DIFFERENT PATTERNS IN MUSCULAR STRENGTH AND HYPERTROPHY ADAPTATIONS IN UNTRAINED INDIVIDUALS UNDERGOING NONPERIODIZED AND PERIODIZED STRENGTH REGIMENS

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ABSTRACT

De Souza, EO, Tricoli, V, Rauch, J, Alvarez, MR, Laurentino, G, Aihara, AY, Cardoso, FN, Roschel, H, and Ugrinowitsch, C. Different patterns in muscular strength and hypertrophy adaptations in untrained individuals undergoing non-periodized and periodized strength regimens. J Strength Cond Res 32(5): 1238–1244, 2018—This study investigated the effects of nonperiodized (NP), traditional periodization (TP), and daily undulating periodization (UP) regimens on muscle strength and hypertrophy in untrained individuals. Thirty-three recreationally active males were randomly divided into 4 groups: NP: n = 8; TP: n = 9; UP: n = 8, and control group (C): n = 8. Experimental groups underwent a 12-week strength training program consisting of 2 sessions per week. Muscle strength and quadriceps cross-sectional area (QCSA) were assessed at baseline, 6 weeks (i.e., mid-point) and after 12 weeks. All training groups increased squat 1RM from pre to 6 weeks mid (NP: 17.02%, TP: 7.7%, and UP: 12.9%, p ≤ 0.002) and pre to post 12 weeks (NP: 19.5%, TP: 17.9%, and UP: 20.4%, p ≤ 0.0001). Traditional periodization was the only group that increased QCSA from pre to 6 weeks mid (NP: 5.1%, TP: 4.6%, and UP: 5.3%, p ≤ 0.0006) and from pre to post 12 weeks (NP: 8.1%, TP: 11.3%, and UP: 8.7%, p ≤ 0.0001). From 6 weeks mid to 12-week period, TP and UP were the only groups that increased QCSA (6.4 and 3.7%, p ≤ 0.02). There were no significant changes for all dependent variables in C group across the time (p ≥ 0.05). In conclusion, our results demonstrated similar training-induced adaptations after 12 weeks of NP and periodized regimens. However, our findings suggest that in the latter half of the study (i.e., after the initial 6 weeks), the periodized regimens elicited greater rates of muscular adaptations compared with NP regimens. Strength coaches and practitioners should be aware that periodized regimens might be advantageous at latter stages of training even for untrained individuals.

KEY WORDS periodization, strength training, muscle cross-sectional area

INTRODUCTION

Strengthen training (ST) is widely used to increase muscular strength and mass (i.e., hypertrophy) across different populations (3,6,12,24). In this regard, the systematic manipulation of ST-related variables (i.e., training periodization) has been advocated to optimize training-induced adaptations (1).

Although there are several periodization models that can be used during an ST program, it is possible to pinpoint the 2 most common ones. Traditional periodization (TP) consists of increasing intensities and decreasing volumes throughout the training period, whereas undulating periodization (UP) is characterized by alternating high-volume low-intensity with low-volume high-intensity training sessions during training (1).

Several studies have suggested that periodized models (e.g., TP and UP) optimize strength gains when compared with nonperiodized (NP) regimens (NP—i.e., constant intensity and volume) (1,14,17,23,29). However, when volume load was equated, the few studies that have compared periodized and NP models did not report superior strength gains between training regimens (8,18,22).

Concentrating muscle hypertrophy (i.e., increase in cross-sectional area–cross-sectional area [CSA]), despite a paucity...
of data on the effects of different periodization and NP regimens on muscle mass accrual, the alleged benefits of periodized training on muscle hypertrophy have been recently challenged (8,15,16,21,22,26). In fact, only De Souza et al. (2014) investigated the effects of TP and UP schemes compared with NP using a gold standard assessment to detect changes on muscle CSA. The authors found similar improvements on muscle hypertrophy (~4.96%) between groups after 6 weeks of volume load–equated protocols (22). However, the short time frame of the training protocol does not allow further conclusions to be drawn on how NP and periodized regimens modulate muscle hypertrophy in untrained individuals over longer periods of time.

Therefore, the purpose of this study was to investigate the effects of NP, TP, and UP training regimens on muscle strength and hypertrophy in recreationally active male college students. We hypothesized that the ST-induced adaptations would demonstrate a similar pattern between experimental groups.

