The Effect of Playing and Training Surface on Vertical Jump Height in elite junior male volleyball players. A pilot study.

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Abstract

Many studies have considered the effect of training techniques (especially plyometric) on jump height. However, previous research has not considered the optimum surface for these training techniques. The aim of this research was to determine which training and/or playing surface is most beneficial in maximising vertical jump height for volleyball players. Attainment of such knowledge will not only assist athletes in optimising results but also help coaches in developing training programs.

Method. Thirteen male elite junior volleyball athletes performed two types of vertical jumps on both wooded floorboards and sand surfaces. The testing was completed post hard-court and beach volleyball seasons. The highest value of the three jump efforts was recorded for further analysis. Matched paired t- tests were performed between the groups on both surfaces post training.

Results. In comparison to post hardcourt season, all jump heights on both surfaces were significantly higher post beach season ($p < 0.05$).

Conclusions. It is reasonable to suggest that sand training and playing surface had a greater effect on increasing vertical jump height on both surfaces.

Key Words

Plyometric, Floorboards, Sand.

Introduction

Beach and hardcourt volleyball incorporate skills such as spiking, blocking and jump serving, all of which involve reaching up as high as possible to clear the net. Therefore, vertical jumping ability is critical for success in both beach and hardcourt volleyball. The major difference between the two styles of volleyball is the playing surface. Beach volleyball is played on sand and hardcourt volleyball is played on floorboards.

'Plyometrics' is a term that is often used to describe explosive jump training. Specific plyometric exercises involve pre-loading the muscle eccentrically, before rapidly contracting the muscle concentrically (Lees & Graham- Smith, 1996). With eccentric meaning 'to lengthen' and concentric meaning 'to shorten' this sequence is referred to as a stretch-shortening cycle. In this cycle, as the muscle lengthens, it produces elastic energy that it can store. The muscle then contracts, utilizing the stored elastic energy to assist in generating the force of the contraction.
After training such mechanisms, Newton et al. (1999) reported an increase in vertical jump performances in elite volleyballers over an eight-week period. Results from Fatouros et al. (2000) also supported this finding concluding that plyometric training over twelve weeks significantly improved vertical jump performance. However, the combination of plyometrics and traditional weightlifting exercises produced significantly greater improvements than plyometrics alone (Fatouros et al., 2000).

With an understanding of how beneficial plyometric training can be in developing vertical jump, it is of importance to elite volleyball athletes to maximize results by conducting these exercises in the best conditions possible. Given that sand has properties that are very close to the soft end of the surface-stiffness continuum it also has high absorptive qualities (Barrett et al., 1998). In comparison, one could hypothesize that the hardcourt surface would be closer to the rigid end of the surface-stiffness continuum and as a result have less absorptive qualities. Hence, it is likely that the hardcourt surface will be much more efficient in returning the energy produced by working muscles in comparison to the sand surface. Zamparo et al. (1992) demonstrated that the energy cost of soft sand running was greater than that for a firm surface by approximately 15- 40%. This indicates that there is a reduction in the capacity for elastic energy to be recovered when performing work on a soft surface making the hardcourt surface more energy efficient.

The absorptive qualities of sand are also likely to increase contraction time, thus allowing the leg extensor muscles to build up an active state and force prior to shortening (Bishop 2002). As discussed in Bobbert et al. (1996), the time available is an important determinant for force development at the start of a jump. This implies that subjects will be able to produce greater work on the sand and this may possibly make up for the energy lost in surface absorption. However, in considering the myostatic stretch reflex, an increase in contraction time is unlikely to enhance the force produced for an explosive contraction.

Muscles are controlled by the central nervous system (CNS). The CNS requires feedback information via proprioceptors such as muscle spindles that respond to stretch in the muscles (Lees et al., 1996). The stretch reflex has accounted for up to 64% of jump height and as a result the role of the muscle spindle must be considered for maximizing jump training (Lees et al, 1996). Lees et al. (1996) state the muscle spindles cause a functional stretch reflex proportional to the rate of the stretch. Therefore, as sand increases contraction time, this also prolongs the rate of muscle stretch indicating a decrease in muscle spindle activity, hence, a reduced shortening contraction.

Muscles also possess inhibitory proprioceptors called golgi-tendon organs. These respond to an increase in muscle tension and ultimately prevent the muscle from becoming over stretched. This reflex is detrimental to improving vertical jump height due to the limitations the golgi-tendon organs place on generating muscle stretch. The inhibitory effect of the golgi-tendon organs is less than the facilitating effect of the muscle spindles; therefore, it is thought that the inhibitory effect can be offset as a result of training plyometrically (Lees et al., 1996).

