Assessment of Lower Limb Neuromuscular Control in Prepubescent Athletes

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Background: Although neuromuscular indices have been extensively studied in adolescents and adults, limited data exist for prepubescent children.

Hypothesis: No differences exist between prepubescent boys and girls in lower limb strength, symmetry on single-legged hop testing, and limb alignment during drop-jump testing.

Study Design: Cross-sectional study (prevalence); Level of evidence, 1.

Methods: The authors tested 27 female and 25 male athletes who were aged 9 to 10 years and matched for both body mass index and years of organized sports participation. In a drop-jump screening test, the distance between the right and left hips, knees, and ankles was measured as an indicator of lower limb axial alignment in the coronal plane. The distance between the knees and ankles was normalized by the hip separation distance. Quadriceps and hamstrings strengths were measured isokinetically at 180 deg/s. Lower limb symmetry was determined from 2 single-legged hop function tests.

Results: Boys demonstrated greater mean absolute and normalized knee and ankle separation distances on the drop-jump test. Even so, 76% of boys had a normalized knee separation distance of 60% or less of the hip separation distance, as did 93% of girls, indicating a distinctly valgus alignment. There were no differences between the sexes in quadriceps and hamstrings peak torques, hamstrings/quadriceps ratio, time to peak torque, total work, or lower limb symmetry values.

Conclusions: A high percentage of the prepubescent athletes studied had a distinctly valgus lower limb alignment during the drop-jump test and a lack of lower limb symmetry during the hop tests. These same indices have been hypothesized to increase the risk for knee ligament injuries in older athletes. Neuromuscular training may be needed to address these issues in children.

Keywords: neuromuscular; isokinetic; limb symmetry; children

Many male and female athletes enter formal sports participation at very young ages. In the United States, an estimated 30 million children aged 5 to 18 years participate in organized sports programs.[1] Unfortunately, approximately one third of these young athletes sustain sports injuries requiring medical treatment, with the ankle and knee being the most commonly injured areas.[1,24,34,37] During the past decade, several studies have reported that female athletes in both adolescent and adult populations have a 4- to 8-fold higher incidence of serious knee ligament injury compared with male athletes participating in the same sport.[4,7,18,27] Whether the difference in knee ligament injury rates between the sexes is present in younger, skeletally immature children is unknown. Studies related to sports injury epidemiology in children have not stratified the injuries according to sex, skeletal maturity, or specific injury such as a complete knee ligament rupture.[9,24,37] In addition, whether the mechanisms responsible for knee ligament injuries in female athletes are the same in younger children as they appear to be in adolescents remains unclear.

Many investigators have described differences between the sexes in neuromuscular indices, such as muscle strength, running, cutting, sidestepping, and landing characteristics. In adolescent and adult populations, these differences are believed to be at least partially responsible for the disparity in injury rates between male and female athletes.[†] However, few studies have measured such neuromuscular indices in young, athletically active children. Only a few authors have conducted isokinetic quadriceps and hamstrings strength testing in young children using modern protocols and techniques,[13,14,40] and to our knowledge, no study has conducted single-legged functional hop

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No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 33, No. 12
DOI: 10.1177/0363546505278257

[†]References 10, 15, 20-22, 26, 30, 31, 41-44.

testing or drop-jump video screening in 9- and 10-year-old athletes. The absence of such data precludes speculation on the causes of lower extremity noncontact injuries in children or whether neuromuscular training programs should be incorporated at an early age to improve strength, balance, and body awareness and positioning.

The purpose of this investigation was to study specific neuromuscular indices in children 9 to 10 years of age. Our goals were to measure muscle strength, lower limb symmetry in single-legged hop testing, and lower limb control and position during a drop-jump screening test in young athletes. Although we realized that children do not master complex motor skills until the ages of 10 to 12 years,[1] we studied a specific population that had already been engaged in organized sports for several years. We questioned whether boys and girls would demonstrate the same differences in these indices that are known to exist in adolescent and young adult populations.[17,36] We also wished to compare our findings with those we previously reported[36] in athletes aged 11 to 19 years to determine if age-related differences existed on lower limb control and position during the drop-jump test.