**METHODS**

**Experimental Approach to the Problem**

This was a randomized, parallel-group repeated-measures design, which investigated the effects of 3 different ST regimens (NP, TP, and UP) on maximum strength adaptations and quadriceps cross-sectional area (QCSA) in recreationally active male college students. All experimental groups trained 2 times a week for 12 weeks. The total number of sets and repetitions was equated between groups, whereas training intensity was manipulated differently across training groups throughout the experimental period. Maximum strength and QCSA were assessed at baseline (pre), after 6 weeks (6 weeks), and after 12 weeks (12 weeks) of training by means of back squat 1RM and magnetic resonance imaging (MRI) of the quadriceps muscle, respectively.

**Subjects**

Forty-one recreationally active male college students (age range: 19 to 33 years) engaged in sports such as soccer, volleyball, and basketball, but not undergoing regular strength and endurance training for at least 6 months before the experimental period volunteered for this study. Participants were stratified based on their pretest QCSA (e.g., CSA [mm²]). Afterward, participants were randomly assigned to the experimental groups. Participants were free from health problems and/or neuromuscular disorders that could affect their ability to complete the training protocols. In addition, they were instructed to maintain their normal diet, refrain from taking any nutritional supplements, and endure exercise throughout the study period. After the initiation of the experimental protocol, 8 participants withdrew because of personal reasons (Table 1), thus data from 33 subjects were included in the statistical analysis. All participants were informed of the inherent risks and benefits before signing a written informed consent form. The current study was approved by the School of Physical Education Review Board of University of São Paulo. Table 1 shows participants’ main characteristics.

**Procedures**

**Familiarization Sessions.** All participants completed 3 familiarization sessions interspersed by a minimum of 72 hours before the commencement of the study. During the familiarization sessions, participants performed a general warm-up consisting of 5 minutes of running at 9 km·h⁻¹ on a treadmill (Movement Technology, Brudden, São Paulo, Brazil) followed by 3 minutes of whole-body light stretching exercises. After warm-up, participants were familiarized with the back squat exercise 1RM testing protocol. Individuals were considered acquainted to the 1RM test if the coefficient of variation (CV) between familiarization sessions 2 and 3 was lower than 5%. Body position and foot placement were determined with measuring tapes fixed on the bar and on the ground, respectively. In addition, a wooden seat with adjustable heights was placed behind the subject to keep the bar displacement and knee flexion angle (~90°) constant on each squat repetition. Participants’ positioning was recorded during the familiarization

**Table 1. Participants’ characteristics.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>C</th>
<th>NP</th>
<th>TP</th>
<th>UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>25.1 ± 3.3</td>
<td>25.6 ± 6.3</td>
<td>25.0 ± 7.0</td>
<td>24.4 ± 5.2</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>173.6 ± 6.8</td>
<td>172.8 ± 6.1</td>
<td>175.3 ± 5.7</td>
<td>176.8 ± 5.3</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>76.8 ± 11.7</td>
<td>79.5 ± 13.0</td>
<td>76.0 ± 9.9</td>
<td>74.9 ± 4.2</td>
</tr>
<tr>
<td>1RM (kg)</td>
<td>126.8 ± 21.3</td>
<td>140.7 ± 23.9</td>
<td>141.1 ± 19.7</td>
<td>149.5 ± 34.6</td>
</tr>
<tr>
<td>CSA (mm²)</td>
<td>8,913.3 ± 1,041.9</td>
<td>8,801.4 ± 983.8</td>
<td>8,738.9 ± 770.8</td>
<td>8,407.6 ± 1,449.0</td>
</tr>
</tbody>
</table>

*C = control group; NP = nonperiodized; TP = traditional periodized; UP = daily undulating periodized; 1RM = one repetition maximum; CSA = cross-sectional area.

*Data are mean ± SD.
sessions and reproduced throughout the study. The CV between familiarization maximum dynamic strength assessments was 3.4%.

**Maximum Dynamic Strength Test (1RM).** After the familiarization procedures (i.e., 72 hours after the last familiarization session), lower limb 1RM was assessed using the back squat exercise on a conventional Smith machine (Portico; São Paulo, Brazil). Testing protocol followed previous recommendations (4). Participants had up to 5 attempts to achieve their 1RM load (i.e., the maximum weight that could be lifted once with the proper technique) with a 3-minute interval between trials. Each lift was deemed successful if participants touched their buttocks on the wooden seat at the end of the eccentric phase and fully extended their lower limb joints at the end of the concentric phase of the lift.

