variations)
Knee flexors (Hamstrings)	Knee flexion (all the variations) Stiff leg deadlift Nordic knee flexion Hip Thrust (all the variations)
Hip adductors (gracilis, obturador externus, adductor brevis, adductor longus and adductor magnus)	Hip adduction (all the variations)
Gluteus medius	Hip abduction (all the variations)
Gluteus maximus	Hip extension (all the variations) Squat (all the variations) Deadlift Leg press (all the variations) Lunges (all the variations) Stiff leg deadlift Hip Thrust (all the variations)
Triceps surae	Plantar Flexion (all the variations)
Tibialis anterior	Dorsiflexion (all the variations)

each muscle group.[9] The relative (%) weekly volume of sets for each muscle group was calculated by dividing the AVS by the sum of all weekly sets performed for all muscle groups assessed and multiplied by 100.

Statistical Analysis

The descriptive analysis was presented in median (Med) and interquartile ranges (IQ), minimal value (Min), maximum value (Max), and variations range. The Kolmogorov-Smirnov test revealed the data were not normally distributed. A k-cluster analysis was performed to subdivide the participants into 3 groups, being classified as low, medium, and high weekly volume of sets per muscle group. The *Kruskal-Wallis* test was also performed in order to assess the differences between the groups of clusters for each variable. The *Nemenyi* test was used for post hoc analysis. The Friedman test was used to assess the differences between the muscle groups, with post hoc Dunn's analysis. The effect size (ES) was calculated in raw values of the variables using the standardized difference based on Cohen's *d* units (Mean 2 – Mean 1/pooled standard deviation).[10] The *d* result was interpreted as follows: <0.2, trivial; 0.2 to 0.6, small; 0.6 to 1.2, moderate; 1.2 to 2.0, large; 2.0 to 4.0, very large; >4.0, extremely large. The *Spearman* coefficient (r_s) was used to assess the correlations between weekly RT frequency, RT experience, and AVS. The 95% interval confidence (95% CI) of the correlation was also calculated. The classification criteria was adopted (r_s): ≤ 0.1, trivial; > 0.1 to 0.3, very weak; > 0.3 to 0.5, weak; > 0.5 to 0.7, moderate; > 0.7 to 0.9, strong; > 0.9, very strong. The significance level adopted was $p \leq 0.05$. All analyses were performed in SPSS – 25.0 software (IBM Corp.; Armonk, NY, EUA).

RESULTS

Subjects were classified into 3 groups: low (n=367), medium (n=492), high (n=160) and total (n=1019) weekly volume of sets (presented in table 2).

A significant difference in RT experience (years) was observed between the 3 groups ($p = 0.001$; ES: low vs medium = 0.04; low vs high = 0.20; medium vs high = 0.16) and weekly frequency ($p = 0.001$; ES: low vs medium = 0.22; low vs high = 0.38; medium vs high = 0.21).

For relative (%) weekly volume of sets, a larger number was noted for quadriceps femoris (34.29%), followed by gluteus maximus (28.57%), knee flexors (11.43%), and hip adductors, gluteus medius and triceps surae (all 8.57%).

The Spearman correlation values (95% CI) and qualitative classification of the associations between weekly RT frequency, RT experience, and AVS showed that there was a positive correlation for all comparisons. A moderate correlation was observed between RT experience and AVS ($r_s = 0.56$; 95% CI = 0.50 to 0.59; $p = 0.001$), a strong correlation between weekly frequency and AVS ($r_s = 0.73$; 95% CI = 0.69 to 0.75; $p = 0.001$), and a weak correlation between RT experience and weekly frequency ($r_s = 0.47$; 95% CI = 0.41 to 0.51; $p = 0.001$).

DISCUSSION

The present study aimed to assess the association between RT experience and the volume of sets performed by recreationally-trained women. In addition, the absolute volume of sets prescribed by each lower limb muscle group was also quantified and compared. Confirming the hypothesis, a significant correlation was observed between RT experience and the weekly volume of sets. In addition, the weekly volume of sets was not balanced between different muscle groups.

Quantifying the absolute volume of sets performed by RT practitioners has great relevance for strength coaches, especially since morphological adaptations are strongly influenced by manipulating this acute RT variable.[11] In this sense, the scientific literature has pointed out that prescribing and controlling RT volume through the weekly number of sets performed is a reliable method.[12] Additionally, subjects aiming to develop strength or muscle mass may beneficiate from strict control of the number of sets performed.

As initially hypothesized, women with more RT experience performed a higher number of sets (63%) for exercises that

Table 2 Descriptive statistics of the weekly frequency, experience and weekly volume of sets per muscle group divides into 3 clusters, low medium, high and total.

