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The Influence of 16-weeks of Periodized Resistance Training on Vertical Leap and TW20meters Performance Tests for Volleyball Players

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Abstract

The aim of this study was to evaluate the influence of 16 weeks of periodized resistance training (pre-season) on vertical leap measurements and performance in a test specific to volleyball (TW20meters). This study investigated 13 volleyball players participating in state-level competitions. Vertical leap and TW20meters assessments were performed before (baseline) and after the fifth, ninth, thirteenth, and the sixteenth weeks of physical training. Progressive improvement ($P < 0.001$) was observed throughout the pre-season compared to baseline values for both tests. In conclusion, periodized resistance training was effective in promoting improvements in vertical leap performance and in a test specifically for volleyball. These data indicate that TW20meters is a test that can be used to detect changes in physical performance induced by resistance training in athletes playing volleyball.

Keywords: resistance training, periodization, volleyball, physical evaluation

Introduction

Volleyball is a sport with an intermittent pace characterized by frequent high intensity and short duration motor actions (jumps, attack moves and blocks), followed by periods of low intensity. Such actions are influenced by the efficiency of the anaerobic metabolism, with the aerobic metabolism contributing to the recovery and maintenance of physical performance (Hedrick, 2007; Sheppard et al., 2009).

Several studies show that higher-level athletes had better values for physical and anthropometric capabilities, compared to lower-level athletes also playing volleyball. (Smith et al., 1992; Forthomme et al., 2005; Malousaris et al., 2007; Gabbett and Georgieff, 2007; Sheppard et al., 2009) Therefore, modern volleyball requires a high level of physical fitness in addition to technical and tactical performance.

In order to maximize the adaptive responses and performance of athletes, volleyball teams implement other physical training systems in addition to the specific physical training on-court, especially during preseason. Among the systems used, resistance training is recognized as an effective method for the development of neuromuscular capacity and it improves competitive performance. Manipulation of acute variables in resistance training (intensity, volume, pauses and others) and their distribution over time, allows for the development of physical capabilities such as endurance, maximum strength and power. (Bird, 2005)

During preseason assessment of physical fitness, it is necessary to monitor and guide physical training routines. Among physical tests, the vertical leap is considered one of the most important motor actions in a volleyball match. (Ziv and Lidor, 2010)

According to a protocol commonly used for physical evaluation in volleyball, the height reached in the vertical leap test reflects the power of the lower limbs (Cronin and Sleivert, 2005). However, volleyball lacks specific protocols that take into account specific motor actions that receive simultaneous inputs from multiple physical capabilities.

Thinking of specific motor patterns, Pellegrinotti and Souza (2001) developed a protocol called the TW20meters to assess the physical performance of volleyball players on the court, through motor actions that simulate real game situations (short sprints, jumps in blocking situations, and changes of direction. In a recent study conducted with female volleyball players (Nascimento et al., 2013), the TW20meters test was performed at high intensity and was correlated with the power of the lower limbs (vertical leap). Evaluation methods that take the specific motor patterns of the sport into consideration are important tools for strength and conditioning coaching, allowing for monitoring of team physical performance both in the training environment and during competition while respecting the particularities of the sport.

The objective of this study was to evaluate the influence of a periodized resistance-training program on vertical leap capability and performance in TW20meters tests of volleyball players during the preseason. Our hypothesis was that periodized resistance training is effective for the progressive improvement throughout the preparatory period in vertical leap performance and in this test specific to volleyball.

Methodology

Subjects

The study included thirteen athletes of mean age 25 ± 1, body mass 75 ± 9 kg and height 179 ± 1 cm. All were members of an adult men's volleyball team and participants in state-level competitions. All athletes had practiced the sport for at least two years and were free of injury prior (one-month at minimum) to the study. The athletes voluntarily signed a free and informed consent form after being informed about the procedures related to the research. The study was approved by the local Research Ethics Committee (protocol n ° 82/11).

Experimental Design

This longitudinal study (16 weeks) was conducted to analyze the influence of resistance training on performance in the vertical leap and in the volleyball-specific test (TW20meters). Physical assessments (1RM test, vertical leap, and the TW20meters) were carried out before (pre) and after the fifth (A1), ninth (A2), thirteenth (A4) and the sixteenth (A5) weeks of physical training. The 1RM test and other evaluations were performed on different days, with a minimum interval of 48 hours.

1RM Test

Determination of maximal muscle strength was assessed using the 1RM test in all the exercises scheduled for each team-training phase, except for abdominal exercises. Each athlete performed 2-3 sets of 5-10 repetitions with ~ 40-60% of 1RM estimated. After warming up, each athlete was required to perform a single maximum muscle action. The test was performed with a maximum number of five attempts per exercise, with a rest interval of 3-5 minutes (Lopes et al., 2012). The evaluation was monitored by two experienced trainers and athletes were already familiar with the 1RM test in all exercises.