We hypothesized that there would be no difference between boys and girls in lower extremity isokinetic quadriceps and hamstrings strengths, lower limb position on drop-jump testing, and lower limb symmetry on single-legged function testing.

MATERIALS AND METHODS

Population

We recruited 27 female and 25 male athletes from area schools and youth soccer leagues to participate in this investigation. Written informed consent was obtained from either the family or legal guardian of each athlete prior to testing. There were no significant differences between girls and boys in mean age (9.7 ± 0.5 years and 9.6 ± 0.5 years, respectively), mean height (136 ± 7 cm and 133 ± 5 cm, respectively), mean weight (39 ± 11 kg and 36 ± 5 kg, respectively), or mean body mass index (BMI; 18 ± 4 and 18 ± 2, respectively). Tanner staging and skeletal maturity were not assessed. Because prior studies on growth prediction demonstrated that significant growth is expected in boys and girls in this age range, we believed that these subjects had not reached skeletal maturity.[3] In addition, maturation, as determined by Tanner staging, has been shown by others to not independently influence the development of isokinetic[13] and isometric[29] knee extension and flexion strengths when stature and mass are controlled for in children. None of the subjects had a history of lower extremity injury, current symptoms of pain or visible joint effusion, or patellar instability. General demographic data were collected, including history of athletic participation and current athletic participation.

All of the girls except 1 were involved in organized soccer, and 10 participated in other organized sports as well. Fourteen of the boys participated in organized soccer, 5 in baseball, 4 in football, 1 in hockey, and 1 in basketball. Ten boys participated in multiple organized sports activities. There were no differences between the girls and boys in mean years of sports participation (4.8 ± 1.4 years and 4.6 ± 0.7 years, respectively) or mean age at which organized sports participation had begun (4.8 ± 1.3 years and 4.9 ± 0.9 years, respectively).

Video Analysis of the Drop-Jump Test

A videographically screened drop-jump test, previously described in detail,[36] was used to measure the distance between the hips, knees, and ankles in the coronal plane. A Sony Mini DV Camcorder equipped with a memory stick (Sony Products, Park Ridge, NJ) was placed on a stand that was 102.24 cm in height. The stand was positioned approximately 365.76 cm in front of a box that was 30.48 cm in height and 38.1 cm in width. Velcro® circles (VELCRO USA Inc, Manchester, NH), 1 inch in diameter, were placed on each of the 4 corners of the box that faced the camera.

Athletes wore fitted, dark shorts and low-cut gym shoes. Reflective markers were placed at the greater trochanter and the lateral malleolus of both legs, and Velcro® circles were placed on the center of each patella. A research assistant demonstrated the jump-land sequence to each athlete, and one trial was conducted to ensure complete understanding of the test. The athletes performed a jump-land sequence by first jumping off the box, landing, and immediately jumping into a maximum vertical jump. The subjects were not given specific instruction on how to land or jump, only to land straight in front of the box to be at the correct angle for the camera to record properly. This sequence was repeated 3 times.

After completion of the test, a research assistant viewed all 3 trials, and the trial that best represented the athlete's jumping ability was selected for measurement. Advancing the video frame by frame, the following images were captured as still photographs: (1) pre-landing, the frame in which the athlete's toes just touched the ground after the jump off the box; (2) landing, the frame in which the athlete was at the deepest point; and (3) takeoff, the frame that demonstrated the initial forward and upward movements of the arms and the body as the athlete prepared to perform the maximum vertical jump.

The captured images were imported into the hard drive of a desktop computer and digitized on the computer screen. A calibration procedure was accomplished by placing the cursor and clicking in the center of each Velcro® marker on each of the 4 corners of the drop-jump box. The anatomical reference points represented by the reflective markers were selected by clicking the cursor for each image in a designated sequence. For the pre-landing image, the sequence of selection was right hip, right knee, right ankle, left hip, left knee, and left ankle.

