Original Article

Traditional vs daily undulling periodization in strength and local muscle endurance gains on trained men

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ABSTRACT

The aim of this study was to investigate the impact of different periodization models on strength and local muscle endurance. Twenty trained men (25.45 ± 2.984 years, 75.34 ± 6.05 kg, 177.25 ± 4.92 cm, 23.96 ± 1.64 kg . m-2) were randomly assigned in two groups: undulling periodization (UPG) and traditional periodization group (TPG), respectively. All the subjects performed one repetition maximum (1-RM) strength test and a local muscle endurance test (60% of 1-RM to failure) before, during and after experimental period. The UPG executed 30 workout sessions with daily modifications regarding intensity, volume and rest period

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Submitted for publication February 2018
Accepted for publication March 2018
Published March 2018
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2018.132.11

length. The TGP was divided into 3 phases (10 workout sessions in each phase) with the same changes executed by the other group in distinct methodological variables (intensity, volume and rest period length). After the ANCOVA analysis, no significant differences were found in both maximum strength attempts, bench press ($p = 0.878$) and triceps pull-down ($p = 0.967$). The same results occurred for local muscular endurance on the bench press ($p = 0.777$) or triceps pull-down ($p = 0.494$). However, the effect size presented moderate post-test strength gains (ESs = 0,352) and local muscular endurance (ESs = 0.367). Our results indicated that daily undulling periodization seems to be more influent in increasing muscular strength and local muscular endurance according to effect size evidence. **Key words:** RESISTANCE TRAINING, MUSCLE STRENGTH, MUSCLE ENDURANCE.

Cite this article as:
Rodrigues, B., Senna, G., Simão, R., Scudese, E., Da Silva-Grigoletto, M., Paoli, A., Messina, G., Bianco, G., Bianco, A., & Dantas, E. (2018). Traditional vs daily undulling periodization in strength and local muscle endurance gains on trained men. *Journal of Human Sport and Exercise, 13*(2), 401-414. doi:https://doi.org/10.14198/jhse.2018.132.11

INTRODUCTION

Periodization in resistance exercise (RE) can be defined as the systematic process of altering one or more program variable(s) over time to allow for the training stimulus to remain challenging and effective (American College of Sports Medicine, 2009). To achieve an optimal training stimulus, one should consider the inclusion of systematic variations on RE routines throughout a determined period (Kraemer and Ratamess, 2004). This method was applied to RE since the 1950s and has grown in popularity since then (Simão et al., 2012). It is well reported in the scientific literature that strength gains were higher when periodization methods are implemented compared to different or non-periodization methods (Baker et al., 1994; Bartolomei et al., 2014; de Lima et al., 2012; Miranda et al., 2011; Painter et al., 2012; Peterson et al., 2008; Prestes et al., 2009a; Prestes et al., 2009b; Rhea et al., 2002; Rhea et al., 2003).

The implementation of heavy training loads can promote positive strength responses for highly trained men (Schoenfeld et al., 2015). In fact, perhaps that high-intensity, low-volume with longer rest periods (i.e. 3-minutes) might be more advantageous than a moderate intensity, high-volume and short rest (i.e. 1 min) for stimulating upper-body strength gains and muscle hypertrophy in resistance-trained men (Magine et al., 2015). Additionally, specific manipulations on high-intensity strength exercise with low intensities to the concentric failure can be also advantageous to strength and hypertrophy (Goto et al., 2004). These results support the implementation of a systematically varied design to optimize the RE outcomes.

Specifically, de Lima et al. (2012) in a randomized controlled study verified the impact of a 12-week muscular endurance training of high repetitions (i.e. 15–30) with 2 different periodization models on body composition, maximal strength, and muscular endurance. In their results, the linear periodization group performed with a high number of repetitions may be considered an appropriate periodization model for untrained young women that would likely lead to the improvement of body composition and maximum strength performance, whereas daily undulation periodization was more effective for the development of local muscle endurance. In another investigation, Simão et al. (2012) reviewed the effects of undulation periodization (non-linear periodization) and traditional (linear) periodization RE on muscle thickness and strength. In conclusion, both linear and non-linear periodization were effective, but non-linear periodization may lead to greater gains in strength and muscle thickness in untrained men over a 12-week training period.

