Knee Valgus Angle During Landing Tasks in Female Volleyball and Basketball Players

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Abstract

Herrington, L. Knee valgus angle during landing tasks in female volleyball and basketball players. *J Strength Cond Res* 25(1): 262–266, 2011–Increased knee valgus angles have been associated with an increased risk of a variety of knee injuries. It has yet to be established if knee valgus angles during jump landing tasks differ between jumping sports with relatively higher and lower knee injury rates–namely, basketball and volleyball. Any difference in knee angles on landing may be related to sport-specific differences, which may in turn relate to the different injury risk rates. Fifteen elite female basketball and volleyball players had their knee valgus angles assessed during 2 landing tasks: 1 bilateral (drop jump landing) and 1 unilateral (step landing task). During the drop jump task knee valgus angle was significantly greater in the basketball group ($p = 0.017$) in the right knee, but there was no significant difference in performance between sports in the left knee ($p = 0.67$). During the step landing task volleyball players had significantly greater knee valgus angles than basketball players for both the left ($p = 0.018$) and right ($p = 0.025$) knees. The basketball group showed superior control of knee valgus during the unilateral task, which may be related to sport-specific skills. The basketball players showed significant asymmetry in knee valgus angle during bilateral drop jump landings; this finding reflects those of previous studies and may be related to the relative increased knee injury risk reported for this population group.

Key Words knee valgus, landing, kinematics, sport specific

Introduction

A valgus or abducted position of the knee on landing has been reported to be associated with a number of different knee injuries including injury to the anterior cruciate ligament (ACL) (4,5) and patellofemoral joint (13). There appears to be a significant gender difference in this knee valgus angle during landing and cutting maneuvers (4,12). This difference has been reported to be a primary reason for the disparity in the number of serious knee injuries, such as ACL rupture, between male and female athletes (5). Although an increasing number of studies have shown the difference between the genders (11), scant literature exists evaluating the performance of landing tasks among participants in different sports (3) in an attempt to explain why injury rates might vary between sports performers of the same gender.

Hootman et al. (6) reported that in female basketball the rate of injury of the ACL was 0.23 per 1,000 athlete exposures (training or playing), whereas in women's volleyball the rate was 0.09 per 1,000 athlete exposures. Both of these sports require the participant to jump and land often while pivoting and changing direction, which are regarded as high-risk activities for injuring the ACL (5). It would be expected that both of these sports would have had a similar injury rate. It has been previously reported that ACL injury in female athletes is primarily related to functional performance (11); because of the difference in injury rates between these 2 sports, the possibility exists that female volleyball players have superior performance during functional tasks such as landing. Any difference in functional performance on landing tasks may provide, at least in part, an explanation for the differing injury rates.

The study undertaken is an attempt to evaluate if knee valgus angle on landing differs in females participating in different sports. The study aims to assess this by comparing knee valgus angle during 2 jump landing tasks–1 unilateral, 1 bilateral–in elite female basketball and volleyball players to see if any differences exist between participants in these 2 sports and between the 2 types of landing.

Methods

Experimental Approach to the Problem

The study undertaken was an observational one comparing landing strategies of females in two different jumping sports.

Subjects

Subjects included 15 national league Division 1 female basketball players (mean age 19.1 ± 1 year, range 18–22 years; height mean 1.78 m, range 1.65–1.84 m; weight mean

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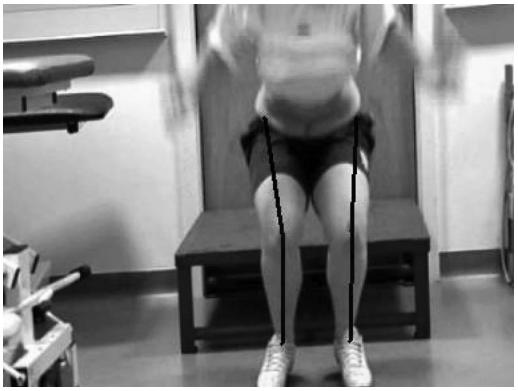

Figure 1. Illustration of knee valgus angle during drop jump landing task.