The absolute separation distance (in centimeters) between the right and left hips, knees, and ankles was calculated with Sportsmetrics Software (Cincinnati Sportsmedicine Research and Education Foundation, Cincinnati, Ohio). The distance between the knees and ankles was then normalized according to the hip separation distance. Therefore, normalized knee separation distance was calculated as knee separation distance/hip separation distance, and normalized ankle separation distance was calculated as ankle separation distance/hip separation distance.

We compared the distribution of subjects who had 60% or less normalized knee separation distance, 61% to 80% normalized knee separation distance, and greater than 80% normalized knee separation distance during prelanding, landing, and takeoff. These percentile groups were chosen arbitrarily, but we believed that 60% represented a distinctly abnormal lower limb valgus alignment position, which was visually evident from the captured photographs.[36]

We also attempted to measure the frontal angle (varus or valgus alignment) of the lower extremities. The frontal angle was determined during the takeoff frame by selecting the center of the midfemur, the center of the patella, and the center of the talocrural joint (in line with the lateral malleolus). We realized that the frontal angular measurements would not represent true osseous alignment and that the coronal measurements could be affected by lower limb internal and external tibial and femoral rotations and translations. The resulting data demonstrated that these angular measurements could not be accurately and reliably determined, and we therefore eliminated this analysis from the study.

The reliability of the drop-jump screening test was previously reported to be adequate for test-retest trials and within-test trials (all intraclass correlation coefficients ≥0.90).[36]

Isokinetic Knee Flexion and Extension Testing

Isokinetic knee flexion and extension testing was performed at 180 deg/s on a dynamometer (Biodex Medical Systems Inc, Shirley, NY). Acceptable reliability of isokinetic measurements in young children has been demonstrated by other investigators.[11,25,32] Measurements were preceded by a dynamic warm-up lasting 5 minutes, followed by flexibility exercises. Subjects were positioned in the device with appropriate torso, pelvis, and thigh straps placed according to the manufacturer's protocol. The lever arm of the dynamometer was aligned with the lateral epicondyle of the knee, with the knee flexed to 90°. The chair was adjusted for each subject to allow proper positioning. The range of motion during the test was fixed from 90° to 0°. Gravitational factors were calculated by the dynamometer and automatically compensated for during the tests. Subjects were familiarized with the machine and the test velocity by performing 3 to 4 submaximal trials. There was a 60-second rest period between the flexion and extension tests. Oral encouragement was given throughout the tests (the athletes were told to kick as hard and as fast as possible), but no visual feedback was available. A total of 10 repetitions was completed, and the highest peak torque value was used for analyses. Mean peak torque values (in newton-meters) were normalized for body weight (BW) in kilograms and were expressed as N·m/BW. Time to peak torque (in milliseconds) and total work (in newton-meters) were also obtained, as calculated by the manufacturer's software.

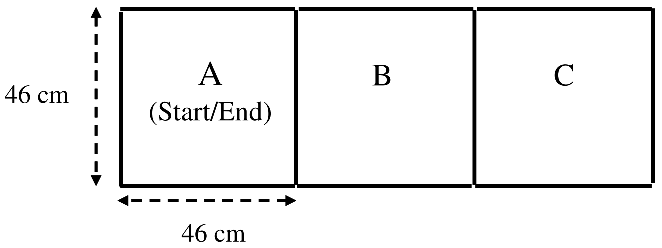

Figure 1. Single-legged timed side-hop function test. The subject begins in box A. Standing on one leg, the subject hops to box B, box C, then back to box B, and box A to complete one course repetition. One trial consists of 3 repetitions. The subject must successfully cross the lines, maintain single-legged balance, and hold each landing without placing the opposite foot down on the floor.

Single-Legged Hop Functional Testing

Two single-legged hop functional tests were conducted: a timed side-hop and a cross-over hop for distance.[35] The athletes were provided with instructions on each task, and one trial was conducted for test familiarization.