Conversely, in high expert population, Painter et al. (2012) compared block to daily undulating periodization in Division I track and field athletes. Thirty-one athletes were assigned to either a 10-week block or daily undulating periodization training groups. Based on training efficiency scores, their data indicate that a block training model is more efficient than a daily undulating periodization model in producing strength gains. Recently, Bartolomei et al. (2014) compared 2 different periodization models in twenty-four strength and power athletes. All subjects were randomly assigned to either a block or linear (traditional) periodization training program. The results indicated that the block periodization may enhance upper-body power expression compared to linear periodization with equal volume. However, no differences were detected for lower-body performance and body composition measures.

Although, despite the recent and increasing evidence, the current scientific literature state remains very limited regarding interactions between periodization's methods, experience in RE, intensity load zone, volume and rest interval length. In addition, the daily undulation *vs* traditional (linear) periodization, both with differences in load zone, volume, and rest interval length, have not being investigated for an already trained population. Therefore, to increase the growing body of knowledge regarding this theme, the aim of this study was to investigate the impact of distinct periodization models with differences on intensity load zones, volume

and rest interval length on strength and local muscle endurance in trained adults. We hypothesized that 30 workout sessions will impact similarly on strength and local muscle endurance gains regardless of periodization model executed for trained men.

MATERIALS AND METHODS

Participants

Twenty trained men with at least one-year of consistent RE experience were selected to participate (25.45 ± 2.98 yrs.; 75.34 ± 6.05 kg, 177.25 ± 4.92 cm; 23.96 ± 1.64kg·m-2; relative strength: 0.96 ± 0.29 kg·kg-1 of body mass). The subjects were randomly separated into 2 groups: undulating periodization group (UPG) and traditional periodization group (TPG). The anthropometrics characteristics for both groups are represented in Table 1. The following inclusion criteria were adopted to standardize subject selection: (a) training frequency of at least 4 times per week, with session duration of approximately 1 hour, with no periodization methods being prescribed over the previous year; (b) non-usage of any ergogenic substance that would enhance repetition performance; (c) no acute or chronic injuries that would affect upper-body exercise performance in last year; and (d) no intense physical activity during the experimental period. Before data collection, all subjects answered "no" to all questions on the PAR-Q (Shephard, 1998). The study procedures had been previously submitted and approved by the Federal University of State of Rio de Janeiro Ethics Committee (nº: 672.648). Participants read and signed an informed consent after being informed of the testing procedures according to the Declaration of Helsinki.

Table 1. Anthropometrics characteristics for group.

	UPG	TPG	*P* Value
Weigh	74.40 ± 5.87	76.28 ± 6.39	0.570
Height	176.50 ± 5.21	178.00 ± 4.78	0.504
IMC	23.86 ± 1.67	24.07 ± 1.71	0.796
Age	24.40 ± 3.16	26.50 ± 2.50	0.115
Experience	4.5 ± 1.51	3.4 ± 0.84	0.137
1-RM BP	91.00 ± 16.73	54.70 ± 8.78*	> 0.001
1-RM TP	45.50 ± 5.52	29.80 ± 5.86*	> 0.001
Relative Strength (BP)	1.22 ± 0.18	0.71 ± 0.11*	> 0.001