64.2 kg, range 59.2–70.0 kg) and 15 national league Division 1 female volleyball players (mean age 20.3 ± 1.2 years, range 18–25 years; height mean 1.74 m, range 1.69–1.82 m; weight mean 63.1 kg, range 59.7–68.2 kg). All subjects had no history of ACL injury or other knee pathology; had no significant lower-limb pathology (missing greater than 1 month of play because of injury), lower-limb fracture, or surgery; and had been injury-free for 3 months prior to the data collection. All subjects were tested in the early evening and were asked to refrain from any training on the day of testing. Written informed consent was obtained from all subjects and the project was approved by the university's research ethics committee.

Procedure

To simulate the landings encountered during athletic participation, subjects were asked to perform a bilateral drop jump and a unilateral step landing task. To orient participants with each task, each subject was asked to perform 3 to 5 practice trials of both tasks. Once subjects were comfortable with the task, they were asked to perform 3 test trials for each task; the sequence of step landing (left or right leg first) or drop jump task was assigned in block order to the subjects. The drop jump task involved standing on the 30-cm–high bench; the subject was then instructed to drop directly down off the bench onto a mark 30 cm from the bench, landing on both feet, and immediately perform a maximum vertical jump, raising both arms to provide countermovement (Figure 1). The step landing task involved the subject stepping off a 30-cm–high bench, landing with the opposite leg onto a mark 30 cm from the bench, and holding the position (Figure 2).

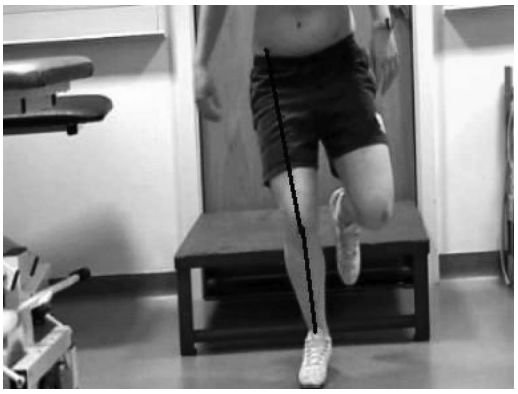

Figure 2. Illustration of knee valgus angle during step landing task.

Table 1. Average knee valgus during 2 landing tasks for volleyball players (degrees).

	Drop jump		Step landing	
	Left	Right	Left	Right
Mean	15	14.25	12.5	13.9
Standard deviation	6.9	7.8	4.8	6.1
Minimum	4	3	5	5
Maximum	23	25	20	21

Two-dimensional frontal projection angle of knee valgus alignment was measured during the 2 tasks. A digital video camera was placed at the height of the subject's knee, 2 m anterior to the subjects' landing target, and aligned perpendicular to the frontal plane. The digital images were imported into a digitizing software program (Quintic 4, Quintic Consultancy Ltd., Cambridge, England, United Kingdom). The angle subtended between the line formed between the markers at the anterior superior iliac spine and middle of the tibiofemoral joint and that formed from the markers on the middle of the tibiofemoral joint to the middle of the ankle mortise was recorded as the valgus angle of the knee (Figures 1 and 2). The average knee valgus angle value from 3 trials

Table 2. Average knee valgus during 2 landing tasks for basketball players (degrees).

	Drop jump		Step landing	
	Left	Right	Left	Right
Mean	13.8	24.2	8.6	9.5
Standard deviation	8.3	11	3.7	4.1
Minimum	2	4	4	4
Maximum	35	37	15	18