Test TW20meters

The TW20meters test was performed in a covered gym (team training site) with the demarcation of the test course in the form of a "W" according to the procedures described by Nascimento et al., (2013). The route consisted of 18.8 meters of running with five changes of direction and three 20 cm vertical leaps adjusted according to the height of each athlete (20 cm above the middle fingers with arms outstretched). For each jump we measured 40 cm of distance, 20 cm to jump and touch a delimiter tape and 20 cm to return to the starting position. These jumps are conducted at the beginning, middle and end (near the net) of the course, adding 1.20 m in vertical leap actions. Thus, the test totals 20 meters (18.80 meters of running + 1.20 meters of vertical leaps) for each round in the course. The test lasted six minutes and the athlete should go as far as possible, starting from the left side of the offensive line. Along the course, the athletes performed vertical leaps with technical blocking movements, touching his fingertips to the delimiter tape. The test was preceded with five minutes of standardized warm ups (running, jumping and stretching). Figure 1 illustrates the course of TW20meters test. For analysis we recorded the maximum distance run during the test.

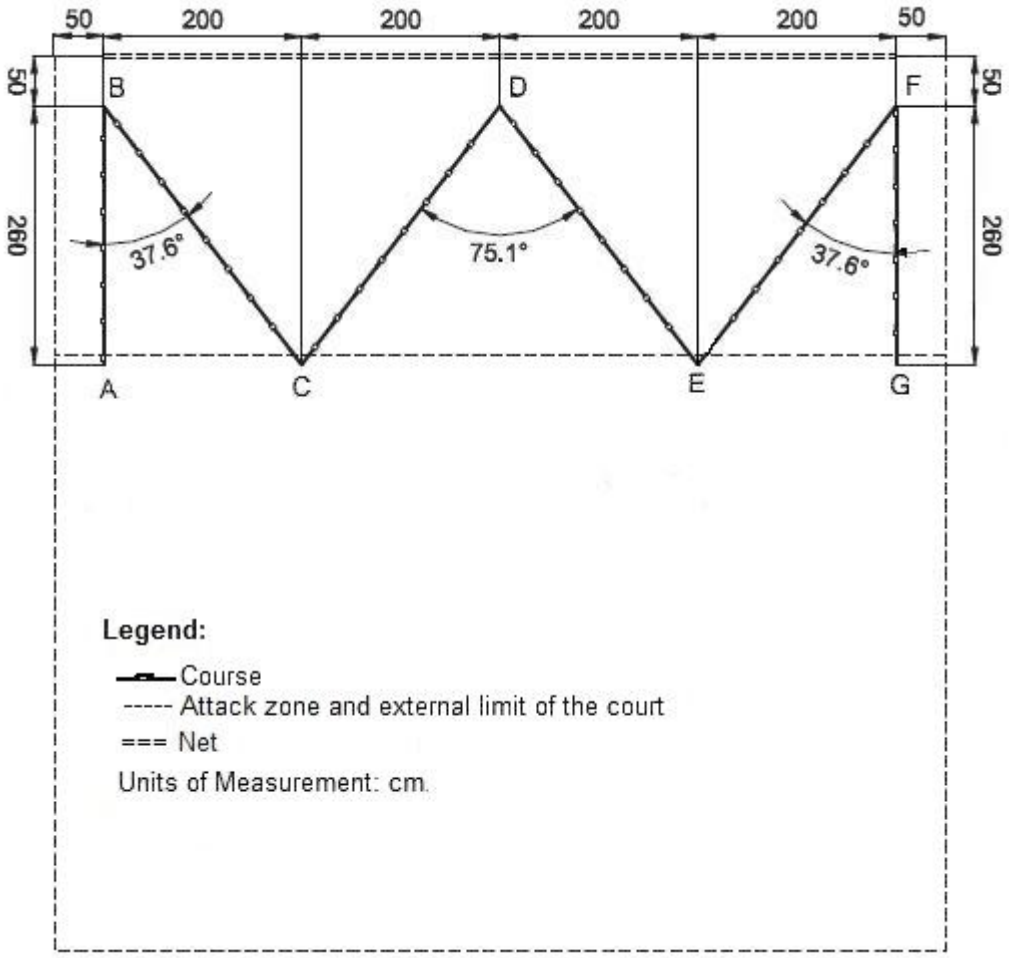

Figure 1. Course demarcation for the TW20meters test. A to B = 260 cm; B to C = 340 cm; C to D = 340 cm; D to E = 340 cm; E to F = 340 cm; and F to G = 260 cm.