**Muscle Cross-Sectional Area.** Dominant leg QCSA was obtained through MRI (Signa LX 9.1; GE Healthcare, Milwaukee, WI, USA). Leg dominance was determined by asking the participants the preferred leg to kick a ball. Participants laid on the device in a supine position with their knees extended. Velcro straps were used to restrain leg movements during image acquisition. 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 the thigh length. Quadriceps cross-sectional area images were acquired at 50% of the segment length in 0.8-cm slices for 3 seconds. The pulse sequence was performed with a view field between 400 and 420 mm, time repetition of 350 ms, echo time from 9 to 11 ms, 2 signal acquisitions, and matrix of reconstruction of $256 \times 256$. The images were transferred to a workstation (Advantage Workstation 4.3; GE Healthcare, Milwaukee, WI, USA) for QCSA determination. In short, the segment slice was divided into the following components: skeletal muscle, subcutaneous fat tissue, bone, and residual tissue. (Figure 1) Finally, QCSA was assessed by computerized planimetry by a blinded researcher (22). The CV for QCSA assessments was 1.8%.

| Table 2. Strength training regimens throughout 12 weeks.* |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Groups                      | Wk. 1–4, 1st mesocycle     | Wk. 5–8, 2nd mesocycle     | Wk. 9–12, 3rd mesocycle    |
| Back squat                  | 3 × 8RM Monday             | 3 × 8RM Monday             | 3 × 8RM Monday             |
| Knee extension              | 2 × 8RM Thursday           | 2 × 8RM Thursday           | 2 × 8RM Thursday           |
| TP                          | Monday 3 × 12RM             | Monday 4 × 8RM             | Monday 3 × 4RM             |
| Back squat                  | 3 × 12RM Monday            | 4 × 8RM Monday             | 3 × 4RM Monday             |
| Knee extension              | 2 × 12RM Monday            | 2 × 8RM Monday             | 2 × 4RM Monday             |
| UP                          | Monday 3 × 12RM             | Monday 4 × 6RM             | Monday 3 × 4RM             |
| Back squat                  | 3 × 12RM Monday            | 3 × 10RM Monday            | 2 × 8RM Monday             |
| Knee extension              | 3 × 12RM Monday            | 3 × 6RM Monday             | 2 × 4RM Monday             |

*NP = Non-periodized; TP = traditional periodization; UP = undulating periodization.

![Figure 1. Overview of the traced dominant leg quadriceps cross-sectional area at 3 different time points (pretest, 6, and 12 weeks).](image-url)
Strength Training Regimens. The participants underwent a 12-week hypertrophy-oriented lower limb strength training regimen. Participants trained 2 days per week with 72 hours between training sessions. Strength training intensity was 4–12 RM (to failure) for both back squat (conventional Smith machine; Portico®®, São Paulo, Brazil) and knee extension (pin-loaded weight machine; Portico®, São Paulo, Brazil) exercises. A 2-minute rest interval was allowed between sets, whereas 3 minutes were respected between exercises throughout the entire study. All exercises were performed with constant speed (2-second eccentric and 2-second concentric muscle actions) and a 90° range of motion at the knee joint. The mesocycles and ST regimens adopted for each of the 3 experimental groups are presented in Table 2.

Statistical Analyses
After normality (i.e., Shapiro-Wilk) and variance assurance (i.e., Levene), a mixed model was performed for each dependent variable (volume load, maximum strength, and quadriceps CSA) assuming group (NP, TP, UP, and C) and time (pre and post) as fixed factors and participants as a random factor. Volume load was analyzed assuming group (NP, TP, and UP) and time (first, second, and third mesocycles) as fixed factors and participants as a random factor (SAS 9.4; SAS Institute, Inc., Cary, NC, USA). Whenever a significant F-value was obtained, a post hoc test with a Tukey adjustment was performed for multiple comparison purposes (25). In addition, mean difference and 95% confidence intervals of the within-group absolute difference (CI_diff) were presented. Within-group effect sizes (ES) were calculated as follows: mean post- minus mean pre- divided by the pooled SD of pretest values. The significance level was previously set at $p \leq 0.05$. Results are expressed as mean ± SD.

