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Knee control and jump-landing technique in young basketball and floorball players

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Abstract

Poor knee alignment is associated with increased loading of the joints, ligaments and tendons, and may increase the risk of injury. The study purpose was to compare differences in knee kinematics between basketball and floorball players during a vertical drop jump (VDJ) task. We wanted to investigate whether basketball players, whose sport includes frequent jump-landings, exhibited better knee control compared with floorball players, whose sport involves less jumping.

Complete data was obtained from 173 basketball and 141 floorball players. Peak knee valgus and flexion angles during the VDJ were analyzed by 3D motion analysis.

Larger knee valgus angles were observed among basketball players (-3.2º, 95%CI -4.5 to -2.0) compared with floorball players (-0.9º, 95%CI -2.3 to 0.6) (P=0.022). Basketball players landed with a decreased peak knee flexion angle (83.1º, 95%CI 81.4 to 84.8) compared with floorball players (86.5º, 95%CI 84.6 to 88.4) (P=0.016). There were no significant differences in height, weight or BMI between basketball and floorball players. Female athletes exhibited significantly greater valgus angles than males.

This study revealed that proper knee control during jump-landing does not seem to develop in young athletes simply by playing the sport, despite the fact that jump-landings occur frequently in practice and games.

Introduction

Good knee control is essential in team sports that require pivoting and jumping. Unfavourable knee joint alignment (specifically increased knee valgus and decreased knee flexion movements) during sporting tasks is associated with increased loading of the joints, ligaments and tendons, and may contribute to acute and overuse knee injuries, such as patellofemoral pain (PFP) and anterior cruciate ligament (ACL) injury [3, 9, 12, 15, 21, 27].

In order to identify athletes with poor knee control, different screening methods have been studied. The vertical drop jump (VDJ) test is widely used for assessing lower extremity alignment [2, 5, 9, 23, 26]. Knee joint kinematics during drop-jump landing can be measured reliably by using three-dimensional (3D) motion analysis [6]. The test can also be executed without any measurement equipment, by using real-time subjective assessment of frontal-plane knee control [24, 31], and can therefore be easily implemented for screening of athletes at all ages and levels.

Excessive knee valgus angle during a jump-landing task seems to be more common among female than male athletes [5, 11]. Females also have a higher incidence of ACL injury [1, 20] and PFP [22, 32]. Knee valgus angle during a drop jump task has a strong correlation with valgus moment, which has also been identified as a risk factor for ACL injury [9]. Previous studies have investigated knee biomechanics during VDJ landing in some team sports, such as basketball, volleyball, and soccer [9, 23]. Floorball is another popular team sport in Europe, and has a high incidence of knee injuries [28].

The purpose of the study is to investigate whether basketball players, whose sport requires frequent jump-landings, exhibit better knee control during jump-landing compared with floorball players, whose sport involves less jumping. Furthermore, this study examines how common excessive knee joint valgus movement is among this young population and whether there are gender differences in knee control. We hypothesized that basketball players would demonstrate better landing technique in VDJ test compared with floorball players, because they are more used to perform jumping. This study offers some important insights into the role of frequent jump-landings on frontal plane knee control. The results further help understanding the magnitude of the knee control problem in youth team sports and implementing training programs to prevent knee injuries.

Materials and methods

Participants

Players were recruited from six basketball and floorball clubs of the Tampere City district, Finland. We invited altogether 475 players from the two highest junior league levels to participate in a baseline screening tests as a part of a prospective cohort study investigating risk factors for sports injuries. Players who were junior-aged (U21) and official members of the participating teams were eligible for participation. Of the invited players, 71 players declined to take part in the study. During the three study years, a total of 404 players (209 basketball players and 195 floorball players) volunteered to participate in the study. One hundred and eighteen players entered the study in May 2011, 84 players in May 2012 and 202 players in May 2013.

Players signed a written informed consent form before inclusion (including parental consent for players aged <18 years). The study was conducted in accordance with the Declaration of Helsinki, and was approved by Ethical Committee of the Pirkanmaa Hospital District, Tampere, Finland (ETL-code R10169). The study follows the ethical standards of the International Journal of Sports Medicine [8].