As sand is mobile and uneven in nature it may be important to consider the role of postural muscles in relation to the balance and co-ordination required for jumping. While these muscles may be insignificant in maximizing jump height, they could be an important factor when considering the specificity of training. Quite simply, if one has not participated in sand training, balancing postural muscles may not fire as effectively in comparison to someone who has trained under these specific (and unstable) conditions. It would be reasonable to assume that being balanced would assist in maximizing jump height. Surely a maximum jump effort could not be generated if balance could not be achieved prior to jumping? And, what is the point of having a well-developed jump on a firm surface if one is unable to balance on an uneven surface?

The important issue for an elite volleyball athlete is to train effectively so that training enhances game performance. As mentioned earlier, vertical jump height is of great importance, and training that develops this skill is necessary. In considering what conditions training should be conducted under, there are many arguments for and against both surfaces. The purpose of this study is to determine whether hardcourt volleyball players can benefit from sand training.

Methods

Subjects

Thirteen male Victorian Institute of Sport (V.I.S.) volleyball players volunteered to participate for this study. Their mean ($\pm$ SD) age, height and mass were 16.3 $\pm$ 0.75 years, 187.7 $\pm$ 7.21 cm and 78.8 $\pm$ 7.90 kg, respectively. Each participant provided informed consent and the study was approved by the Victorian University Human Research ethics Committee.

Overview

The junior men's V.I.S. program involves training and game play on both wooden floorboards and sand surfaces at different times of the year; April-October and November-March for hardcourt and beach volleyball respectively. Testing was conducted at the completion of each season on both surfaces in question. Tests performed in the sand were completed in bare foot whereas those performed on the floorboards were completed with the subject's volleyball footwear. Subjects were allowed to wear any supportive braces for strapping they regularly wore to training. During the sand trials, the sand was raked level between attempts. Prior to testing, subjects completed a warm-up consisting of a two-minute jog and whole body stretch guided by an instructor. Subjects rested between jumps until they felt fully recovered and ready for the next maximal effort. Subjects were excluded if at any stage they were unable to complete the jumping movement required.

Experimental design

Jump and reach heights were measured using a Yardstick (SWIFT Performance Equipment, Lismore, NSW) (see Figures 1a and b).

Figure 1a and b: Yardstick Demonstration (taken from www.spe.com.au)

This device has been found to be both reliable and accurate in comparison to other methods of jump measurement, such as the board method (Young, MacDonald, Heggen and Fitzpatrick, 1997). Reach height was calculated by having the subject stand flat-footed and reach comfortably with their dominant hand to displace a zero marker on the Yardstick. The Yardstick was adjusted to the individuals standing reach height. Maximum jump height was determined by the number of vanes that were displaced on the Yardstick (see Figure 1b). Subjects had three attempts to reach maximum jump height with their preferred hand. After the first jump, displaced vanes were not returned. This provided a visual target for the subjects on subsequent jumps. The lowest vane remaining in its original position was recorded as the maximal jump.

Subjects performed two types of jump:

Countermovement jump (CMJ) - from a standing start the subject dipped to a self-selected depth before jumping and reaching for maximum height. Spike approach jump (SAJ) - using a run up, the subject chose how many steps they required before jumping and reaching for maximum height.

Both jumps were performed with a two-foot take off. In the countermovement jumps, subjects used both hands to contact the vanes. These jumps were chosen because they are very similar to the block jump and spike jumps executed in a volleyball game. Subjects were repeatedly reminded to aim for their maximum height. In relation to SAJ it has been documented by Young et al. (1997) that jump height increases with an approach of 3-5 strides for double leg take off, where as seven strides is detrimental. Hence, subjects were recommended a 3-5-stride approach, but this was not imposed as a condition.

Statistical analysis

Data was analysed using SPSS version 11.0 for Windows. Match paired t-tests were conducted to determine if there was a significant difference between post hardcourt and post beach seasons on both surfaces for each individual. Significance level was set using a Bonferroni adjustment ($p = 0.5/4 = 0.0125$).