	LOW (n=367)					MEDIUM (n=492)					HIGH (n=160)					TOTAL (n=1019)				
Variables	**Med**	**Min**	**25**	**75**	**Max**	**Med**	**Min**	**25**	**75**	**Max**	**Med**	**Min**	**25**	**75**	**Max**	**Med**	**Min**	**25**	**75**	**Max**
Weekly frequency	1.0	1.0	1.0	1.0	2.0	2.0	1.0	2.0	2.0	3.0	2.0	2.0	2.0	3.0	3.0	2.0	1.0	1.0	2.0	3.0
Experience (years)	0.5	0.5	0.5	0.5	4.0	2.0	0.5	1.0	3.0	15.0	2.0	0.5	1.0	3.0	6.0	1.0	0.5	0.5	2.0	15.0
Quadriceps femoris	16.0	0.0	12.0	18.0	24.0	24.0	14.0	24.0	32.0	44.0	48.0	36.0	40.0	54.0	64.0	24.0	0.0	18.0	32.0	64.0
Knee flexors (Hamstrings)	6.0	0.0	6.0	12.0	36.0	10.0	0.0	6.0	16.0	32.0	12.0	0.0	8.0	16.0	38.0	8.0	0.0	6.0	14.0	38.0
Hip adductors	6.0	0.0	0.0	0.6	14.0	6.0	0.0	6.0	8.0	18.0	8.0	0.0	6.0	8.0	20.0	6.0	0.0	4.0	8.0	20.0
Gluteus medius	6.0	0.0	0.0	0.6	14.0	6.0	0.0	6.0	8.0	18.0	8.0	0.0	6.0	8.0	20.0	6.0	0.0	4.0	8.0	20.0
Gluteus maximus	12.0	0.0	6.0	12.0	18.0	24.0	12.0	18.0	28.0	40.0	46.0	32.0	40.0	52.0	64.0	20.0	0.0	12.0	30.0	64.0
Triceps surae	6.0	0.0	6.0	6.0	24.0	6.0	0.0	6.0	8.0	32.0	12.0	0.0	8.0	16.0	24.0	6.0	0.0	6.0	8.0	32.0
Tibialis anterior	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	8.0

Legend: Med: median; Min: minimum; 25: 25% interquartile range; 75: 75% interquartile range; Max: maximum; LOW: low volume of sets; MEDIUM: medium volume of sets; HIGH: high volume of sets (classification between low, medium and high was performed within this sample just to classify the division of clusters)

emphasize the quadriceps femoris and gluteus maximus muscle groups. This may be justified by cultural factors that tend to overestimate the aesthetics of these muscle groups by women.[9] It is also interesting to note that, based on a previous study conducted by Teixeira et al. (2018), the volume of sets performed for hamstrings was 2.5 times lower than for quadriceps femoris (10 vs 25, respectively). This imbalance in RT volume between antagonist muscle groups may have future implications in strength and the quadriceps/hamstring ratio (Q/H ratio).[13,14] Indeed, imbalances between hamstrings /quadriceps strength (i.e., H/Q peak torque ratio < 0.75) correlates to an increased incidence of lower extremity injury in female athletes.[13]

For the gluteus maximus, the subjects that reported a high weekly volume of sets presented more than 64 sets. Probably, these differences are due to cultural factors that tend to overestimate aesthetics for the gluteus maximus. Therefore, it is also important to consider the number of sets performed for each muscle group in multi-joint exercises.[9]

In the current study, a significant moderate correlation was observed ($\rho = 0.56$) between RT and AVS. Then, it is important to progress in volume based on the RT experience,[4] however, data describing the association between RT experience and the weekly volume of sets are still lacking.

It is relevant to mention that our study collected data exclusively from lower-limbs muscle groups, which represents an important limitation. It should not be completely discarded that participants could eventually put a greater focus on upper body exercises as opposed to lower during a given period of time, and, if so, this could bias the estimate of total volume. In this sense, our conclusions should not be extrapolated to exercises prescribed for the upper-limbs and future investigations should carefully take into account these muscles groups of women engaged in RT-programs as well.

CONCLUSION

In conclusion, the present study observed that strength and conditioning coaches usually prescribe a higher RT volume for the lower limbs muscle groups of recreationally-trained women. In addition, a larger weekly volume of sets is usually prescribed for the quadriceps femoris and gluteus maximus muscles compared to hamstrings, which highlights the requirement of strict control of the volume prescribed for antagonist muscle groups to reduce muscle imbalances and possible asymmetries.

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