Of the 404 players in the study, 57 players did not participate in the VDJ test due to ongoing injury or illness. In addition, the test results of 33 players were excluded from the analysis due to gaps in marker trajectories that could not be interpolated. In most of these cases, the ASIS (anterior superior iliac spine) markers were occluded by the player's upper body in the bottom phase of the jump due to a deep landing strategy. Complete data was obtained from 314 players (173 basketball and 141 floorball players), of which 161 were female and 153 male. The characteristics of the participants are shown in Table 1. The mean (SD) age of the participants at the time of entering the study was 15.7 ± 1.8 years (range 12–21 years). The basketball players were younger than the floorball players (mean age 14.8 ± 1.6 years and 16.7 ± 1.4 years for basketball and floorball, respectively) (p<.001). There were no significant differences in height, weight or BMI between basketball and floorball players.

Test protocol

Each participant underwent a series of screening tests performed in 3D motion analysis laboratory at the year they enrolled the study. One part of this test battery was a vertical drop jump task from a 30 cm box (Fig. 1). The testing protocol was adopted from the risk factor study by Nilstad et al. [23].

The players wore a tight shorts and indoor sports shoes during the test. Male players were shirtless, whereas female players used sports bras. We measured height and weight, as well as knee and ankle joint widths. Sixteen reflective markers were placed over anatomical landmarks on the lower extremities according to the Plug-In Gait marker set (Vicon Nexus v1.7; Oxford Metrics, Oxford, UK) (on the shoe over the second metatarsal head and over the posterior calcaneus, lateral malleolus, lateral shank, lateral knee, lateral thigh, anterior superior iliac spine, posterior superior iliac spine). Prior to the drop jump task, the subjects had performed a standardized warm-up procedure.

We instructed players to drop off a 30 cm box and perform a maximal jump upon landing with their feet on two separate force platforms (AMTI BP6001200; AMTI, Watertown, MA). Participants were allowed to practice the task up to three times. . A minimum of three successful trials were collected from each participant. A trial was considered valid if the participant landed with one foot on each of the adjacent force platforms and performed a maximal vertical jump after the first landing.

Eight high-speed cameras (Vicon T40, Vicon) and two force platforms were used to record marker positions and ground reaction force data synchronously at 300 and 1500 Hz, respectively. A static calibration trial was completed prior to task to determine the anatomical segment coordinate

systems. Marker trajectories were identified with the Vicon Nexus software (Vicon Nexus v1.7; Oxford Metrics). Interpolation using the Pattern Fill algorithm was performed if the markers disappeared momentarily (time period of 25 frames or less). We excluded trials if the reflective markers were out of sight for longer than 25 frames. Both movement and ground reaction force were filtered using a fourth-order Butterworth filter with cutoff frequencies of 15 Hz [14].

Data analyses were performed using the Plug-in Gait model (Vicon Nexus v1.7, Oxford Metrics). Knee angles were determined across three successful trials. Peak knee valgus angles and peak knee flexion angles during the landing phase of the drop jump task were recorded. Both legs were analyzed and the mean angle for each trial was calculated and used in the analyses. The landing phase was defined as the period when the ground reaction force exceeded 20 N. Based on the average values of three trials for each subject, frontal plane knee control was classified as good (varus angles >0.0º), reduced (valgus angles ranging between -0º to -10º) or poor (valgus angles <-10.0º) (modified according to Fox et al. [7] and Nilstad et al.[24].

Statistical analysis

Independent samples t-test was used for statistical comparisons of the participants. A multivariate analysis of variance with age as a covariant was used to determine the effect of gender (male vs. female) and sport (basketball vs. floorball) on peak knee valgus angle and peak knee flexion angle. Chi-square test was used to compare gender differences in frontal plane knee control (categorical variable). P-values less than 0.05 were considered significant.