In the timed side-hop test, a course was created on the floor using masking tape to mark 3 boxes that were 46 cm × 46 cm in length and width (Figure 1). The athletes were encouraged to hop as fast as possible but to maintain enough balance to be able to complete the test. If the subject did not clear the lines, double-bounced between hops, or could not hold his or her balance on landing, a zero was recorded. Two tests were completed for each limb, and mean times were calculated with a standard stopwatch to the nearest 1/100 of a second. Limb symmetry was calculated by dividing the mean of the right limb by the mean of the left limb and multiplying the result by 100. Limb symmetry values less than 85% were previously reported to represent functional limitations in older-aged populations.[5]

In the cross-over hop for distance testing, a marking strip made of masking tape, extending approximately 6 m, was placed on the floor. The athletes hopped 3 consecutive times on one foot, crossing diagonally over the tape on each hop, and they were encouraged to go as far as possible while maintaining balance and control. The total distance hopped was measured and each leg tested twice, with the average distance calculated. Limb symmetry was calculated as previously described.

Statistical Analyses

To evaluate the primary study outcome (knee separation distance on landing and takeoff), sample-size calculations and the power to detect a difference between the sexes were determined by an independent statistician. With 27 female and 25 male subjects in this study, there was sufficient power (>90%) to detect differences of at least 15%

TABLE 1
Normalized Ankle Separation Distances
During the Drop-Jump Screening Test[a]

	Boys				Girls			
Phase	Mean	SD	SE	95% CI	Mean	SD	SE	95% CI
Pre-landing	96	12	2.4	91-101	79[b]	11	2.1	75-83
Landing	92	20	4.0	84-100	71[b]	13	2.5	66-76
Takeoff	91	20	3.9	83-99	70[b]	11	2.2	66-74

[a]All values are in percentages. SE, standard error; 95% CI, 95% confidence interval.
[b]$P < .001$ compared with the mean value in boys.

TABLE 2
Normalized Knee Separation Distances
During the Drop-Jump Screening Test[a]

	Boys				Girls			
Phase	Mean	SD	SE	95% CI	Mean	SD	SE	95% CI
Pre-landing	60	10	1.9	56-64	48[b]	10	1.9	44-52
Landing	49	18	3.6	42-56	41[c]	12	2.4	36-46
Takeoff	49	18	3.5	42-56	44	10	2.0	40-48

[a]All values are in percentages. SE, standard error; 95% CI, 95% confidence interval.
[b]$P < .001$ compared with the mean value in boys.
[c]$P < .05$ compared with the mean value in boys.

between the sexes in knee separation distance at a significance level of .05.

Unpaired 2-tailed Student t tests were used to determine if significant differences existed between boys and girls for normalized knee and ankle separation distances, all isokinetic variables, and limb symmetry values. Correlation coefficients were calculated to determine if a relationship existed between mean normalized knee and ankle separation distances during pre-landing, landing, and takeoff. A Fisher exact test compared the distribution of girls to boys for those with 60% or less normalized knee separation distance, 61% to 80% normalized knee separation distance, and greater than 80% normalized knee separation distance during pre-landing, landing, and takeoff. An analysis of variance was used to determine if correlations existed within each sex between knee flexion and extension peak torques and normalized knee and ankle separation distances. Paired 2-tailed Student t tests were conducted on the isokinetic data to determine if significant differences existed within each sex between the dominant and nondominant limbs. The 95% confidence intervals (95% CI) were calculated on the normalized knee and ankle separation distance values during pre-landing, landing, and takeoff for each sex.[16]