**Significant difference between groups.*

Strength Test

All subjects participated in 2 familiarizations weeks (four training sessions) before the Pre-test. The one maximum repetition test (1-RM) was used as a measure of Pre-, Mid- and Post-training upper-body strength on two non-consecutive days (each day for each exercise) using the bench press (BP) and triceps pull-down (TP; 2 sessions for 1-RM tests). Following the test, if individuals exceeded or did not completed one repetition with the stipulated intensity, adjustments in load were made for each subject, and a new attempt was performed with a rest period no shorter than 5-minutes (Scudese et al., 2015; Senna et al., 2016). The resistance was progressively increased (2 kg) after each successful attempt until failure. To minimize measurement error, the following strategies were adopted: (a) standard instructions concerning the experimental procedures were given to the subjects before the test; (b) subjects received standardized instructions on exercise technique (Baechle and Earle, 2000); (c) body position was held constant; (d) verbal encouragement was provided during the BP and TP sets in order to elicit the maximum effort from each subject (McNair et al., 1996); and (e) the mass of all plates and bars used was determined using a precision

scale. The greatest load lifted over the testing sessions for each exercise was recorded as the 1-RM load. Subjects performed a maximum of 5 attempts during each visit. The warm-up before each test consisted of 2 sets of 12 repetitions at 40% of 1-RM self-related load of the BP exercise (Senna et al., 2011).

Local Muscle Endurance Test

The local muscular endurance (maximum number of repetitions performed with 60% of 1-RM) was assessed for each of the exercises at the Pre-, Mid- and Post-training (Campos et al., 2002), in 2 non-consecutive days (each day for each exercise) using the BP and TP (2 sessions for local muscle endurance tests). After the 1-RM load determination, with a sufficient recovery period between sessions (48 hours), 60% of the 1-RM value was calculated for the local muscular endurance test. The subjects performed as many repetitions as possible with 60% of 1-RM until failure in BP and TP in non-consecutive days. In order to minimize errors, the same procedures used on the BP were conducted on TP along with the same warm-up strategy.

Procedures

After pretesting measurements, the UPG and TPG completed the 30 workout sessions. The RE program consisted of the following exercise sequence: BP, lat pull-down, shoulder press, TP, and biceps curl in this order. In UPG, modifications on methodological variables were conducted for each session (daily undulling periodization) in an alternate design. At the first session, the subject execution 5 sets, 60% of 1-RM with 30-second of the rest period between sets and exercises (i.e. endurance recommendations). For the second session, 4 sets with 75% of 1-RM with 1-minute of the rest period between sets and exercises were performed (i.e. hypertrophy recommendations). In the third session, 3 sets with 90% of 1-RM with 3-minute of the rest period between sets and exercises (i.e. strength recommendations) were performed. The TPG training program was divided into 3 phases: initially (10 sessions) composed by 5 sets, 60% of 1-RM with 30 second of rest period between sets and exercises; for the second phase (10 sessions) 4 sets with 75% of 1-RM with 1-minute of rest period between sets and exercises; and for the third phase (10 sessions) 3 sets with 90% of 1-RM with 3-minute of rest between sets and exercises were performed. All sets, for all exercises, workout sessions, and groups were conducted until the concentric fail was reached. The 1-RM load for each exercise was assessed after 10 workout sessions to access any strength improvement levels. During the exercise sessions, the participants were verbally encouraged to perform all sets to concentric failure (McNair et al., 1996) and the same definitions of a complete range of motion used during the 1-RM testing were implemented to define completion of a successful repetition. There was no attempt to control the velocity of the repetitions performed.

The frequency of the training program was 3 sessions per week with at least 48 hours of rest between sessions. All workout sessions were conducted between 7 and 9 am and the training programs were performed during the second semester. Before each training session, all subjects performed a specific warm-up, consisting of 2 sets and 12 repetitions at approximately 40% of the 1-RM verified in the last test for BP (first exercise). Adherence to the program was 100% for both training groups, and all the training sessions were supervised by an experienced strength and conditioning professional. Maximum strength and local muscle endurance values were systematically assessed at Pre-, Mid and Post-training period.