Results

Significantly larger peak knee valgus angles were observed in the basketball players compared with the floorball players (P=0.022). The age adjusted mean peak valgus angle was -3.2º (95% CI, -4.5 to -2.0) in basketball and -0.9º (95% CI, -2.3 to 0.6) in floorball. The female athletes exhibited significantly (P<0.001) larger peak knee valgus angles (-7.5º, 95% CI, -8.7 to -6.2) than the male athletes (3.4º, 95% CI, 2.1 to 4.6) (Table 2).

The basketball players landed with a decreased peak knee flexion angle (83.1º, 95% CI, 81.4 to 84.8) compared with the floorball players (86.5º, 95% CI, 84.6 to 88.4) (P=0.016) (Table 2). There were no differences in the peak knee flexion angles between the male (84.5º, 95% CI, 82.8 to 86.2) and female players (85.1º, 95% CI, 83.5 to 86.8).

When mean values of the peak knee valgus/varus angles (range -52.9º to 14.6º) were classified into three categories, fifty-one percent of all players landed with a good frontal plane knee control. Reduced knee control was observed among 28% and poor knee control among the remaining 21% of the players (Table 3). The results differed considerably according to gender: only 22% of the female players were classified as having a good knee control compared with 80% of the male players (P<0.001).

Discussion

Basketball players exhibited larger peak knee valgus angles during the jump-landing compared with floorball players. The basketball players also landed with a decreased peak knee flexion angle compared with the floorball players. Half of the young team sport players had difficulties maintaining a good knee joint control during the VDJ task. The higher proportion of female players with poor knee control is in line with earlier studies [4, 5, 11, 18].

The vertical drop jump task simulates rebounding in basketball [2] and it is designed to screen athlete's ability to maintain good knee alignment in an impact. Serious injuries typically occur during rapid movements, such as landing from a jump or changing direction [12, 15, 27]. Floorball is a ballgame which includes accelerations, running, stopping and changing directions, but involves less jumping and rebound movements. Contrary to our expectations that basketball players would benefit from jump and rebound practice, the results revealed that the basketball players actually landed with a greater peak knee valgus compared with the floorball players. Furthermore, the basketball players tended to have more extended knees during the landing phase compared with the floorball players. These findings indicate that good knee control is not developed simply by playing the sport. Hence, more focused training is needed to improving the ability to control the knee alignment during jump-landing [10, 30]. Studies have shown that lower limb alignment can be changed by specific neuromuscular training program [25, 26]. Neuromuscular training is also effective to increase pre-activation of the hamstring muscles during sidecutting [33] and to prevent injuries [17, 29]. Thus, more attention should be paid to enhance the knee control of young athletes and also to teach them safe movement techniques.

The current study has a high sample size and utilizes 3D motion analysis, which has been referred to as the gold standard for assessing lower extremity kinematics and kinetics [19, 24]. Nevertheless, marker-based motion analysis has limitations. The kinematical calculations are highly dependent upon marker placement and may also be influenced by soft-tissue movement artifact [16]. However, because we had large groups and all subjects-groups were equally exposed to these methodological issues, it is unlikely that the consistent group differences in this study were due to measurement errors. Another limitation is that we were not able to include the data from 33 players (9 basketball players and 24 floorball players) due to gaps in marker trajectories. Furthermore, the valgus angles between legs were averaged, which might underestimate the results if there were high asymmetry between sides.

The current investigation focused on knee valgus and flexion angles to study knee control. By adding more variables, such as external/internal rotation or valgus moment, we would have been able to provide a better understanding of knee loading. However, previous studies have revealed a high correlation between valgus angle and valgus moment during a jump-landing task [9]. Valgus angle in jump-landing also correlates moderately with valgus in sidestep cutting maneuver [13], another sports movement known to cause knee injuries [15]. Moreover, the VDJ test can be used as a field test to examine knee valgus and knee flexion angles without any measurement equipment [24]. The test is simple, easy to use and learn, also for nonprofessional coaches and team staff. The basketball players were approximately two years younger than the floorball players. Thus, their physical strength and skills might be less developed. We used age-adjustment in our analyses, and

since there were no other group differences in anthropometrics (height, weight or BMI), we believe the groups were comparable.