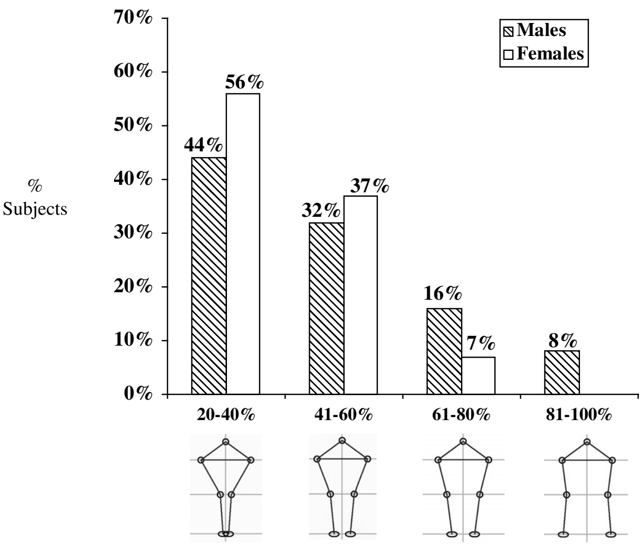

Figure 2. The distribution of male and female athletes according to normalized knee separation distance on landing. These percentile groups were chosen arbitrarily. There were no differences in the distribution of athletes among the categories shown. The stick figures are representative of the knee separation distance but not of the ankle separation distance.

RESULTS

Drop-Jump Screening Test

There was no difference between female and male subjects in the mean hip separation (in centimeters) for each phase of the jump-land sequence. The mean hip separation distance was 36 ± 3 cm on pre-landing and 35 ± 3 cm on landing and takeoff for both boys and girls. No statistical relationships were found between normalized knee and normalized ankle separation distances for either sex on pre-landing, landing, or takeoff.

Male athletes had greater absolute ankle separation distances compared with the female athletes (pre-landing, 35 ± 5 cm and 28 ± 5 cm, respectively; landing, 32 ± 6 cm and 24 ± 6 cm, respectively; takeoff, 32 ± 6 cm and 24 ± 5 cm, respectively; $P < .001$) and greater normalized ankle separation distances, as shown in Table 1. A wider 95% CI range was noted for male athletes compared with the female athlete values for all 3 phases of the test.

Male athletes had greater absolute knee separation distances on pre-landing and landing compared with female athletes (pre-landing, 22 ± 4 cm and 17 ± 4 cm, respectively; landing, 18 ± 7 cm and 14 ± 5 cm, respectively; $P < .05$) and greater normalized knee separation distances in these phases, as shown in Table 2. A wider 95% CI range was found for male athletes on landing and takeoff compared with the female athlete values.

There were no statistically significant differences between boys and girls in the distribution of athletes who had normalized knee separation distances on landing of 20% to 40%, 41% to 60%, 61% to 80%, or 81% to 100% (Figure 2). A marked decrease in the normalized knee separation distance of 60%

Figure 3. Photographs of the toe-touch and takeoff phases of the videographically screened drop-jump test for 2 subjects. A 10-year-old female subject demonstrates poor knee separation distance in both (A) pre-landing (11 cm; 31% normalized) and (B) takeoff (12 cm; 33% normalized) phases. A 9-year-old male subject demonstrates good knee separation distance on (C) pre-landing (24 cm; 68% normalized); on takeoff (D), however, the valgus position is apparent, with a large decrease in knee separation distance (13 cm; 38% normalized).

TABLE 3
Results of Isokinetic Knee Flexion and Extension Testing at 180 deg/s[a]

Variable	Flexion/Extension	Leg	Girls	Boys
Peak torque, N•m/BW	Extension	Dominant	93 ± 23	94 ± 14
		Nondominant	101 ± 21	99 ± 14
	Flexion	Dominant	80 ± 17	82 ± 20
		Nondominant	78 ± 15	82 ± 20
Hamstrings/quadriceps ratio, %	Extension	Dominant	77 ± 12	81 ± 15
		Nondominant	73 ± 10	75 ± 19
Total work, N•m	Extension	Dominant	57 ± 13	55 ± 11
		Nondominant	62 ± 13	59 ± 12[b]
	Flexion	Dominant	49 ± 11	51 ± 12
		Nondominant	53 ± 12[b]	50 ± 14
Time to peak torque, ms	Extension	Dominant	162 ± 60	195 ± 93
		Nondominant	172 ± 58	186 ± 58
	Flexion	Dominant	183 ± 63	214 ± 74
		Nondominant	211 ± 94	225 ± 82

[a]Values are given as means ± SDs. BW, body weight.
[b]$P < .05$ compared with the dominant leg.

or less, indicating a notably valgus alignment, was found in 19 boys (76%) and 25 girls (93%) on landing (Figure 3).