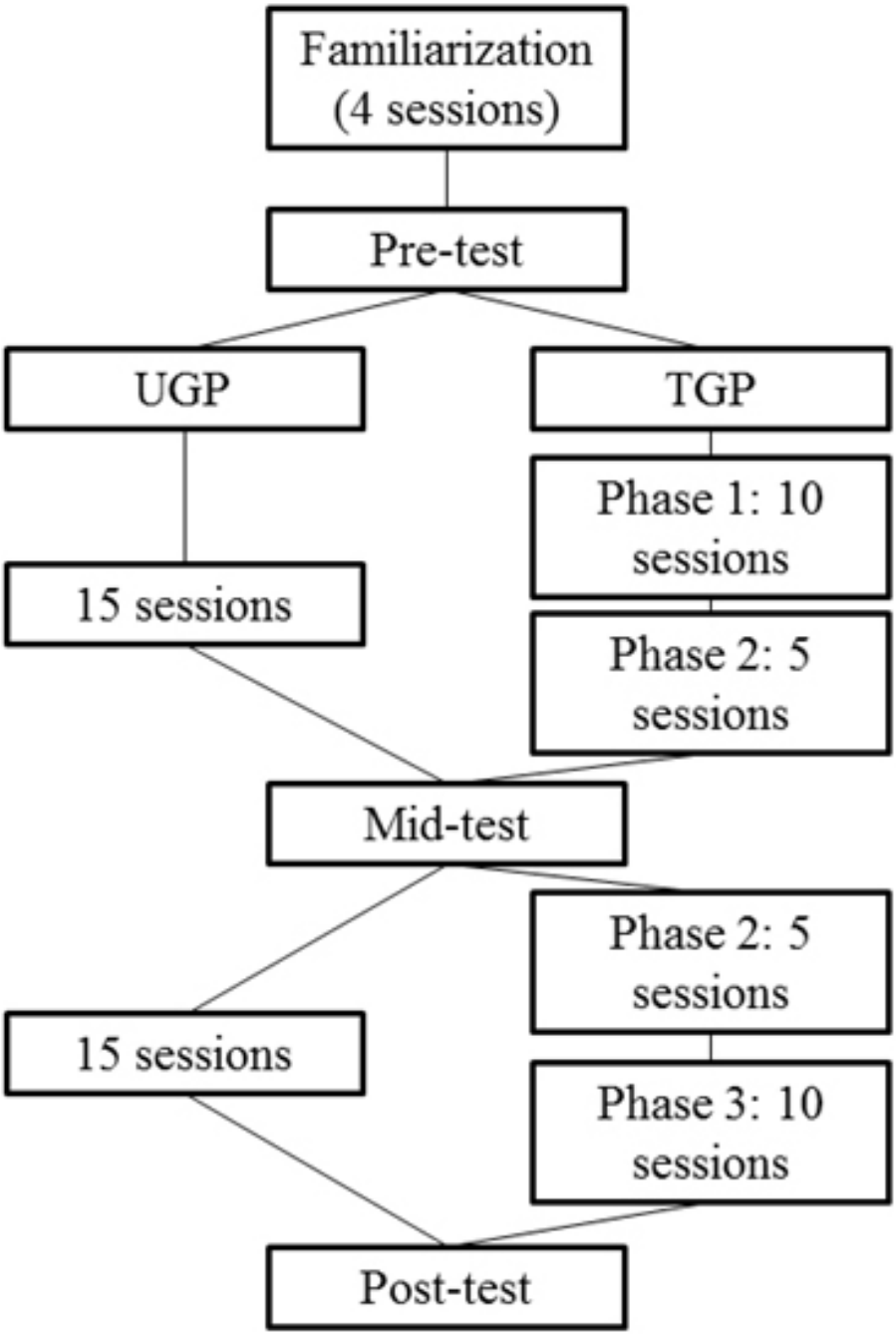


Figure 1. Experimental design.

Table 2. Training Program.

Groups	Phases	Training duration	Resistance training	Repetition range	Rest length
UGP		30 sessions workout	Local Muscle Endurance	5 sets x 60% of 1-RM	0.5 min
			Hypertrophy	4 sets x 75% of 1-RM	1 min
			Strength	3 sets x 90% of 1-RM	3 min
TGP	Phase 1	10 sessions workout	Local Muscle Endurance	5 sets x 60% of 1-RM	0.5 min
	Phase 2	10 sessions workout	Hypertrophy	4 sets x 75% of 1-RM	1 min
	Phase 3	10 sessions workout	Strength	3 sets x 90% of 1-RM	3 min

UGP = Daily Undulling Periodization Group; TGP = Traditional Periodization Group; RM = Repetition maximum.

