Effect of 29 Weeks of Periodized Soccer Training on the Neuromuscular Performance of Soccer Players Under 20 Years of Age

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¹Department of Science of Human Movement, Methodist University of Piracicaba, Piracicaba, São Paulo, Brazil, ²Faculty Adventist of Hortolândia (UNASP), Hortolândia, São Paulo, ³Post-graduate program in Food and Nutrition, Nutritional Sciences, São Paulo State University (UNESP), Araraquara, SP, Brazil

ABSTRACT

Corrêa DA, Soares DS, Gonelli PRG, Cesar MC, Sindorf MAG, Crisp AH, Verlengia R, Balbino HF, Lopes CR. Effect of 29 Weeks of Periodized Soccer Training on the Neuromuscular Performance of Soccer Players Under 20 Years of Age. JEPonline 2016;19(4):32-41. The purpose of this study was to investigate the effects of 29 weeks of periodized soccer training (linear during pre-season and ondulatory during the competitive period) on the neuromuscular performance of soccer players under 20 yrs of age. Ten regionally ranked male athletes (19.2 ± 1.3 yrs, body mass 71.1 ± 6.8 kg, height 179.0 ± 0.2 cm) participated in this study. The pre-season physical training program lasted 9 wks. The competitive period lasted 19 wks. The assessments were conducted at specific times during training periodization: baseline, 4, 8, and 19 wks. The results showed improvements in squat jump performance and maximal strength during the pre-season and the competitive period, respectively. On the other hand, repeated sprint ability and the 15-m sprint performance were reduced at the end of competitive period. Thus, the findings indicate that 29 wks of periodized soccer training increased the soccer players’ maximum strength and maintained their vertical jump performance. However, the models adopted did not improve repeated sprint ability and the 15-m sprint time.

Key Words: Periodization, Soccer, Sports Training, Sprint
INTRODUCTION

Soccer is an intermittent sport modality that requires intense aerobic and anaerobic training. The athlete’s motor actions during the game are performed at high-intensity while running long and short durations that include sprinting, dribbling, kicking, tackling, and others athletic skills. These actions as well as high levels of strength, velocity, and power are required of soccer athletes (2,9,10).

Physical training periodization is recognized as an effective method for the development of athletic performance (17). The planning and distributions of external training loads during pre-season are designed to increase the athlete’s neuromuscular performance (5,12). During the competitive period, long tournaments are common. Soccer training is then characterized by an increase in attention given to technical and tactical training with a decrease in time devoted to physical training (8,11).

The reduction in physical training during the competitive period is necessary to ensure proper recovery between the soccer games (8). As a result, the competitive period is commonly associated with significant changes in the athlete’s physical abilities acquired during the pre-season (3). This is why it is important to plan for the maintenance of the athlete’s physical abilities (6,7).

Among the theoretical periodization models, linear periodization is the most commonly applied to young soccer athletes. Recently, Hermassi and colleagues (9) have proposed an undulatory periodization model for soccer athlete that has been shown to increase sprint and muscle strength performance. Interestingly, in this regards, the undulatory periodization model was proposed initially by Poliquin (13) with the expectation to generate variations in the athlete’s training loads with greater frequency compared to linear periodization.

In our point of view, the use of different periodization models contributes to an increase in control of the training loads and adaptive responses in accordance with the characteristics of physical training period. Thus, the purpose of this study was to investigate the effects of 29 wks of periodized soccer training (linear during the pre-season and undulatory during the competitive period) on the neuromuscular performance of under-20 soccer players. It was hypothesized that linear periodization would result in physical fitness improvements and undulatory linear periodization would result in in physical fitness maintenance in the young soccer athletes.

METHODS

Subjects
Ten under-20 male athletes (age 19.2 ± 1.3 yrs, body mass 71.1 ± 6.8 kg, height 179.0 ± 0.2 cm) volunteered to participate in this study. All the subjects were members of the men’s soccer teams and participants in state-level competitions. The inclusion criteria were: (a) at least 2 yrs of competitive soccer training; (b) at least 1 yr of resistance training experience; and (c) free of injury prior to the study (one-month at minimum). All the athletes voluntarily signed an informed consent to participate in the study. For athletes under age of 18 yrs, parental or guardian informed-consent forms were submitted prior to the study. The study was approved by local Research Ethics Committee (80/12).
Experimental Design
A longitudinal study design (29 wks) was conducted to assess the effects of linear training periodization during pre-season (9 wks) and the effects of ondulatory training periodization during the competitive period (19 wks) on the neuromuscular performance of under-20 soccer player. In the week prior to the pre-season physical training baseline, the following tests were assessed: (a) 1RM strength; (b) squat jump (SJ); (c) counter movement jump (CMJ); (d) 15-m sprint; and (e) repeated sprint ability (RSA).