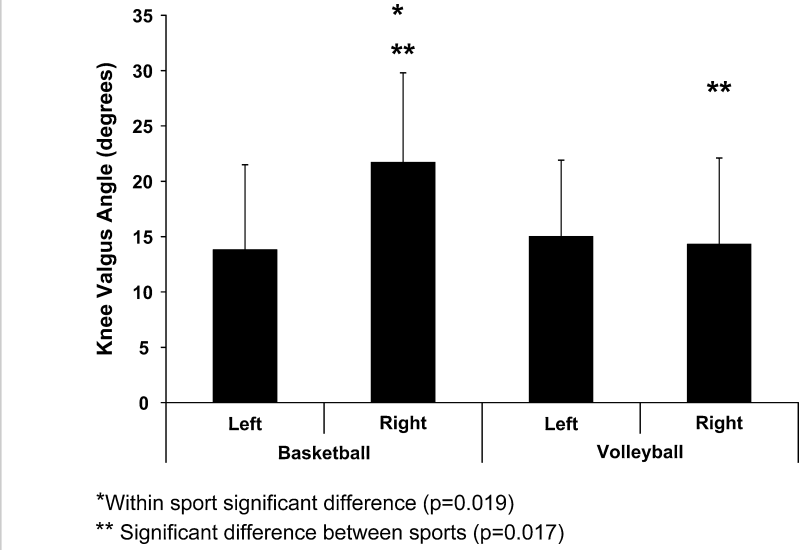

Figure 3. Comparison between sports of average knee valgus angle during the drop jump task.

was used for analysis. Within-day reliability testing of this method resulted in an intraclass correlation coefficient (ICC value) (model 3,k) of $r = 0.9$.

Statistical Analyses

Means and *SDs* were calculated for all knee valgus measures. Independent *t*-tests were used to evaluate differences between sports in knee valgus during both tasks. Paired *t*-tests were used to evaluate differences in task (unilateral vs. bilateral) and limb (left vs. right) performance within each sport. The *p*-value was set at $p < 0.05$.

Results

The average knee valgus angles occurring during both landing tasks for volleyball and basketball players are shown in Tables 1 and 2, respectively. In the drop jump task there was a significant difference between knee valgus angle for right and left knees in basketball players ($p = 0.019$), with the right knee demonstrating a greater knee valgus angle. There was no significant difference between left and right knees in the step landing task for basketball players ($p = 0.55$) and for both drop jump landing ($p = 0.66$) and step landing ($p = 0.28$) tasks for volleyball players.

When comparing sports during the drop jump task knee valgus angle was significantly greater in the basketball group ($p = 0.017$) in the right knee, but there was no significant difference in performance between sports in the left knee ($p = 0.67$). During the step landing task volleyball players had significantly greater knee valgus angles than basketball players for both the left ($p = 0.018$) and right ($p = 0.025$) knees. These results are shown in Figure 3 for the drop landing and Figure 4 for the step landing.

When comparing the valgus knee angle between drop landing and step landing tasks in volleyball players there was no significant difference between left ($p = 0.081$) and right legs ($p = 0.56$). For the basketball players knee valgus angle was significantly different between the 2 tasks, with the angle being significantly smaller for the left ($p = 0.006$) and right ($p = 0.0005$) knees during the step landing task.

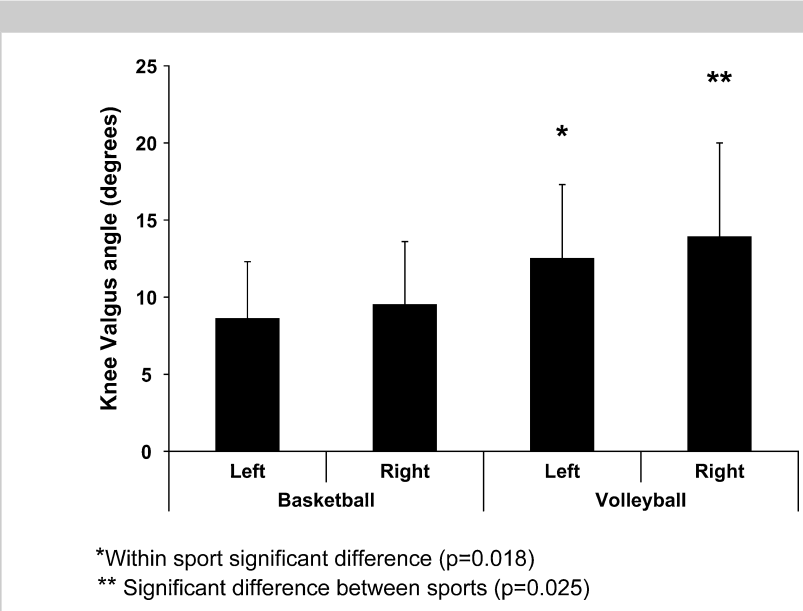

Figure 4. Comparison between sports of average knee valgus angle during the step landing task.

