IJSPT
INTERNATIONAL JOURNAL OF SPORTS PHYSICAL THERAPY

McGinley JJ, Randoing B, Saleem L, et al. Lower-Quarter Y-Balance Test Differs by Age: Younger Athletes May Not Be Generalized to High School-Aged Counterparts. *IJSPT*. 2024;19(8):989-996. doi:10.26603/001c.120898

Original Research

Lower-Quarter Y-Balance Test Differs by Age: Younger Athletes May Not Be Generalized to High School-Aged Counterparts

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Keywords: dynamic balance, lower extremity, reference values, return to sport, youth sports

https://doi.org/10.26603/001c.120898

International Journal of Sports Physical Therapy

Vol. 19, Issue 8, 2024

Background

Given rising youth sport participation, 8 to 10-year-olds increasingly display comparable lower-extremity injury incidence to 11 to 17-year-olds and require effective return to sport criteria. One such criterion which quantifies dynamic stability is the Y-Balance Test (YBT), though it has not been validated in children under age 11.

Hypothesis/Purpose

The purpose of this study was to examine the performance of 8 to 10-year-old patients on the YBT after lower-extremity injury and determine how these results compare to larger samples of age-grouped athletes within the validated 11 to 17-year-old range. It was hypothesized that 8 to 10-year-olds would display different normalized YBT distances compared to 11 to 17-year-olds.

Study Design

Cross-sectional Study.

Methods

Patients (N=1093) aged 8 to 17 who presented to a pediatric sports medicine practice with a lower-extremity injury and completed the YBT between December 2015-May 2021 were included. Anterior, posteromedial, and posterolateral YBT scores were collected at return-to-sport for affected and unaffected limbs. Scores were normalized to limb length, and composite scores were created. Between-limb differences were calculated in groups of ages 8-10, 11-12, 13-14, and 15-17. Groups were also evaluated for differences by sex.

Results

A rise in performance was observed in unaffected limb anterior reach from ages 8 to 10 years to 11 to 12 years followed by a subsequent significant decrease at older ages ($p<0.001$). Affected limb anterior reach differed between the youngest group and two oldest groups ($p=0.004$). Anterior and composite difference were significantly different between the oldest three groups ($p=0.014$ anterior; $p=0.024$ composite). No differences were observed between sexes in 8 to 10-year-olds, though 11 to 12-year-old females

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reached further during all eight distances. In the older three groups, males generally displayed greater between-limb differences.

Conclusion

YBT scores, specifically anterior reach, demonstrated inconsistency by age and sex across a large adolescent cohort. Existing return-to-sport standards should not be used with younger athletes, and individual validation is required.

Level of Evidence

Level III

INTRODUCTION

An estimated 30 million children are involved annually in organized sport.[1] However, given frequent year-round participation of youth athletes, injuries have steadily increased.[2] Specifically, youth anterior cruciate ligament (ACL) injuries have grown by 2.3% per year over the last 20 years.[3] Youth athletes are often more susceptible to sport-related injury due to skeletal immaturity and/or underdeveloped coordination.[4] In fact, 8 to 10-year-olds may undergo similar injury levels to older youth,[5] due in part to rising sport specialization as early as six years of age.[6] This increased prevalence is especially true in youth athletes with prior injury,[7] with one study demonstrating that one in four youth athletes will suffer a repeat lower-extremity injury.[8] Moreover, increased injury prevalence is perpetuated by reduced recovery time and insufficient emphasis on rest,[1] yet prediction is multifactorial and not fully understood.[3] Therefore, it is essential that evidence-based screening measures are available and appropriate for determining return to play readiness for athletes of all ages.

Dynamic movement screens, such as the Y-Balance Test (YBT), have been implemented in return-to-play protocols to quantify a patient's readiness for activity. Specifically, the YBT is a screening measure that evaluates the dynamic limits of stability, strength, and asymmetrical balance in the anterior, posterolateral, and posteromedial directions. Normative values of the YBT have been shown to increase with age, falling in the range of 85-115 percent of leg length for 10-18-year-old patients.[9-11] The YBT may also relate to injury risk,[12,13] although some studies have shown otherwise.[14] Specifically, anterior reach has been associated with both injury risk and limb asymmetry at return-to-play.[15-17] Injury risk may also be anticipated by anterior reach asymmetry greater than four centimeters, though these studies have focused on adults.[17] As re-injury risk may relate to measures of the YBT, specifically in the anterior direction, it is important to establish normative values of all at-risk populations.

