Effects of Training Surface on Physiological Characteristics of Prepubescent Female Volleyball Players

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Abstract

Purpose: The present study investigated the effects of different training surfaces on physiological characteristics of prepubescent female volleyball players.

Method: 45 prepubescent girls (age: 11.1 ± 0.5 years) were separated in groups S (N=15) and H (N=15) that consisted of volleyball players, while group C (N=15) consisted of girls that had no volleyball training experience. Groups S and H participated in a 10-week volleyball training program including sprints, jumps and technical exercises, while group C executed only technical skills exercises. Group S trained on sand surface, while groups H and C trained on hard surface indoors. Aerobic capacity (20m shuttle run), agility (Illinois test), countermovement (CMJ) and squat jump (SJ) as well as 10m sprint test were conducted before, in the middle (5th week) and after the end of the training program for groups S and H. Group C was tested only before and after the training period.

Results: Aerobic capacity, agility, jumping and sprinting ability were significantly (p<0.01) improved in groups S and H even from the 5th week of training. Group S achieved greater improvements than group H in all tested variables.

Conclusion: Training on sand surface seems to promote training adaptations improving the physiological characteristics of prepubescent female volleyball players.

Keywords: Children; Team Sport; Aerobic Capacity; Jumping Ability.

Introduction

Volleyball is characterized by frequent explosive bouts of exercise, mainly short (3-5m) sprints and jumps, interspersed by time periods of active or passive recovery [1] and can be played upon both hard flat surface or/and sand surface (beach volleyball). Beach volleyball is gaining more and more attention the last years [2] and has been developed into a professional sport. In both volleyball and beach volleyball physiological characteristics such as sprinting and jumping ability, agility as well as aerobic capacity seem to affect performance [3-6].

Agility is defined as the ability to change direction with a minimal loss of control and/or average speed [3]. Agility is highly correlated with sprinting performance seem to be linked to agility and thereafter to sport performance in many field and court sports [7, 8]. In volleyball in particular, they seem to play a critical role in jumping ability [2, 3, 6] as well as in the development of volleyball players [9]. Lidor & Ziv (2010) [5] reported that skilled volleyball players could produce greater power and therefore perform better compared with the less skilled ones. In accordance Sheppard et al., (2008) [9] demonstrated that both strength and power contribute to jumping performance in elite volleyball players and a potential increase in volleyball performance can be achieved through strength and power improvements. More recently Schaal et al., (2013) [6] found that NCAA Division-I female collegiate volleyball players produced significantly more power and jumped higher during countermovement jump when compared with high school varsity volleyball athletes.

Agility is defined as the ability to change direction with a minimal loss of control and/or average speed [3]. Agility is highly correlated with sprinting performance seem to be linked to agility and thereafter to sport performance in many field and court sports [10-13]. Sassi et al., (2009) [14] showed that agility is highly correlated...
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(groups x time) for independent samples. Significant differences between means were determined using Tukey’s Post hoc tests. Effect sizes (ES) of the differences were also calculated [32]. The magnitude of the differences was considered trivial (ES < 0.2), small (0.2 ≤ ES < 0.5), moderate (0.5 ≤ ES < 0.8) and large (ES ≥ 0.8). Statistical analysis was performed using the JMP statistical package (JMP11, SAS, USA). The level of significance was set to α = 0.05 and the results are presented as mean ± standard deviation (effect size).

Results

No statistical significant differences among groups were detected regarding age (p = 0.73), body weight (p = 0.22) and body height (p = 0.69) of the participants.

Aerobic Capacity

Changes in the distance covered during the 20m shuttle run test over the 10-week training program are presented in Figure 1. No significant differences among groups were detected in the pre measurements (p = 0.09), while training induced significant (fig. 1, p < 0.01) increases in distance covered even from the 5th week for both groups (Pre: S = 481.3 ± 32.5 m, H = 461.3 ± 31.6 m vs. 5th week: S = 669.4 ± 87.5 (3.1) m, H = 524.0 ± 66.4 (1.3) m). Performance in the 20m shuttle run test was further significantly improved (p < 0.05) in the last five weeks of the training program (10th week: S = 796.0 ± 70.2 (1.6) m, H = 596.0 ± 50.3 (1.2) m), but group S achieved greater improvements and therefore a statistically significant difference among groups was detected (Figure 1, p < 0.01). Group C also improved its performance (Pre = 458.4 ± 31.2 m vs. 10th week = 503.4 ± 48.4 (1.1) m, p < 0.05), but at the end of the 10-week training program differed significantly from both groups S and H (Figure 1, p < 0.01).