Discussion

Despite the reported differences in injury incidence among various female sports and the relationship between knee valgus angle and injury, comparison of landing technique among participants in different sports has received only limited study (2). The study presented showed significant differences in knee valgus angle between female volleyball and basketball players during a unilateral landing task ($p = 0.025$) and in the basketball player's dominant (right) limb during a bilateral landing task ($p = 0.017$). The findings of this study are in contrast to those of Crowley et al. (2), who found no significant difference in drop jump landing knee valgus angles between female soccer and basketball players. Hootman et al. (6) found ACL injury rates to be similar in female soccer and female basketball players (0.28 and 0.23 ACL injuries per 1,000 athlete exposures, respectively). It might be the case that both of these sports participants have similar levels of neuromuscular control with regard to knee valgus angle control, but volleyball players adopt different control strategies and hence have lower angles, and this then may be related to lower injury rates and the disparity in this study's results.

During a single-leg step landing task in female subjects, Lawrence et al. (9) found that knee valgus was 6.2 ± 7.1 degrees for the weak leg and 7.7 ± 7.3 degrees for the strong leg and Jacobs et al. (7) found average knee valgus angle to be 7.26 ± 6.6 degrees. These findings reflect those of the present study for the basketball players, although they are considerably lower than the knee valgus angles for the volleyball players. With regard to the drop jump task, Ford et al. (3) found that female basketball players' dominant leg had a knee valgus angle of 27.6 ± 2.2 degrees and the nondominant leg had an angle of 12.5 ± 2.8 degrees during a drop jumping task; the difference between limbs was significant ($p < 0.0001$). These findings echo those of the current study, with the dominant leg (right in all cases in this study) having a significantly greater valgus angle on drop jump task than the nondominant (left) leg ($p = 0.019$) in the basketball players. Chappell and Limpisvasti (1) found that female basketball players demonstrated knee valgus angles of 25.7 ± 14.7 degrees during a drop jumping task; they averaged the results across both legs, which is reflected in the large standard deviation and may also indicate an (unreported) difference between limbs. The knee valgus angles found for the volleyball players are similar to those reported by Ford et al. (3) for the nondominant leg, but no significant difference was shown between limbs.

Crowley et al. (2) also found differences between sides–in their case, external valgus moment–in both soccer and basketball players during drop jump landing. This asymmetry may suggest a neuromuscular imbalance between limbs, which is present in the basketball but not the volleyball players in our study, which could in turn be linked to the different injury risk levels. Side-to-side imbalances in neuromuscular strength, flexibility, and coordination have been shown to be important predictors of increased injury risk (5,8). These asymmetries between landing tasks and athletes from different sports require further investigation before their relationship to injury can be clearly defined.

Pappas et al. (10) and Crowley et al. (2) both reported knee valgus angles to increase when unilateral landing tasks were undertaken compared with the bilateral task of drop jump landing. The findings of these studies are in contrast to those of the present study, where it was found that in volleyball players there was no difference between unilateral and bilateral tasks and for basketball players there was a significant reduction in knee valgus angle on undertaking the unilateral task. The difference between the present study and those of Crowley et al. (2) and Pappas et al. (10) might be related to the task undertaken. In the study of Crowley et al. (2), the subjects landed on the limb, then undertook an immediate 45-degree cutting maneuver, and in the study of Pappas et al. (10), the subjects jumped from a 40-cm platform. Both of these factors would increase the loads placed on the knee compared to a step landing and hence may result in greater valgus moments and angles than found in the present study.

During the step landing task volleyball players had significantly greater knee valgus than basketball players for both the left ($p = 0.018$) and right ($p = 0.025$) knees. This result could be regarded as unexpected, with basketball players showing a significant decrease in knee valgus angle between tasks (from bilateral to unilateral). The difference between the sports on the step landing tasks and the relative decrease in valgus in basketball players might be related to the nature of the sports. In basketball the player will stand and pivot on and around a stance leg, whereas in volleyball there are minimal sports-specific unilateral balance tasks within the game. Therefore, there is a familiarity with single-leg stance tasks for the basketball player, which may have resulted in better performances in this task.