RESULTS

Volume Load and Training Compliance
No significant differences were observed in overall volume load between training groups NP: 100,460.1 ± 17,155.5 kg, TP: 95,642.5 ± 16,340.6 kg, and UP: 102,780.1 ± 18,119.9 kg (Figure 2A). When volume load was analyzed per mesocycle, there was a significant main effect of time ($p \leq 0.0001$); all the experimental groups significantly decreased volume at the third mesocycle when compared with the first and second mesocycles ($-26.10\%$, $-28.49\%$; $p \leq 0.0003$), respectively (Figure 2B). Training compliance was 95.17% (i.e., 22.8 sessions).

<table>
<thead>
<tr>
<th>Group</th>
<th>(1RM kg) pre</th>
<th>(1RM kg) 6-wk</th>
<th>(1RM kg) 12-wk</th>
<th>ES-pre-6 wk</th>
<th>ES-6 wk-12 wk</th>
<th>ES-pre-12 wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>126.8 ± 21.30</td>
<td>127.68 ± 21.62</td>
<td>132.05 ± 20.12</td>
<td>0.03</td>
<td>0.14</td>
<td>0.20</td>
</tr>
<tr>
<td>NP</td>
<td>140.76 ± 23.9</td>
<td>164.87 ± 31.2†</td>
<td>170.95 ± 36.85†</td>
<td>0.95</td>
<td>0.19</td>
<td>1.19</td>
</tr>
<tr>
<td>TP</td>
<td>141.15 ± 19.57</td>
<td>152.96 ± 31.82†</td>
<td>166.43 ± 30.29††</td>
<td>0.45</td>
<td>0.38</td>
<td>0.99</td>
</tr>
<tr>
<td>UP</td>
<td>149.57 ± 34.67</td>
<td>167.35 ± 36.01†</td>
<td>178.35 ± 36.76†</td>
<td>0.70</td>
<td>0.58</td>
<td>1.13</td>
</tr>
</tbody>
</table>

*ES = within-group effect size; NP = nonperiodized; TP = traditional periodization; UP = undulating periodization.

$p \leq 0.05$ when compared with pre (within-group comparisons).

References

Figure 2. Volume load. A- Total volume load, B-Volume load per mesocycle. *$p \leq 0.05$ when compared with first mesocycle (main time effect). # $p \leq 0.05$ when compared with second mesocycle (main time effect).
Maximum Dynamic Strength

No significant between-group differences in maximum dynamic strength were detected at pretest ($p > 0.05$). There was a significant group by time interaction ($p = 0.002$) in which squat 1RM values significantly increased in all training groups from pre to 6 weeks (NP: $17.0\% - \Delta_{\text{diff}}$ mean 25.1 kg, 13.9–36.2 kg; TP: $7.7\% - \Delta_{\text{diff}}$ mean 11.8 kg, 1.3–22.3 kg; UP: $12.9\% - \Delta_{\text{diff}}$ mean 17.7, 6.6–28.9 kg) and from pre to 12 weeks (NP: $19.5\% - \Delta_{\text{diff}}$ mean 28.1 kg, 16.9–39.2 kg; TP: $17.9\% - \Delta_{\text{diff}}$ mean 252 kg, 14.7–35.7 kg; UP: $20.4\% - \Delta_{\text{diff}}$ mean 28.7, 17.6–39.9 kg). In addition, TP was the only group that significantly increased squat 1RM from 6 to 12 weeks (9.4%–$\Delta_{\text{diff}}$ mean 13.4 kg, 2.9–23.9 kg, $p = 0.008$). However, there was a strong trend towards significant increase at the same period for UP group (6.9%–$\Delta_{\text{diff}}$ mean 11.0, −0.141 to 22.1 kg, $p = 0.053$). There were no significant differences from 6 to 12 weeks in NP group (1.5%–$\Delta_{\text{diff}}$ mean 2.9 kg, −8.1 to 14.1 kg, $p = 0.79$). There were no significant changes in RM for C group across time ($p \geq 0.05$) (Table 3).