Results

The mean and standard deviation for all tests are listed in Table 1. When compared with the completion of the hardcourt season, all jump heights had significantly improved after the beach season ($p< 0.0125$). The greatest difference in vertical jump height was between the sand spike approach jumps ($p= 0.000$). Hardcourt spike approach, countermovement jumps on both sand ($p = 0.004$) and wooden ($p = 0.001$) surfaces increased after the beach season compared to the hardcourt season (see fig 1).

Table 1. Maximum Jump Heights for Post Hard-Court and Post Beach Season.

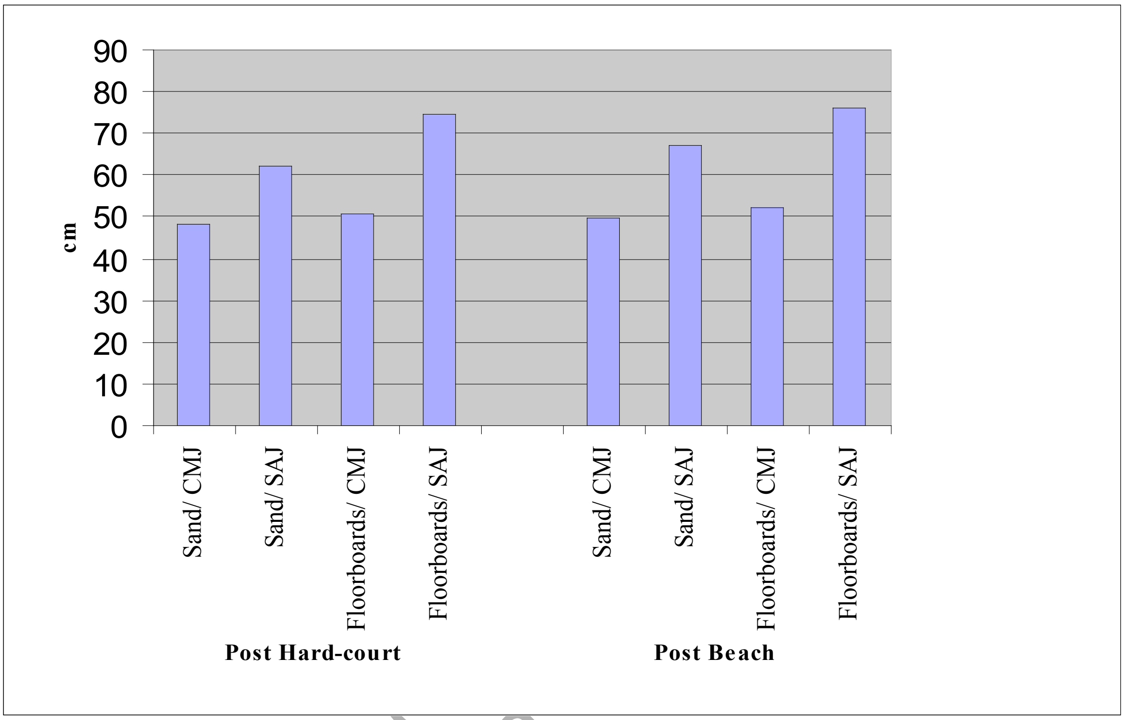
	Post Hard-Court		Post Beach Season	
Surface/ Jump type	**Mean (cm)**	**Stand Dev.**	**Mean (cm)**	**Stand Dev.**
Sand/ Countermovement jump	48	6.892	49.54	7.15
Sand/ Spike Approach jump	62.08	1.972	67.31	7.80
Floorboards/ Countermovement jump	50.69	1.722	52.23	5.97
Floorboards/ Spike Approach jump	74.62	10.05	76.31	10.06

Table 2. Match Paired T- test: A comparison Between Jumps.

	Mean	Std Dev.	t	Sig. (2 tailed)
Sand: Countermovement	-1.54	1.56	-3.554	.004
Sand: Spike Approach	-5.23	2.048	-9.211	.000
Floorboards: Countermovement	-1.54	1.266	-4.382	.001
Floorboards: Spike Approach	-1.69	1.437	-4.382	.001

After completing statistical analysis using SPSS matched paired t-tests is was found that all comparisons made between post hardcourt and post beach season jump results were statistically significant (p<0.0125).

Figure 1: Mean Jump Heights



Jump heights improved over all tests suggesting that sand training is beneficial for improving jump height. It was not possible to compare the effects of training on hard surface in comparison to sand, as the subjects were not tested before subjects began training for the hard-court season.