Agility

Changes in the Illinois agility test over the 10-week training program are presented in Figure 2. Both groups S and H (S = 22.2 ± 0.5 sec & H = 22.0 ± 0.7 sec) performed significantly better (p < 0.01) than group C (C = 23.1 ± 1.3 sec) at the pre measurements, but there was no significant difference between groups S and H (p = 0.35). After 5 weeks of training both groups S and H performed better (S = 21.1 ± 0.5 (1.9) sec & H = 21.6 ± 0.7 (0.5) sec) but it was only performance in group S that reached significant levels (Figure 2, p < 0.01). At the end of the 10-week training program, time during the program differed significantly (p < 0.01) from both groups H and C, while group H in turn performed significantly (p < 0.01) better than group C (20.5 ± 1.8 (0.9) cm).

Jumping Ability

The changes in jumping ability as reflected in Squat and Counter
movement jump over the 10-week training program are shown in Figure 3. Both groups S and H performed significantly better (Figure 3, p < 0.05) in squat (S = 20.3 ± 1.2 cm & H = 19.6 ± 1.4 cm) as well as countermovement jump (S = 21.4 ± 1.1 cm & H = 20.6 ± 1.4 cm) in comparison with group C (18.1 ± 1.7 cm & 19.0 ± 1.6 cm respectively) at the pre measurements, but there was no significant difference between groups S and H in neither squat (p = 0.08) nor countermovement jump (p = 0.10). After 5 weeks of training both groups S and H improved significantly their jumping performance in comparison with the pre measurements (SJ: S = 22.4 ± 1.8 (1.4) cm, p<0.01 & H = 20.8 ± 1.6 (1.1) cm, p < 0.05, CMJ: S = 24.0 ± 1.9 (1.1) cm & H = 21.9 ± 1.6 (1.2) cm, p < 0.01 respectively). At the end of the 10-week training program both groups S and H improved further their jumping performance in squat jump (S = 24.8 ± 1.2 (1.6) cm, p<0.01 & H = 23.7 ± 1.5 (1.8) cm, p < 0.05) compared with the 5th week measurement, while performance in group S differed significantly (fig. 3A, p < 0.01) from both groups H and C (C= 19.2 ± 2.0 (0.5) cm). In accordance are the results of the countermovement jump (Figure 3B). Jumping performance was improved in both groups S and H (S = 26.1 ± 1.8 (1.4) cm & H = 23.1 ± 1.4 (0.8) cm), but it was only in group S that differed significantly (fig. 3B, p < 0.01) from the 5th week measurement. Furthermore performance in group S at the end of the 10 program differed significantly (p < 0.01) from both groups H and C, while group H in turn performed significantly (p < 0.01) better than group C (20.5 ± 1.8 (0.9) cm).

**Sprinting Ability**

Changes in sprinting ability over the 10-week training program are presented in Figure 3. Time during the 10m sprint test in the pre measurement did not differ significantly among groups (S = 2.41 ± 0.05 sec, H = 2.40 ± 0.05 sec & C = 2.44 ± 0.06 sec, p = 0.18). After 5 weeks of training performance time was decreased in both groups S and H (S = 2.33 ± 0.03 (1.9) sec & H = 2.38 ± 0.04 (0.6) sec), but it was only performance time in group S that reached significant levels (Figure 4, p < 0.01). At the end of the 10-week training program, time during the 10m sprint test decreased further in group S and differed significantly from the 5th week measurement (S = 2.25 ± 0.05 (1.8) sec, p < 0.01). Furthermore performance in group S differed significantly (p<0.01) from both groups H and C (H = 2.36 ± 0.04 (0.2) sec and C = 2.42 ± 0.07 (0.3) sec respectively), while performance in group H differed significantly (Figure 4, ES = 0.7, p < 0.01) from the respective pre measurement.

**Figure 3. Jumping height during squat (A) and countermovement (B) jumps before (pre), in the middle (5wks) and at the end of the 10-week training program in all three groups.**

**Figure 4. Time needed for the completion of the 10m sprint test before (pre), in the middle (5wks) and at the end of the 10-week training program in all three groups.**
Discussion

The present study is the first to examine the effects of sand surface during a 10-week training program on aerobic capacity, agility, jumping and sprinting ability among prepubescent female volleyball players. The main findings were that a) aerobic capacity improved significantly in both groups S and H during the 10-week training program, but group S achieved greater improvements compared with group H, b) agility was also improved in both groups S and H, but after the 10-week training program group S performed significantly better than group H, c) jumping (SJ and CMJ) and sprinting (10m sprint) ability of prepubescent female volleyball players were significantly improved, as a result of the training stimulus, while the group that trained on sand surface (group S) achieved greater improvements compared to group H.