Quadriceps Muscle Cross-Sectional Area

No significant between-group differences in QCSA were detected at pretest ($p > 0.05$). There was a group by time interaction ($p = 0.0006$). Quadriceps cross-sectional area increased significantly in all training groups from pre to 6 weeks (NP: $5.1\% - \Delta_{\text{diff}}$ mean 453.1 mm$^2$, 159.1–743.9 mm$^2$; TP: $4.6\% - \Delta_{\text{diff}}$ mean 409.8 mm$^2$, 134.9–685.0 mm$^2$; UP: $5.3\% - \Delta_{\text{diff}}$ mean 414.5 mm$^2$, 122.4–706.6 mm$^2$) and from pre to 12 weeks (NP: $8.1\% - \Delta_{\text{diff}}$ mean 715.0 mm$^2$, 422.9–1,007.0 mm$^2$; TP: $11.3\% - \Delta_{\text{diff}}$ mean 991.7 mm$^2$, 716.2–1,267.0 mm$^2$; UP: $8.7\% - \Delta_{\text{diff}}$ mean 749.9 mm$^2$, 457.7–1,042.0 mm$^2$). In addition, only TP and UP significantly increased QCSA from 6 to 12 weeks (TP: $6.4\% - \Delta_{\text{diff}}$ mean 581.9 mm$^2$, 306.5–857.3 mm$^2$; UP: $3.7\% - \Delta_{\text{diff}}$ mean 335.4 mm$^2$, 43.2–672.6 mm$^2$, $p = 0.02$). NP demonstrated a weak trend toward significant increase in QCSA (2.8%–$\Delta_{\text{diff}}$ mean 263.8 mm$^2$, −28.3 to 555.9 mm$^2$, $p = 0.008$), whereas there were no significant changes in C group for QCSA across time ($p \geq 0.05$) (Table 4).

**DISCUSSION**

The purpose of the current study was to investigate the effects of different training regimens on muscle strength and hypertrophy in recreationally active male college students. Data support the hypothesis of similar ST-induced gains in muscle strength and mass after 12 weeks of training between experimental groups. Even though there were no significant differences between training groups both at 6 and 12 weeks of training, our within-group analyses suggest that after 6 weeks of an NP regimen, maximum strength improvements were suboptimal when compared with periodized regimens. In addition, periodized training programs seem to be more effective than NP training programs at latter stages of training, as only these groups presented significant increases in muscle mass from the 6 to 12 weeks of training.

After 12 weeks of training, similar strength gains (−20%) were observed between groups. Our data are in agreement with previous literature demonstrating similar strength improvements following NP and periodized training models in untrained individuals (2,16,24). Interestingly, despite comparable end points, time course in strength gains was different across groups. For instance, although not statistically significant, the NP group seemed to have the greatest rate of change in 1RM after 6 weeks (17%) compared with all the other groups (TP = 8%; UP = 12%) (Table 3). However, NP did not improve 1RM in the last 6 weeks of training (1.5%, $p = 0.79$). However, UP demonstrated a strong trend (6.9%, $p = 0.053$) and TP significantly increased 1RM (9.4%, $p = 0.008$) at the latter phase of the study. Although it is attractive to suggest that periodized models may add a benefit to strength gains, the specificity might, at least, explain our results. For example, the TP was the group that performed more training sessions at higher intensities during the second part of the study (e.g., TP: 4 sessions at 8RM and 8 sessions at 4RM), whereas UP group performed 2 sessions at 10RM, 2 sessions at 6RM, 4 sessions at 8RM, and 4 sessions at 4RM. Therefore, TP and UP had more sessions at higher intensities than NP group, which can explain why the periodized groups demonstrated better
strength gains at the second half of the study. In addition, a recent meta-analysis suggested that periodized models have a small to moderate effect on 1RM compared with NP models. Importantly, those authors reported that study length was positively related to 1RM changes in periodized models (28). In this regard, the second half of our study partially agrees with the outcomes reported by this recent meta-analysis, as ES from 6 to 12 weeks suggests a small advantage for the periodized regimens (Table 3).