While researchers have validated the YBT in patients aged 11 to 17 years,[10,11,18] clear physical and physiological differences exist between athletes across different stages of maturation.[6] For example, postural stability may improve with age in youth.[19] As athletes continue to grow, they display different stability, flexibility, and control as their center of mass shifts and muscles develop. Similarly, athletes who have recently undergone growth spurts may be disposed to muscular imbalances, which can be monitored by dynamic movement screens such as the YBT.[20] Dynamic stability may also differ by sex as females have been reported to attain further anterior reach[21] and males have been observed to have larger anterior asymmetry,[22] posteromedial reach, and posterolateral reach.[23] Given the variation among age and sex in characteristics of dynamic stability, it is necessary that sports care providers have a sufficient understanding of how each developmental age performs. Therefore, despite reliable dynamic movement screening being essential for maximizing adolescent health, extrapolating physical therapy screening across age cohorts without rigorous examination is potentially problematic.[24]

Provided the YBT has only limited investigation in a cohort of youth athletes aged less than 11 years[25,26] and no comparisons with older athletes to the authors' knowledge, therefore, the purpose of this study was to examine the performance of 8 to 10-year-old patients on the YBT after lower-extremity injury and determine how these results compare to larger samples of age-grouped athletes within the validated 11 to 17-year-old range. It was hypothesized that 8 to 10-year-olds would display different normalized YBT distances compared to 11 to 17-year-olds.

MATERIALS AND METHODS

The local Institutional Review Board (IRB) approved this retrospective review of patients who presented with a lower-extremity injury at a pediatric sports medicine practice, and informed consent was waived. Patients were included if they completed functional performance testing for return-to-play decision-making between December 2015 to May 2021 from a single pediatric sports medicine physical therapy department and had an available diagnosis of lower-extremity injury. Lower-quarter YBT scores completed at the time of return-to-play evaluation were collected from a functional performance test database called Move2Perform (Evansville, IN). Demographics and sports type were collected from patients' electronic medical records. As only the final YBT score was analyzed for each return-to-sport decision, patient scores prior to activity release were excluded from data analysis. The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) statement checklist is provided as Supplementary Material.[27]

The lower-quarter YBT is a screening measure that evaluates dynamic stability in the anterior, posterolateral, and posteromedial directions, demonstrating interrater reliability with an acceptable level of measurement error.[23] Each patient performed a lower-quarter YBT using the test kit (Functional Movement Systems; Chatham, VA) as part of a return-to-play evaluation conducted by a trained physical therapist. Prior to testing, limb length of the right leg was measured from the right anterior superior iliac spine to the distal tip of the right medial malleolus to the nearest half centimeter. Next, verbal instructions were provided alongside a live demonstration performed by the physical therapist certified by Functional Movement Systems. Patients completed three practice trials in each direction prior to testing so that the patient was familiar with the test. Each patient was tested bilaterally in the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions for a total of three trials. During the testing phase, trials were excluded if any of the testing faults occurred: kicking the push box, not returning to the starting position under control, touching down during testing, or placing the foot on top of the push box. Reach distance was estimated to the nearest half centimeter.

Normalized component scores for each test condition were then calculated by dividing each component by limb length and multiplying by 100. In addition, a composite score (COMP) was computed by averaging the three normalized component scores. Between-limb differences (Δ) were calculated for each score (components and composite) as the absolute value of the difference between the scores of the affected and unaffected limb.

Patients were separated into age groups of 8 to 10, 11 to 12, 13 to 14, and 15 to 17 years. Group separations were based on the average adolescent growth spurt and peak growth (near ages 11 and 13, respectively).[28] Patients were not initially separated by sex or severity of their lower-extremity injury to allow for a large-scale survey only dependent on age grouping. Given that patients were evaluated for return-to-play, affected and unaffected limbs were separated in analysis. Each limb of bilaterally affected patients was included individually in the affected limb analysis, but all bilaterally affected patients were excluded from between-limb differences. After age group comparisons, patients were separated for a within-group comparison by sex.