The soccer team performed 145 physical training sessions during this study. The physical tests were repeated during physical training periodization at specific times: 4 wks (M1), 8 wks (M2), and 29 wks (M3). Prior to testing, the subjects performed a standard warm-up that included 3 min of jogging at comfortable speed, 4 sets of 10-m short sprints, and light stretching exercises of the lower extremities. All athletes were familiar with the tests protocols, and they were encouraged to make a maximum effort during the tests. Figure 1 illustrates the experimental design of the study.

![Figure 1. Illustrative Scheme of the Design of the Study.](image)

Training Periodization
The soccer team performed two training periodization models. The pre-season period lasted 9 wks and the physical training content was distributed by linear periodization. Maximum strength training was considered with greater importance during the first 4 wks of physical training (12 physical training sessions). After these 4 wks, the physical training emphasis was for power training (12 physical training sessions). The sprint training was conducted once a week during the pre-season (9 physical training sessions), which occurred in a separated period of resistance training. Endurance training was performed by small-side games two times a week during the pre-season (18 physical training sessions). The physical training during the pre-season are describe below:

- **Maximum Strength Training** was performed during 1 to 4 wks. The training sessions were performed three times a week (Monday, Wednesday, and Friday). Each session consisted of 3 sets of 3 RM for the bench press, seated row, back squat, and power clean exercises. The rest interval between sets was 3 to 5 min.
• **Power Training** was performed during 5 to 9 wks. The training sessions were performed three times a week (Monday, Wednesday, and Friday). Each session consisted of 4 sets of 8 multiple jump and drop jump (40 to 60 cm). The rest interval between sets and exercise was 2 to 5 min.

• **Endurance Training** was performed during 1 to 9 wks. The training sessions were performed two times a week (Tuesday and Tuesday). Each session consisted of 2 min of small-side games with three players per team. The games were performed on a natural-grass soccer pitch (30 m wide and 30 m in length) and goalkeepers were added. There was a maximum of two ball touches per player and when this occurred, players were immediately replaced. This was done to maintain the game intensity. The rest interval between sets was 4 min.

• **Sprint Training** was performed during 1 to 9 wks. The training session was performed once a week (Monday). It consisted of 4 sets of eight 15-m sprints. The rest interval between sprints was 2 min.

The competition period lasted 20-wks and the physical training content was distributed by ondulatory periodization. During the competitive period, the purpose of the physical training program was to maintain the athletes' power and maximum strength capabilities (20 physical training sessions for each) acquired during the pre-season. Additionally, endurance strength training was conducted one time a week during the competitive period (20 physical training sessions). The soccer games occurred once a week on Saturday or Sunday. The physical training during competition period is described below:

• **Maximum Strength Training** was performed during 10 to 29 wks. The sessions were performed once a week (Monday). Each session consisted of 3 sets of 3 RM for the bench press, seated row, back squat, and power clean exercises. The rest interval between sets was 3 to 5 min.

• **Power Training** was performed during 10 to 29 wks. The sessions were performed once a week (Wednesday). Each session consisted of 4 sets of 8 continuous jumps over 40- to 60-cm obstacles. The rest intervals between sets and exercise were 2 to 5 min.

• **Endurance Strength Training** was performed during 10 to 29 wks. The sessions were performed once a week (Friday). Each session consisted of 3 sets of 15 RM for back squat, power clean, bench press, seated rows, stiff-legged deadlift, calf raise, abdominal crunch, and lower back extension). The rest intervals between sets were 1 min and 2 to 3 min between exercises.