Furthermore, 1 benefit of periodization that has been underrated for untrained individuals is that varying training stimulus more frequently may enhance recovery and allow subjects to manage fatigue properly. It is noteworthy mentioning that reduction in the overall number of repetitions at the third mesocycle was only planned for the periodized groups (i.e., TP and UP), whereas NP kept the total number of repetitions constant. Despite a greater total number of repetitions in the third mesocycle (i.e., NP: 320, TP: 160 and UP: 224), NP demonstrated similar reduced volume loads when compared with TP and UP groups. Although interesting, it is difficult to determine what produced an inability to sustain volume load during the last mesocycle by the NP group. One important characteristic of the current study was that all sets were performed until failure. Although there is no consensus on the efficacy of training to failure on strength gains, some studies have suggested that fatigue and training to failure may not be critical for strength gains in untrained individuals (7,9). Therefore, our findings suggest that even for untrained individuals, ST planning is important to reduce fatigue and maximize strength gains over longer periods of time.

Regarding muscular hypertrophy, the training groups exhibited similar increases in QCSA after 12 weeks (e.g., NP: 8.1%, TP: 11.3%, and UP: 8.7%). To this point, the study has investigated the short-term effects of periodized and NP regimens on QCSA, which demonstrated similar changes between the groups (22). Furthermore, the studies have compared the effects of TP and UP on muscle hypertrophy parameters (i.e., CSA and muscle thickness) reported no differences between the groups (13,16,21). In fact, a recent meta-analysis comparing TP and UP demonstrated that in matched volume load studies there is no evidence supporting that 1 periodized regimen can produce greater hypertrophic adaptations (10). In addition, a systematic review demonstrated an average increase in QCSA of 8.5% after different ST regimens (27). Therefore, from pretest to 12 weeks, the magnitude of muscular hypertrophy reported in the current study was similar between groups, and it is in agreement with previous literature. Nonetheless, the within-group ES from pretest to 12 weeks suggest a small advantage for the magnitude of muscle hypertrophy of the periodized groups when compared with NP regimen (Table 4).

Yet, as observed with the strength data, despite similar increases overall, muscle hypertrophic responses differed between groups over time. Only periodized training regimens significantly increased QCSA in the second half of the study (i.e., from 6 to 12 weeks). However, it is important to mention that the magnitude of muscle hypertrophy was similar across the group from 6 to 12 weeks. In our study, the total number of repetitions was very similar between groups before the commencement of the experimental period, whereas there were no differences in volume load. Our group has previously demonstrated that after an 8-week ST period, reductions of ~54% in volume load were sufficient to sustain QCSA during additional 8 weeks of reduced volume load training in untrained individuals (24). In this respect, although volume load was not significantly different between groups, the 2 groups that reduced volume load the most during 7–12 weeks when compared with 1–6 weeks (i.e., TP: −20.5% and UP: −18.7% vs. NP: −7.3%) and trained at higher intensities were the only groups to show significant muscle hypertrophy in that period. These outcomes suggest that even in untrained individuals, ST planning may affect the time course of muscular adaptations. Finally, although low-load schemes have been shown to be efficient as heavy-load regimens inducing muscle hypertrophy (19), our findings are in agreement with previous literature in untrained individuals demonstrating that in volume load–equated conditions, muscle hypertrophy might favor higher training intensities (5,11,20).

Certainly, our study has inherent limitations. For example, although the participants were strictly instructed to maintain their normal diet, the lack of diet control might be a confounding factor modulating muscle hypertrophy in different directions. Second, longer training periods and more exercise variation would provide further insight into the effects of training variability on muscle adaptations. Finally and perhaps the most important is that periodization is not a strict defined program. Rather, it is a concept that encompasses different ways to manipulate training variables. In this regard, a study scrutinizing the effects of training regimens used in our study on muscle hypertrophy while manipulating training variables in a different fashion might report outcomes different from the reported herein.

In conclusion, our results demonstrated similar ST-induced adaptations after 12 weeks of either NP or periodized training regimens. Importantly, NP training stimulus seems to induce suboptimal muscular adaptations at latter training stages (i.e., after the initial 6 weeks), suggesting that, even for untrained individuals, ST planning might be important to manage fatigue and optimize training-induced adaptations.

Practical Applications
Strength coaches and practitioners focusing on improving muscular adaptations in untrained individuals should be aware that early-phase (≤6 weeks) organization of training loads does not significantly affect strength or hypertrophy, although NP may produce slightly greater strength gains.
than the other groups. However, periodized ST models may be advantageous at latter stages of training (after the initial 6 weeks), properly adjusting training stimuli and ultimately optimizing muscular adaptations (i.e., strength performance and hypertrophy) in untrained individuals.

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