Isokinetic Testing

There were no differences between boys and girls in the knee flexion and extension isokinetic indices (Table 3). There were no statistically significant correlations between flexion and extension peak torque values and limb alignment indices in the 3 phases of the drop-jump test. There were also no correlations between the isokinetic indices and body weight or BMI for either sex.

Functional Hop Testing

Asymmetrical lower limb symmetry values (<85%) were found in 77% of the girls and 84% of the boys in the timed side-hop test and in 55% of the girls and 56% of the boys in the triple-hop test. There were no differences between boys and girls in the mean limb symmetry values for the timed side-hop test (68% ± 22% and 74% ± 22%, respectively) or the cross-over hop for distance test (78% ± 21% and 76% ± 21%, respectively). There were no correlations between limb symmetry values and the isokinetic indices for either sex.

DISCUSSION

This study provides data, for the first time that we are aware, on lower limb axial alignment during a videographically screened drop-jump test and lower limb symmetry during single-legged functional hop testing in children 9 to 10 years of age. Our first hypothesis was that no difference would be detected between boys and girls in lower limb position during drop-jump testing. Authors have postulated that female athletes land from a jump in a distinctly valgus lower limb alignment, in contrast to male athletes, who tend to land in a more neutrally aligned position. A valgus lower limb alignment assumed during athletic maneuvers has been hypothesized to increase the risk for a serious knee ligament injury, based on studies involving adolescent and adult athletes.[17,23] We believed that prepubescent children would not demonstrate these sex differences because their muscle strength and motor skills have not yet fully developed.

The results of our study showed that 76% of boys and 93% of girls had a marked valgus alignment (≤60% normalized knee separation distance) during the drop-jump screening test. This valgus lower limb alignment occurred even though the male subjects had greater ankle and knee separation distances throughout the drop-jump sequence. For example, the boys had a mean knee separation distance on landing of 49% ± 18% (95% CI, 42%-56%) compared with girls, who had a mean knee separation distance of 41% ± 12% (95% CI, 36%-46%). The mean normalized ankle separation distance for the boys of 92% on landing has a theoretical advantage in providing a broader base (Figures 3 C and D). However, the majority of boys still showed an overall lower extremity valgus alignment on landing and takeoff, presumably due to hip adduction and internal rotation. We previously noted that the effect of the final position of the knee joint is influenced by a multitude of factors: importantly, the center of gravity of the upper body and the trunk over the lower extremity, hip adduction or abduction, and foot-ankle position and separation distances.[36]

The findings of this study are in agreement with a similar analysis we conducted on 325 female and 130 male athletes aged 11 to 19 years.[36] In that investigation, a notably valgus lower limb alignment was reported in 62% of female athletes and in 75% of male athletes on landing during the drop-jump test. A comparison of the indices is shown in Table 4. The 9- to 10-year-old female athletes had poorer knee separation distances than the older female subjects ($P < .01$). No such age effect was found for the male athletes. Additional testing of younger athletes is required before definitive conclusions can be reached toward an age effect on knee separation distance during the drop-jump test.

TABLE 4
Comparison of Normalized Knee Separation Distance on Landing Between Athletes of Different Ages[a]

Subjects	Percentile Group ≤60%	61%-80%	>80%	Mean ± SD
Male athletes				
9 to 10 years old (n = 25)	76	16	8	49 ± 18
11 to 19 years old (n = 130)	75	20	5	51 ± 15
Female athletes				
9 to 10 years old (n = 27)	93	7	0	41 ± 12
11 to 19 years old (n = 325)	62	24	13[b]	51 ± 19[c]

[a]Data for athletes aged 11 to 19 years are from reference 37. Values are given as the percentage of hip separation distance.
[b]$P = .005$.
[c]$P < .01$.