Anthropometric, somatotype and body composition seem to have a significant impact on sport [33, 34] and volleyball [4, 10, 22] performance while during the developmental stages of growth. In the present study, no significant differences in the anthropometrical characteristics of participants were observed neither before nor after the 10-week training program and therefore observed differences should be attributed to the impact of training surface. Aerobic capacity and its importance in volleyball performance has been questioned [5, 10]. In a recent study by Meckel et al., (2015) [19] aerobic fitness was significantly correlated with repeated sprint ability, but not with repeated jump ability. The researchers had concluded that aerobic fitness seems to be more important in repeated running activity and therefore does not affect volleyball performance. In our study the 10-week training program resulted in significant improvements (ES = 1.2 – 3.1) in the 20m shuttle run test in all three groups. This is in accordance with previously reported data by Noyes et al., (2011) [24] which reported that a 6-week volleyball specific training program can significantly increase VO2max in female pubescent volleyball players. Significant improvement of the aerobic capacity in the present study were observed in both groups (S and H) even after only five weeks of training (Figure 1), despite the fact that the training program included mainly explosive exercises like sprinting and jumping. A part of the achieved improvements should though be attributed to growth and maturation of the participants since the control group achieved significant improvements too (ES = 1.1).

Jumping and sprinting performance were also significantly improved as a result of the 10-week training program. More specifically participants in both groups S and H performed significantly better (ES = 0.6-1.9) in 10m sprint test, while group C also improved significantly its performance (ES = 0.3) probably as a result of maturation. According to Sheppard et al., (2008) [9] any training triggering the neuromuscular system to generate maximal tension should contribute to higher vertical jump heights as a result of higher power outputs. In our study participants executed jumping and sprinting exercises even when they trained the technical skills part and this could have led to the observed improvements. Furthermore and as it was mentioned previously in the text, a part of the improvements should be attributed to the participants growth during the 10-week training program since even group C improved its sprinting ability. Improvements in speed, jumping ability and power result in significant improvements in agility [11, 13, 55] and this is also observed in the present study. Both groups S and H decreased their time to completion during Illinois agility test and differed significantly (Figure 2) from the control group. Differences were observed even in the pre measurement probably as a result of the previous training experience that both groups S and H had.

In our study, group S achieved greater improvements during and after the 10-week training program in all tested variables (aerobic capacity, agility, jumping and sprinting ability) compared with both groups H and C. Differences caused on biomechanical variables as well as energy expenditure during human locomotion on sand surface have been examined previously [36, 37]. The instability of a non-solid ground, like sand, can result in reductions in maximum produced force during squat jump compared to force produced during jumping on rigid surface [2]. The ankle-, knee- and hip joint kinematics are altered because of sand instability implying altered demands on the neuromuscular system [2, 38]. Furthermore sprinting and jumping on sand surface seems to decrease significantly stride length, because of loss of energy during acceleration, leading in a larger number of surface contacts in order to cover the same distance [36-38]. Gaudino et al., (2013) [36] reported also that running on sand surface increases the energy cost by 30% compared with the values achieved during running on grass surface. In accordance Lejeune et al., (1998) [39] showed that the power loss due to energy absorption of the sand may lead to increased mechanical work and therefore increased energy demand for the same work load.

Thus training on sand surface seems to increase the relative intensity of the conducted exercises, as well as altering the kinematics of the movements evoking changes in the neuromuscular junctions. Hence the greater improvements in group S might be the result of training adaptations caused by differences in relative intensity and kinematics of the exercises compared with groups H and C.

Conclusion

In conclusion our results revealed significant improvements of aerobic capacity, agility, sprinting and jumping ability in prepubescent female volleyball players, as a result of a 10-week training program. Group S which trained on sand surface achieved the greater improvements in all tested variables, highlighting the effectiveness of a non-solid training surface. Differences among groups should be attributed to the altered kinematics of the movements and the increased energy demands when training on sand surface, which in turn seem to promote training adaptations and therefore improve performance.

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