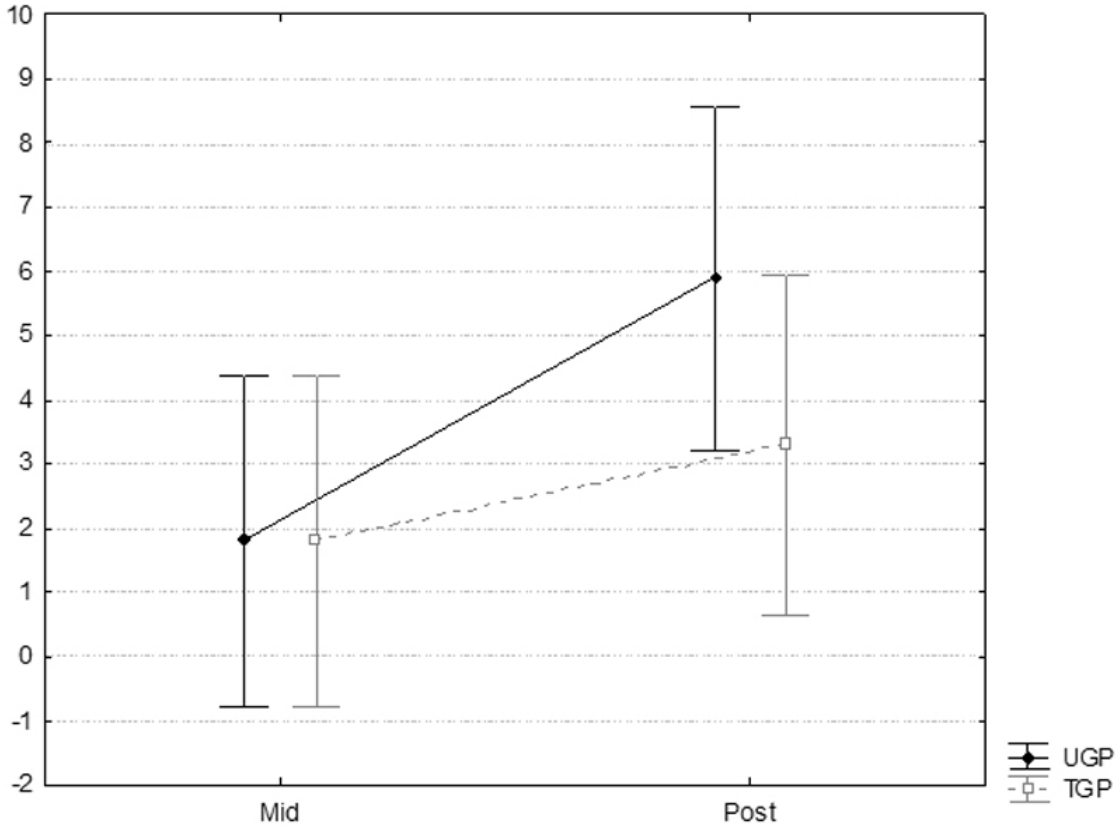
Analysis

The maximum strength (1-RM) and local muscle endurance (number of repetitions) data were presented by mean ± standard deviation (SD). The 1-RM was statistically analyzed using a periodization group (UPG *vs* TPG) versus time (Pre *vs* Mid *vs* Post) by ANCOVA. The area under the curve (for 1-RM) was calculated using the trapezoidal method and compared by ANCOVA. The cofactor used to normalize the difference in strength (for TGP and UGP) was a relative strength in BP. The number of repetitions was analyzed by two-way ANOVA (periodization group *vs* time period). In addition, the area under the curve (for the number of repetitions) was calculated using the trapezoidal method and compared by two-way ANOVA. Additionally, the effect size (ESs) compared the mid and post verifications versus pre (baseline) and the thresholds proposed by Cohen (1988). The level of significance was set at $p \leq 0.05$. SPSS software 21.0 version was used for statistical analyze (IBM, Inc, USA).