Vertical Leap Test

The test to determine vertical leaping capacity was performed as described by Hertogh et al. (2005). Athletes were standing with arms extended overhead; a small mark was made with chalk dust applied to the fingertips at the highest point that each athlete could reach on a scale attached to the wall. Then, each athlete performed a small flexion of the knees and jumped, marking another point on the scale at highest point reached. Each athlete performed three attempts, and the baseline value was subtracted from the highest jump.

Physical Training

The periodization and physical training program was developed and implemented by the volleyball team's technical committee and had no researcher influence or interference. The program consisted of two cycles, described by the strength and conditioning coaches as: the basic preparatory period (BPP) and the specific preparatory period (SPP). Resistance training sessions were performed on the same days (Monday through Friday) with volleyball specific training sessions on the court (Monday through Friday), but in different periods (resistance training: between 12:00 and 13:30; volleyball specific training between 16:00 and 18:00).

Specific training sessions were composed of: plyometric jumps; short sprints; agility circuits; medicine ball throws (3 kg) and a technical/tactical training session lasting approximately 2 hours.

The BPP lasted 10 weeks, and endurance strength capacity was emphasized. The selection and order of resistance exercises were: bench press, squat hack, row; leg press (45 °); triceps curl; biceps curl; calf raise; lateral rise; tibial anterior; abdominal crunch; deadlift; abdominal side crunch. The coordination of acute variables is described below:

- 1st-2nd weeks: 1 set - 15-20 repetitions (50% 1RM) - 1 min rest interval;
- 3rd-5th weeks: 2 sets - 12-17 repetitions (60% 1RM) - 1 min rest interval;
- 6-8th weeks: 3 sets - 12-17 repetitions (60-70% 1RM) - 1 min rest interval;
- 9-10th weeks: 4 sets - 10-15 repetitions (70% 1RM) - 1 min rest interval.

The SPP was divided into two phases, each lasting 3 weeks. The first phase emphasized maximum strength. The choice and order of strength exercises were: hack squat; row; leg press (45 °); triceps curl; biceps curl; calf raise; lateral rise; tibial anterior; abdominal crunch; deadlift and abdominal side crunch. The coordination of acute variables is described below:

- 11th week: 4 sets - 6-8 repetitions (80% 1RM) - 3 min rest interval;
- 12-13th weeks: 3 sets - 4-7 repetitions (80-85% 1RM) - 4 min rest interval.

The second phase emphasized the development of muscle power. The choice and order of the exercises were: bench press; row; back squat (60°); triceps curl; biceps curl; deadlift; abdominal crunch and snatch. The manipulation of acute variables is described below:

- 14th week: 1 set of 6-7 repetitions (40% 1RM) - 4 min rest interval;
- 15-16th weeks: 2 sets of 3-5 repetitions (40-50% 1RM) - 4 min rest interval.

Statistical Analysis

First, data normality was checked using the Shapiro-Wilk test. One-way analysis of variance (ANOVA) repeated measures followed by Tukey's post-hoc test was used for means comparisons. Effect size (ES) was calculated (*mean baseline values – mean of evaluation during training period / pooled standard deviation*) to determine the magnitude of the difference between comparisons. The threshold adopted was: small (<0.40), moderate (.40 to .70), large (0.70-1.00) and very large (> 1.00) according to Sheppard and Newton (2012). The significance level was P <0.05. Data are expressed as mean ± standard deviation (SD).

Results

There were progressive improvements (P <0.001) in vertical leaping capacity in the periods: A1 (ES = 0.29), A2 (ES = 0.60), A3 (ES = 0.72) and A4 (ES = 0.96), when compared to baseline values (Figure 2). For performance in TW20meters, there was an increase (P <0.001) in maximum distance run during the test in the periods A1 (ES = 1.22), A2 (ES = 1.72), A3 (ES = 2.03) and A4 (ES = 2.50) (Figure 3).

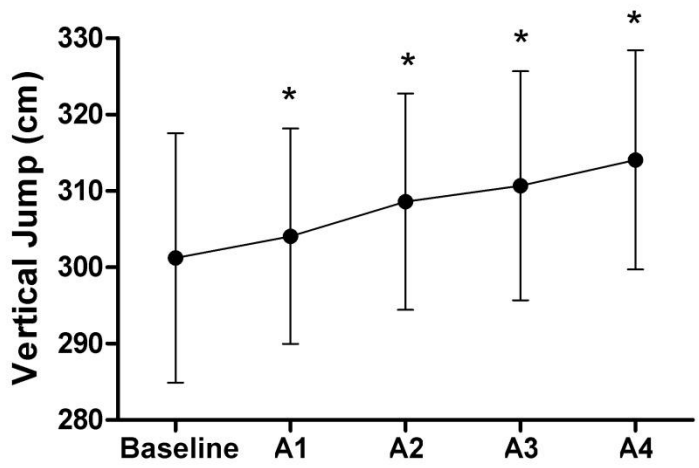

Figure 2. Vertical leap (cm) performance obtained in the periods: baseline, fifth (A1), ninth (A2), thirteenth (A4) and sixteenth (A5) weeks of physical training. *Significant difference (P <0.001) compared to baseline values. Data are expressed as mean ± SD (n = 13).