The study undertaken showed knee valgus angles to vary significantly between female volleyball and basketball players during bilateral and unilateral jump landing tasks. The basketball group showed superior control of knee valgus during the unilateral task, which may be related to sport-specific skills. The basketball players showed significant asymmetry in knee valgus angle during bilateral drop jump landings; this finding reflects those of previous studies and may be related to the relative increased knee injury risk reported for this population group.

Practical Applications

Elite female basketball and volleyball players appear to have different knee valgus angles during bilateral and unilateral landing tasks. The basketball players demonstrate significantly less knee valgus angles on landing during the step landing task than the volleyball players, which may reflect sport-specific adaptations. During the bilateral jump landing

task the basketball players showed significant asymmetry, which has been previously reported and has been associated with knee injury. Those individuals involved in conditioning these athletes should consider the specifics of these findings, with basketball players possibly needing to improve factors related to bilateral jump landing mechanics and volleyball players needing to improve unilateral landing strategies.

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References

1. Chappell, J and Limpisvasti, O. Effects of a neuromuscular training program on the kinetics and kinematics of jumping tasks. *Am J Sports Med* 36: 1081–1086, 2008.
2. Crowley, H, Ford, K, Myer, G, Kernozek, T, and Hewett T. Differences in Neuromuscular strategies between landing and cutting task in female basketball and soccer athletes. *J Athl Train* 41: 67–73, 2006.
3. Ford, K, Myer G, and Hewett, T. Valgus knee motion during landing in high school female and male basketball players. *Med Sci Sports Exerc* 35: 1745–1750, 2003.
4. Hewett, T, Lindenfeld, T, Riccobene, J, and Noyes, F. The effect of neuromuscular training on the incidence of knee injury in female athletes. A prospective study. *Am J Sports Med* 27, 699–706, 1999.
5. Hewett, T, Myer, G, Ford, K, Heidt, R, Colosimo, A, McLean, S, van den Bogert, A, Paterno, M, and Succop, P. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: A prospective study. *Am J Sports Med* 33: 492–501, 2005.
6. Hootman, J, Dick, R, and Agel, J. Epidemiology of collegiate injuries for 15 sports: Summary and recommendations for injury prevention initiatives. *J Athl Train* 42: 311–319, 2007
7. Jacobs, C, Uhl, T, Mattacola, C, Shapiro, R, and Rayens, W. Hip abductor function and lower extremity landing kinematics: Sex differences. *J Athl Train* 42: 76–83, 2007.
8. Knapik, J, Bauman, C, Jones, B, Harris, J, and Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med* 19: 76–81, 1991.
9. Lawrence, R, Kernozek, T, Miller, E, Torry, M, and Reutemann, P. Influences of hip external rotation strength on knee mechanics during single leg drop landings in females. *Clin Biomech* 23: 860–813, 2008.
10. Pappas, E, Hagins, M, Sheikhzadeh, A, Nordin, M, and Rose, D. Biomechanical differences between unilateral and bilateral landings from a jump: gender differences. *Clin J Sports Med* 17: 263–268, 2007
11. Renstrom, P, Ljungqvist, A, Arendt, E, Beynnon, B, Fukubayashi, T, Garrett, W, Myklebust, E, Roos, E, Roos, H, Schamasch, P, Shultz, S, Werner, S, Wojtys, E, Georgoulis, L, Hewett, T, Johnson, R, Krosshaug, T, Mandelbaum, B, Micheli, G, and Engebretsen T. 2008 Non-contact ACL injuries in female athletes: An International Olympic Committee current concepts statement. *Br J Sports Med* 42: 394–412, 2008.
12. Sigward, S and Powers, C. The influence of experience on knee mechanics during side-step cutting in females. *Clin Biomech* 21: 740–747, 2006.
13. Willson, J and Davis, I. Utility of frontal plane projection angle in females with patellofemoral pain. *J Orthop Sports Phys Ther* 38: 606–615, 2008.