RESULTS

One repetition maximum results

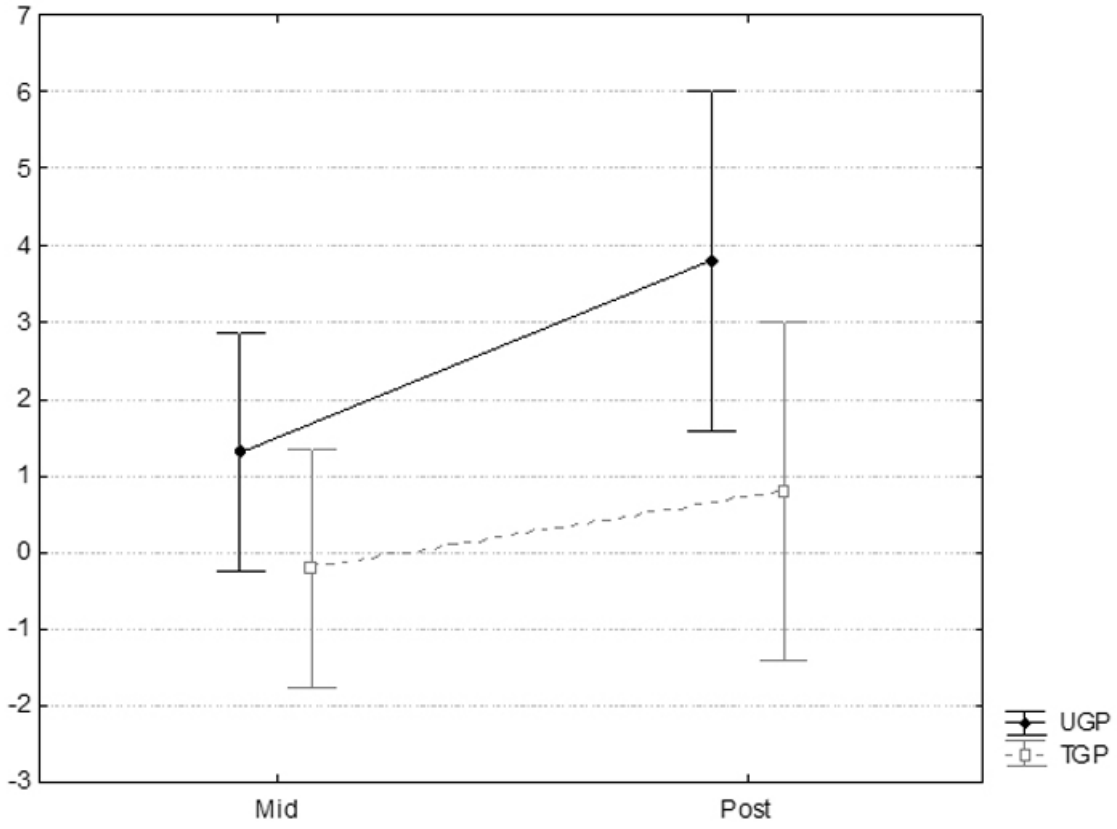
There was no significant difference found in the interaction between time *vs* periodization ($p = 0.878$) for the BP exercise. In the following time condition, no significant differences were observed between Pre, Mid or Post-test values ($p = 0.812$). No differences were verified for different periodization conditions (UPG *vs* TPG) ($p = 0.108$). The area under the curve did not present significant difference for UPG *vs* TPG ($p = 0.582$). In addition, the ESs presented a trivial effect in the BP 1-RM values for UPG in Mid (ESs = 0.103) and moderate elevations for the Post-test (ESs = 0.352) situation. For TPG, a trivial elevation in strength values in Mid (ESs = 0.103) and Post-test (ESs = 0.256) situations.



UGP: Undulling Group periodization; TGP: Traditional Group Periodization.