**Measures**

**1RM Strength Test**
Maximal muscle strength was measured by 1RM test for half back squat exercise (Smith Machine), according to the procedures described by Brow and Weir (1). Briefly, the subjects performed a warm-up of 2 to 3 sets of 5 to 10 repetitions at ~50% of their estimated 1RM
before the protocol. During the exercise performance, the subjects were required to execute the squat to knee angles of 90°. The test was performed with a maximum of five attempts with a rest interval of 3 to 5 min between each attempt.

**Vertical Jumping**
Two vertical jumps (squat jump and counter movement jump with use of the arms) were measured using a jump platform (CEFISE®, Brazil). Each subject performed the SJ and CMJ 3 times to determine jump height (cm). The jumps were performed in following order: SJ and CMJ with 1 min rest interval between jumps. The SJ was conducted with subject starting from half-squat position (~120° knee angle), with the trunk straight and both hands positioned on the hips, and after verbal stimulus the jumped with no counter movements. For CMJ, subjects started in a standing position with the truck straight, after a verbal stimulus the subject performed a vertical jump with an earlier fast counter movement with the arms. The best jump height was considered for analysis.

**Repeated Sprint Ability**
The RSA was determined by Running Anaerobic Sprint Test (RAST) protocol in accordance with the procedures described by Zagatto et al. (14). The RSA protocol consisted of 6 sprints of 35 m with a 10-sec rest interval between sprints. The time to complete 35 m was assessed using two photocells (CEFISE® Standard photocells, Brazil). The test was conducted on an official soccer field. The athletes wore standard training clothing and soccer boots. Analysis included: total time (sum of 6 sprints), ideal time (best sprint time multiplied by 6) and percentage performance decrement ([total time ÷ ideal time * 100] – 100) (4).

**15-M Sprint Performance**
The determination of 15-m sprint times was performed on a natural-grass soccer field. The athletes wore standard training clothing and soccer boots. The athletes were positioned behind the start line (0.5 m) and were instructed to perform the sprint with maximal effort, after a start signal. The time to complete 15 m was assessed using two photocells (CEFISE® Standard photocells, Brazil). Each athlete performed two attempts with a rest interval of 1 min. The best result was recorded.

**Statistical Analyses**

Data normality and homogeneity were confirmed by the Shapiro-Wilk and Levene’s test. A one-way repeated measures (ANOVA) followed by the Turkey post hoc test were used to statistically analyzed the data. The effect size (ES) was calculated according to Cohen (1992). The thresholds were based on the following criteria: (a) small (<0.40); (b) moderate (0.40-0.70); (c) large (0.70-1.00); and (d) very large effect (>1.0). The level of significance was set at 5%. Data are expressed as mean ± standard deviation.

**RESULTS**

Table 1 shows the data from the RAS test. A significant (P<0.05) decrease in total sprint time was observed for M3 compared with M2 (ES = 0.36, small), M1 (ES = 0.29, small) and baseline (ES = 0.38, small) measurements. Additionally, a significant (P<0.05) decrease for ideal sprint time for M3 in relation to M1 (ES = 1.10, very large), M2 (ES = 1.07, very large),
and baseline (ES = 1.05, very large) measurements. However, no significant changes were observed for sprint performance decrement between measures.

Table 1. Mean Values of Repeated Sprint Ability Test

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total Time</strong></td>
<td>31.17 ± 1.03*</td>
<td>31.21 ± 1.46*</td>
<td>31.20 ± 0.95*</td>
<td>31.62 ± 1.32</td>
</tr>
<tr>
<td><strong>Ideal Time</strong></td>
<td>28.81 ± 0.75*</td>
<td>28.81 ± 0.52*</td>
<td>28.73 ± 0.93*</td>
<td>30.16 ± 1.65</td>
</tr>
<tr>
<td><strong>Performance Decrement (%)</strong></td>
<td>8.20 ± 2.77</td>
<td>8.30 ± 4.40</td>
<td>8.67 ± 3.44</td>
<td>8.30 ± 3.43</td>
</tr>
</tbody>
</table>

*Significant (P<0.05) difference compared to M3. Values are mean ± SD

Table 2 shows the data from the vertical jump and the 15-m sprint tests. Significant (P<0.05) increase was found in the SJ test for M1 (ES = 0.60, moderate effect), M2 (ES = 0.54, moderate effect), and M3 (ES = 0.23, small effect) in relation to the baseline measurement. No significant (P>0.05) increase in CMJ test were detected for M1 (ES = 0.32, small effect), M2 (ES = 0.21, small effect), and M3 (ES = 0.24, small effect) compared to the baseline measurement. Regarding the 15-m sprint time, significant decreases were observed for M2 (ES = 0.87, large) and M3 (ES = 1.29, very large) compared to the baseline measurement.