In a prior study, a subset of 62 female athletes (11 to 16 years of age) underwent a 6-week neuromuscular training program.[36] Statistically significant increases were found after training in the absolute and normalized knee and ankle separation distances for all phases of the drop-jump test ($P < .001$). Whether a similar training effect would exist in younger athletes such as those in the current study is unknown. Few controlled studies have been conducted to investigate strategies to prevent injuries in children.[6,28,33] The drop-jump screening test provides a general indicator of an athlete's lower limb axial alignment in the coronal plane during landing and takeoff. We do not propose that this general screening test can be used as a risk indicator for knee ligament injury.[36] However, the pictorial sequence provides information to athletes, parents, and coaches in viewing and understanding body positioning on landing and takeoff. There are no formal national education or certification requirements for coaches in the United States, and it is unknown how many coaches have had formal training in conditioning and training, growth and development, or injury prevention.[33] We strongly advise continued analysis of knee ligament injury mechanisms, with the belief that newer coaching techniques and strategies may be effective in addressing the ACL injury problem.

Our findings of a lack of a difference in any of the isokinetic muscle strength values between male and female athletes agree with other recent studies in children of similar ages.[13,14,40] Sex-based strength differences are not expected to become apparent until the mid-teens.[13,14,19,38,39] One purpose of conducting isokinetic testing in our study was to assess if a correlation existed between knee flexion and extension peak torques and knee or ankle separation distances, and none was found.

We hypothesized that there would be no difference between boys and girls in lower limb symmetry as determined by single-legged hop tests. One previous study assessed the reliability of 2 sports-related functional tests that involved speed and agility during double-legged activities (slalom and hurdle tests) in 11 athletes (8 boys and 3 girls) aged 11 years.[2] The intraclass correlation coefficients demonstrated adequate reliability of these tests. The standing balance of children 10 years and younger has been shown to be poorer than that of adults because of their still-developing vestibular system.[8] Postural sway has been shown to be greater in children aged 9 to 10 years than in those aged 15 to 18 years.[45] In our study, limb symmetry values of less than 85% (indicating a more than 15% difference between right and left limb measurements) were found in 77% of the girls and 84% of the boys in the timed side-hop test and in 55% of the girls and 56% of the boys in the triple-hop test. The timed side-hop test induces medial and lateral forces, and the children had a difficult time maintaining balance on one leg while hopping in those directions.

We also wished to determine if a correlation existed between quadriceps and hamstrings peak torques and lower limb symmetry on the single-legged hop tests. Prior studies have shown a relationship between quadriceps strength and single-legged hop testing in older populations 16 to 48 years of age.[5,35] No such relationship was found in the current investigation. The results of the functional tests could be because of motor development skills and neuromuscular indices such as balance, proprioception, and hip muscle strength not analyzed in this study. Cross-sectional investigations using single-legged hop tests on children and adolescents younger than 18 years of age are necessary to determine if an age effect exists similar to those that exist for isokinetic muscle strength[12] and standing balance.[8]

One of the limitations of this study was the small cohort. In addition, the drop-jump screening test provides only a general indicator of an athlete's lower limb axial alignment in a single plane. The results of this investigation showed that a high percentage of male and female athletes 9 to 10 years of age had a notably valgus lower limb alignment during the drop-jump screening test and a lack of symmetry between lower limbs in single-legged hop tests. These same indices have been hypothesized to increase the risk for serious knee ligament injuries in adolescent and adult athletes. We believe that consideration should be given to incorporating neuromuscular training techniques that educate proper landing mechanisms and body positioning and that improve balance and muscle strength to younger athletes.

ACKNOWLEDGMENT

The research was funded by the Cincinnati Sportsmedicine Research and Education Foundation and the Noyes Knee Center. The authors thank Michelle Brock, Amy Dudley, Cassie Fleckenstein, Jill Miller, and Jennifer Riccobene for their assistance with the test and data collection in this study.

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