Figure 2. Difference between to Pre 1-RM values in bench press for undulling daily and traditional periodization.

For the TP, there was no difference in interactions between time *vs* periodization (p = 0.967). In the following time condition, no differences were observed between Pre, Mid or Post-test values (p = 0.910). No differences were found between distinct periodization conditions (UPG *vs* TPG) (p = 0.786). The area under the curve did not show any significant difference between UPG *vs* TPG (p = 0.341). In addition, the ESs presented a trivial elevation in the BP 1-RM values for UPG in both Mid (ESs = 0.107) and Post-test (ESs = 0.252). For the TPG method, a trivial elevation was observed in strength values in Mid (ESs = 0.059) and Post-test (ESs = 0.294) situations.



UGP: Unduling Group periodizaton; TGP: Traditional Goup Periodization.

Figure 3. Difference between to Pre 1-RM values in triceps pull-down for undulling daily and traditional periodization.

Local muscle endurance results

There was no significant difference found in the interaction between time vs periodization (p = 0.777) for the BP exercise. In the following time condition, no differences were observed between Pre, Mid or Post-test values (p = 0.141). There were no significant differences between distinct periodization conditions (UPG vs TPG; p = 0.952). The area under the curve did not show a significant difference for UGP vs TPG (p = 0.906). Furthermore, the ESs presented a trivial elevation in local muscle endurance values for UGP in Mid (ESs = 0.107) and moderate elevations for the Post-test (ESs = 0.367). For the TPG, a trivial elevation was observed in local muscle endurance in Mid (ESs = 0.059) and Post-test (ESs = 0.294) situations.

For the TP exercise, no significant difference was found for interactions between time vs periodization (p = 0.494). In the following time condition, no significant difference was observed between Pre, Mid or Post-test values (p = 0.235). No significant differences was observed for both periodization conditions (UPG vs TPG) (p = 0.086). The area under the curve did not show any significant difference between UPG vs TPG (p = 0.074). The ESs demonstrated a trivial elevation in local muscle endurance values for UPG for the Mid (ESs = -0.066) and Post-test (ESs = 0.088) situations. For TPG, a trivial elevation in local muscle endurance values was observed for the Mid (ESs = 0.175) and Post-test (ESs = 0.245) situations.

Table 3. Number of Repetitions in local muscle endurance test (60% of 1-RM) for undulling group periodization and traditional group periodization for each exercise.

	Pre	Mid	Post
Bench Press			
UGP	15.00 ± 0.8	15.10 ± 0.7	15.30 ± 1.4
TGP	15.00 ± 1.7	15.00 ± 1.5	15.50 ± 1.3
Triceps Pulldown			
UGP	21.50±4.5	21.20±4.2	21.90 ± 3.4
TGP	23.90±2.2	24.40±2.5	24.60 ± 2.1

UGP: Undulling Group periodization; TGP: Traditional Group Periodization.

DISCUSSION

The key finding of this experiment was the absence of difference observed between both interventions groups (UPG *vs* TPG) for strength and local muscle endurance. In Addition, the ESs presented trivial and moderate effects for strength and local muscular endurance in Mid and Post-test situations for both groups. More specifically, the ESs evidenced a positive effect in both strength.

Several studies also observed chronic differences regarding distinct methods of periodization (Simão et al., 2012; Bartolomei et al., 2014; de Lima et al., 2012; Painter et al., 2012). The previous investigations differ from our experiment mainly for the population and RE methodology applied. Specifically, Simão et al. (2012) investigated the effects of undulling (non-linear) and traditional (linear) periodization linear RE on muscle thickness and strength, measured by an ultrasound technique and 1-RM, respectively. Thirty untrained men were assigned to 3 groups. The authors assessed the right arm biceps and triceps muscle thickness and 1-RM strength before and after 12 weeks of training for the exercises BP, lat-pull down, TP, and biceps curl. After intervention, both trained groups presented significant 1-RM strength gains in all exercises. The 1-RM of the undulling periodization group was significantly higher than traditional periodization. There were no significant differences in biceps and triceps muscle thickness between baseline and post-training for any group. The ESs were higher in undulling periodization for most observed variables. In conclusion, both periodization's methods were effective, but may undulling periodization lead to greater gains in 1-RM and muscle thickness over a 12-week training period. Conversely, Painter et al. (2012) compared the effects of RE using traditional (block) and daily undulating periodization model on maximal strength. Thirty-two college track athletes were assigned into both groups and trained with a frequency of 3-day per week for 10 weeks. The authors found that the block model was superior even on a short term.