Table 2. Mean Values of Vertical Jump and 15-M Sprint Test.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SJ (cm)</strong></td>
<td>37.07 ± 4.24</td>
<td>39.60 ± 4.07*</td>
<td>39.46 ± 4.57*</td>
<td>38.00 ± 3.65</td>
</tr>
<tr>
<td><strong>CMJ (cm)</strong></td>
<td>45.64 ± 4.86</td>
<td>47.15 ± 4.56</td>
<td>46.73 ± 5.45</td>
<td>47.00 ± 6.53</td>
</tr>
<tr>
<td><strong>Sprint 15 (sec)</strong></td>
<td>2.27 ± 0.09</td>
<td>2.31 ± 0.06</td>
<td>2.34 ± 0.07*</td>
<td>2.38 ± 0.08*</td>
</tr>
</tbody>
</table>

*Significant (P<0.05) difference compared to baseline. Values are mean ± SD

Significant differences for the 1RM strength test were detected for baseline vs. M1 (105.80 ± 12.80 vs. 124.80 ± 12.76 kg; ES = 1.49, very large effect), M2 vs. M3 (110.00 ± 14.14 vs. 142.00 ± 18.73 kg; ES = 1.93, very large effect), and M3 vs. baseline (ES = 2.26, very large effect) (Figure 2).
DISCUSSION

The purpose of this study was to investigate the effects of 29 wks of periodized soccer training during pre-season (9 wks linear periodization) and competition period (20 wks ondulatory periodization) on neuromuscular performance of under-20 soccer players. The main findings were: (a) RSA and a 15-m sprint performance were reduced in the end of competitive period; (b) improvements in SJ performance during pre-season; and (c) significant improvements in maximum strength compared to baseline measurements.

The objectives of the organization of the physical training sessions were to promote physical and technical peak performance for competition and/or maintain optimal levels of physical capabilities during the competitive season, to ensure adequate recovery, to reduce potential overtraining responses, and to avoid a plateau in performance. While several theoretical models of periodization were investigated in the literature (11,12,14), the present study examined the effects of linear (preparatory period) and ondulatory periodization (competitive period) in soccer players.

The findings indicate that linear periodization adopted during the preparatory period affects positively some neuromuscular responses. Specifically, there was an improvement in the soccer players’ squat jump performance during the M1 and M2 periods while maximal strength increased during the M1 period. On the other hand, the players’ counter movement jump and RAS were not affected by linear training periodization. Additionally, the 15-m sprint time performance decreased at the M2 period. These data indicate that the effects of linear periodization on neuromuscular performance are unclear, and possibly an overreaching state induced during pre-preparatory may have interfered with some performance parameters.
Given that the soccer players' 15-m sprint and RAS performance were reduced during the competitive period, the ondulatory periodization model adopted during the competitive period was not effective in maintaining important physical capabilities required of high performance soccer players. In contrast to these findings, Lopes and colleagues (11) indicated that ondulatory periodization during a short-term preparatory period (4 wks) improved maximum strength and 15-m sprint performance in under-20 soccer players. Hence, our hypothesis that ondulatory periodization during the competitive period would favor the maintenance of physical capabilities was not confirmed.

On the other hand, ondulatory periodization did result in improvements in the under-20 soccer players' maximal strength (1RM). But, the observed improvement in maximal strength during a resistance exercise (half-back squat) did not have a direct transfer to more specific physical tests such as the 15-m sprint time and RAS. A limitation in the study is that the training load was not quantified in the weeks that interceded the preparatory and competitive periods. Had the training load been quantified, it might have helped in the comparisons between the periods on the volume of training.

CONCLUSIONS

The present study demonstrated that 29 wks of periodized soccer training resulted in an increase in maximum strength while maintaining the soccer players' vertical jump performance. However, the models adopted did not improve repeated sprint ability and the players' 15-m sprint time.

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