Discussion

After training and playing on sand all vertical jump heights had significantly increased in comparison to measurements taken after hard surface (wooden floorboards) training. The increase in maximum jump height was found to flow into jump results on both hardcourt and sand surfaces. Therefore, it seems possible that sand training/playing cannot only improve the vertical jump of beach volleyball players but also hardcourt volleyball players. However, the subject sample and the order in which the testing was conducted may give an explanation for these results.

Firstly, the age of the subjects was 16.3 $\pm$ 0.75 years. As growth and muscle development for males often continues into their early twenties, the subjects used in this study may have undergone a natural progression in strength and muscle development. This is relevant as the testing for the post beach season was conducted five months after the hardcourt season. Hence, it may be possible that subjects improved regardless of what code they were training for. To eliminate this in future studies more subjects of an older age group would be needed to eradicate this unknown.

Secondly, at the time of post hardcourt-testing subjects had no experience of playing/ training in sand. As a result participants had had little or no experience jumping in sand. This was most evident on observation at the first sand-based testing session. The majority of subjects used techniques that seemed inefficient for sand jumping. For example, the spike approach in sand appeared to be much like the approach used on a hard surface with the emphasis on speed and a quick foot take off. As sand is not a hard surface, subjects were expending a great deal of energy in preparation for the jump only to have the sand give way underneath them.

On testing post beach season, it was noticeable that subjects had altered their approach to a slower bounding action. This could be attributed to a learning effect (of training) as subjects appeared to be much more efficient in their approach. This may also explain the significant increase in jump height on sand post beach season. While jump technique in sand may partly explain why the most significant increase was in sand surface spike approach (p = 0 .000), it does not explain the co-existing increase in hardcourt spike approach and countermovement jump on both surfaces. If this increase were purely a technical adjustment, then a significant increase would not be seen in all jumps on all surfaces.

Bishop (2002) reported land and sand-based tests for assessment of jump heights. The research suggested that jumping ability is not greatly influenced by testing surface. Whilst sand jump heights were also found to be significantly less, this was found in four types of jumps tested. The results from the present study support these findings by Bishop (2002), as all recorded sand jumps were on average less than the hard court jumps. The increase in jump heights over five months of training/ playing also supports this theory as subjects generally jumped higher on hard-court in comparison to sand. While technical efficiency may explain the greatest improvement found in spike approach, the increase in all jump heights can confidently be explained by an improvement in the subjects.

Given that none of the participants had trained or played on the beach before and due to sands position on the soft surface continuum (Barrett, 1998), it is reasonable to suggest training on sand would continually increase in resistance to all movements during training/playing. As a result, the lower limb became stronger and more explosive which is seen by an increase in jump heights. This information in useful to organizations such as the VIS in validating there junior development program for including a sand training and playing component. It is fair to say that training in the sand is not just beneficial for sand athletes but hardcourt athletes as well.

While previous studies have discussed the importance of speed in the stretch-cycle reflex in plyometric training for improving jump height, researchers have also stated that a hard surface would be optimal to promote this principle (reference required). This would lead beach volleyball (soft surface) players to believe that they too must train this reflex on a hard surface to increase maximum jump height. The purpose of this study was to determine which surface (sand or wooden floorboards) provides the most significant increase in maximum vertical jump height, and the importance of specificity training? Given that the training/-playing environment caters for many explosive jumps, subjects are considered to have conducted numerous plyometric activities each session on the respective surface determined by the V.I.S. program. The results indicate that it is not only important to train on the specific surface, but it is also beneficial for hardcourt players to conduct some jump training in sand. Even though the absorptive factors of the softer sand surface are considered to deplete valuable muscular energy, the benefits seem obvious. In the case of the subjects involved in the present study there is a possible explanation for this unexpected increase in maximum jump height, as mentioned earlier. However, sand training seems to have many logical benefits. The softer surface not only reduces the risk of injury and the impact on joints, but it also assists in injury prevention by improving balance and joint stabilization. With the results from the current study finding an increase in maximum jump height, hopefully sand training will be considered more seriously for jumping athletes.

Conclusion

In conclusion, it appears that sand is the most beneficial surface for increasing maximum jump height in comparison to wooden floorboards in junior elite Volleyball players. This suggests that training and playing in sand is recommended for volleyball athletes of both codes to improve vertical jump height. Due to the small number of subjects participating in this study and the order of testing, these results are not totally conclusive. There is a sound indication for future research to be conducted in this area, especially on the effect of hardcourt training and playing on the performance of sand-based volleyball players.

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