In the present study, we observed interactions between periodization's methods (traditional *vs* daily undulling periodization), with differences in intensity zone, volume and rest interval length. Similarly to Simão et al. (2012) and Painter et al. (2012) we found increments (verified by ESs) in maximum strength (1-RM) regardless of the periodization method, even though the population was composed of well-trained individuals. Furthermore, we found changes in local muscle endurance and this adaptation may be due to the variations in load zone, volume and rest interval length. In fact, the ESs data revealed a moderate effect in UPG for muscular strength and a moderate variance in local muscular endurance for the BP. These results demonstrated a little superiority adaptation for UPG, but both periodization's methods were efficient in our experience.

Several other studies investigated the relationship between traditional *vs* undulling periodization. (Miranda et al., 2011 ; Rhea et al., 2002 ; Apel et al., 2011 ; Bufford et al., 2007 ; Franchini et al., 2015 ; Hoffman et al., 2003 ; Monteiro et al., 2009). For instance, Rhea et al. (2002) compared the effect of traditional and daily undulling periodization on strength gains in previously trained individuals with 3 sessions per week for a whole-body program. The authors observed significant increases in maximal strength (for leg press and BP) after both periodization methods. However, daily undulling periodization induced superior increases in maximal strength compared with traditional. Monteiro et al. (2009) compared traditional, undulling periodization and non-periodized workouts. After 12 training weeks, the undulling periodization resulted in greater strength gains than traditional and non-periodized methods. Apel et al. (2011) showed that both the traditional and weekly undulling periodization made significant increases in strength at eight and 12 weeks. However, for strength gains, the authors found that the traditional periodization strategy was more effective than the weekly undulling periodization.

It is becoming evident that the type of population investigated will directly dictate the outcomes of the long-term periodization interventions. Besides, the distinct methodological approaches between investigations could generate different outcomes. In our study, subjects with extensive experience in RE were able to obtain strength and local muscle endurance gains. Moreover, the data that we observed (verified by the ESs), indicated that a higher frequency of change in load, volume, and rest interval, regardless of the equalized intensity provided by the UGP, triggered positive strength and local muscle endurance responses in well-experienced trained men.

CONCLUSIONS

This investigation contributes to the growing body of knowledge that different periodization methods, more specifically, the traditional and daily undulling periodization, with altered intensity load zones, volume, and rest interval length, produced no significant muscular strength and local muscular endurance gains for experienced trained men. However, we found that daily undulling periodization appears to be more effective increasing strength and local muscle endurance (verified by the ESs). In fact, due to the population being composed of well-trained men, an inexpressive strength and local muscular endurance gain was already expected. Our findings presented little (trivial in ESs) strength and local muscular endurance gains for both periodization methods, in addition to a moderate strength and local muscle endurance found in BP for the daily undulling periodization method. In this regard, the daily undulling periodization method can be applied as an effective strategy to help variations in volume and intensity occurring from one training session to the next, with the potential to reduce the ‘‘monotony’’ of performing repetitive training sessions and resulting in higher adherence (Simão et al., 2012). Apparently, this phenomenon resulted from the frequent variations on load, volume and rest interval, regardless of the equalized intensity performed during the daily undulling protocol. In our perspective, these findings could add to training prescription evidence focusing on specifically trained populations. However, we highlight the need for more studies comparing periodization methods for different objectives and specific populations.

ACKNOWLEDGMENTS

We are grateful to all participants for their patience.

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