Conclusions and implications

This study investigating dynamic knee control and jump-landing technique among young team sport athletes revealed that basketball players who are used to performing jumps and rebounds, in fact demonstrated poorer knee control during jump-landing compared with floorball players, whose sport involves less jumping. Poor knee control was especially common among young female athletes. An important clinical implication of these findings is that young team sport athletes need to be taught a safer technique for landing and also need specific neuromuscular training in order to avoid potentially harmful movement patterns. A natural progression of this work is to analyze biomechanical risk factors for acute and overuse knee injuries among young team sport population.

Competing interest

The authors declare that there are no conflicts of interests regarding the publication of this paper.

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Table 1. Characteristics of the participants (n=314). *Mean ± SD; **P-value <0.05 regarded as significant.

	Basketball (n=173)		Floorball (n=141)		All (n=314)			All (n=314)		
	Male (n=79)	Female (n=94)	Male (n=74)	Female (n=67)	Male (n=153)	Female (n=161)	p-value	Basketball (n=173)	Floorball (n=141)	p-value
Age (years)*	15.2 ± 1.6	14.6 ± 1.6	16.7 ± 1.2	16.6 ± 1.7	15.9 ± 1.5	15.4 ± 1.9	0.007**	14.8 ± 1.6	16.7 ± 1.4	<0.001**
Height (cm)*	179.4 ± 9.1	168.4 ± 6.7	178.6 ± 6.7	166.6 ± 5.8	179.0 ± 8.0	167.7 ± 6.4	<0.001**	173.4 ± 9.6	172.9 ± 8.7	0.622
Weight (kg)*	68.2 ± 12.9	60.8 ± 9.7	68.9 ± 8.1	60.9 ± 6.5	68.5 ± 10.8	60.8 ± 8.5	<0.001**	64.2 ± 11.8	65.1 ± 8.4	0.416
BMI*	21.1 ± 3.0	21.4 ± 2.7	21.6 ± 2.2	21.9 ± 2.0	21.3 ± 2.7	21.6 ± 2.5	0.329	21.2 ± 2.9	21.7 ± 2.1	0.067

Table 2. Peak knee varus/valgus and flexion angles (age adjusted) according to gender and sport. Mean (95% CI); *Negative values referring to valgus and positive to varus movement; **P-value <0.05 regarded as significant.

	Male (n=153)	Female (n=161)	p-value	Basketball (n=173)	Floorball (n=141)	p-value
Peak knee varus/valgus* angle; mean (95% CI)	3.4 (2.1–4.6)	-7.5 (-8.7– -6.2)	<0.001**	-3.2 (-4.5– -2.0)	-0.9 (-2.3–0.6)	0.022**
Peak knee flexion angle; mean (95% CI)	84.5 (82.8–86.2)	85.1 (83.5–86.8)	0.607	83.1 (81.4–84.8)	86.5 (84.6–88.4)	0.016**

Table 3. Frontal plane knee control according to sport and gender. n (%). Knee control classified into three categories according to peak knee valgus/varus angle: good (varus angles >0.0º), reduced (valgus angles ranging between -0º to -10º) and poor knee control (valgus angles <-10.0º).

	Basketball (n=173)			Floorball (n=141)			Total
	Male	Female	All	Male	Female	All	
Good knee control	59 (75%)	20 (21%)	79 (46%)	64 (87%)	16 (24%)	80 (57%)	159 (51%)
Reduced knee control	16 (20%)	40 (43%)	56 (342%)	8 (11%)	25 (37%)	33 (23%)	89 (28%)
Poor knee control	4 (5%)	34 (36%)	38 (22%)	2 (3%)	26 (39%)	28 (20%)	66 (21%)
Total	79 (100%)	94 (100%)	173 (100%)	74 (100%)	67 (100%)	141 (100%)	314 (100%)

Figure 1. Vertical drop jump -test in 3-D motion laboratory.