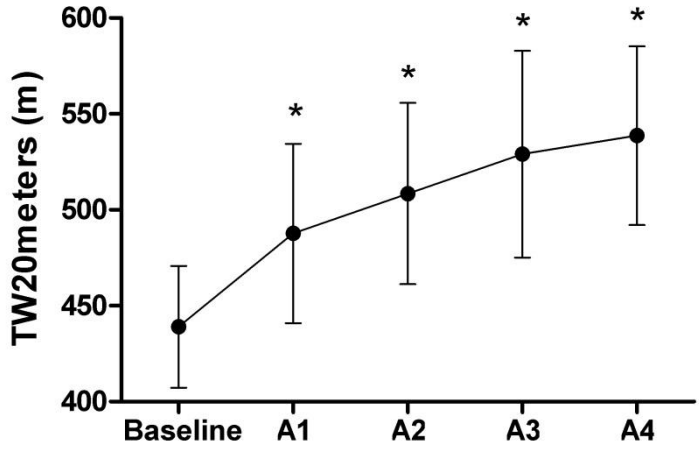

Figure 3. Maximum distance run (in meters) in the TW20meters test in the periods: baseline, fifth (A1), ninth (A2), thirteenth (A4) and sixteenth (A5) weeks of physical training. *Significant difference (P <0.001) compared to baseline values. Data are expressed as mean ± SD (n = 13).

Discussion and Conclusion

The purpose of this study was to evaluate the influence of periodized resistance training on vertical leap capacity and TW20meters performance in volleyball players. Our main finding was that periodized resistance training resulted in significant improvements in the test specific to volleyball and in the vertical leap. Therefore, our initial hypothesis was confirmed, suggesting that TW20meters can be a practical and efficient evaluation protocol for monitoring volleyball athletes throughout the preparatory period.

Besides technical and tactical aspects, maximum strength and muscle power are important factors for the success of high-level volleyball teams. Thus, methods such as plyometric and resistance training (Sheppard et al., 2008; Simões et al., 2009; Sheppard et al., 2009; Sheppard et al., 2012b; Sheppard and Newton, 2012) are efficient means of improving the physical fitness of athletes playing volleyball. In particular, vertical leap capacity is recognized as one of the key performance indicators in volleyball players.

The improvement in vertical leap performance observed in our study is probably related to increased levels of strength and muscle power in the lower limbs. (Sheppard et al., 2008) By analysis of vertical leap evaluations during the preparatory period reveal progressive performance improvement across all periods analyzed (A1, A2, A3, A4 and A5). The magnitude of increase (effect size) of the vertical leap was considered small in the A1 period (fifth week) and moderate in the A2 (ninth week) period. However, it was considered large in the A4 and the A5 periods (thirteenth and seventeenth weeks). These data indicate that improvement in vertical leap capability was associated with the characteristics of the proposed periodization model. The first ten weeks of resistance training emphasized the development of muscular endurance (higher volume and lower intensity), while training from the eleventh week on emphasized maximum strength and muscle power capacities.

Regarding the TW20meters test, progressive performance improvement was observed over the training periodization (Figure 3). The magnitude (effect size) was identified as very large, in all periods (A1, A2, A3, and A4), indicating that the development of different manifestations of strength capacities (endurance, maximum strength and power) contributed effectively to the performance improvements in the volleyball-specific test. The TW20meters test was performed continuously (6 min) and the performance peak was observed when resistance-training periodization had a greater emphasis on maximum strength and power.

The effects of the TW20meters test on female athletes were recently assessed by Nascimento et al. (2013). In the study, a significant correlation was found between vertical leap performance and maximum distance run in the TW20meters. This indicates that athletes with higher level of power in the lower limbs were had the best performance in the test specific to volleyball. The present study confirms this finding, as the increase in vertical leaping capacity and maximum distance run in TW20meters test were related to the periodization of physical training. The lack of a control group was a limitation of our study. Therefore, improvements in physical fitness should not be credited solely to the resistance-training program, since sessions of volleyball-specific training on the court were also performed. However, from a practical point of view, the inclusion of a control group on a sports team may be considered unethical as it might negatively influence competitive performance.

In conclusion, the periodized resistance training was effective in promoting improvement in vertical leap performance and in a test specific to volleyball. These data indicate that the TW20meters test can be used to detect changes in physical performance induced by resistance training in volleyball players.

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