For each YBT metric, a Kruskal-Wallis ANOVA was performed to determine significant differences between age groups, and Mann-Whitney post-hoc testing specified significance between age group pairings. A conventional 95% confidence interval was set for all statistical tests.

RESULTS

A total of 1093 bilateral patients were included and analyzed for YBT reach distances. All age groups were majority female and were significantly different from other groups in age (p<0.001), weight (p<0.001), and limb length (p<0.001) (Table 1). Among all patients, 70.3% participated in contact sports. Patients were treated for a variety of lower-extremity conditions which merited return-to-play evaluations including injury of the ACL (41.7%), ankle (17.8%), patella (16.1%), hip (13.3%), Achilles tendon (1.8%), meniscus (1.6%), and other (7.7%). Seventeen patients were missing weight measurements (2%, 1%, 1%, and 2%, from youngest to oldest age group, respectively).

Computed mean and sample standard deviation of the eight YBT reach metrics and four YBT between-limb differences described groups of 8 to 10, 11 to 12, 13 to 14, and 15 to 17-year-old athletes. Significant differences were observed between age groups in affected limb ANT (p=0.004), unaffected limb ANT (p<0.001), Δ ANT (p=0.014), and Δ COMP (p=0.024). Post-hoc analyses revealed that YBT scores were not significantly different in the 8 to 10-year-old group than 11 to 12 years. However, 8 to 10-year-olds were significantly greater in both affected and unaffected ANT than 13 to 14-year-olds (p=0.021 affected; p=0.004 unaffected) and 15 to 17-year-olds (p=0.001 affected; p<0.001 unaffected). Between 11 to 12-year-olds and 13 to 14-year-olds, unaffected ANT (p=0.031), Δ ANT (p=0.029) and Δ COMP (p=0.015) were greater in the younger group. Additionally, 11 to 12-year-olds had significantly greater unaffected ANT (p=0.002), affected PM (p=0.035), and Δ COMP (p=0.008) than 15 to 17-year-olds. Finally, the 15 to 17-year-olds recorded a greater Δ ANT than 13-14-year-olds (p=0.011) (Table 2).

Though, reach distances demonstrated lower scores at 8 to 10 years, a peak in performance from 11 to 12 years, a decline at 13 to 14 years, and a further decline at 15 to 17 years, these differences were not statistically significantly different. Between-limb comparisons in the anterior direction, posterolateral direction, and composite score showed similar non-significant trends, though the oldest group did not continue to decline in YBT scores after falling from 13 to 14 years. A decline starting at ages 8 to 10 was observed in between-limb comparisons of the posteromedial direction, with a rise at 15 to 17 years (Table 2).

When categorized by sex, the 8 to 10-year group displayed no within-group differences in YBT score. However, females in the 11 to 12-year group achieved greater reach distances in all categories (p<0.001 affected ANT; p=0.014 unaffected ANT; p=0.001 affected PM; p=0.007 unaffected PM; p=0.001 affected PL; p=0.002 unaffected PL; p<0.001 affected COMP; p=0.002 unaffected COMP), with males showing greater Δ PL (p=0.016). Similarly, the 13-14-year group differed by greater Δ ANT (p=0.039) in males, while the 15 to 17-year group only saw males report a significantly greater Δ PL (p=0.017). Complete sex comparison data are included in the Supplementary Material.

DISCUSSION

AGE COMPARISON

As youth injuries continue to rise due to increasing year-round sport participation and earlier specialization of sport,[2,6] it is becoming increasingly important to develop accurate and efficient screening measures for return-to-play assessments at all ages. As such, understanding how YBT scores may be influenced by age is an essential aspect of ensuring children have accurate screening. In this study, reach distances underwent a noticeable peak in patients

Table 1. Patient Demographics

Age Group	8-10	11-12	13-14	15-17	ANOVA p-value
N (total = 1093)	52	138	313	590	
Age (years; mean ± SD)	9.5 ± 0.6	11.6 ± 0.5	13.6 ± 0.5	16.0 ± 0.8	**<0.001***
Weight (kg)	43.2 ± 16.2	54.1 ± 16.2	64.0 ± 15.5	70.6 ± 16.6	**<0.001***
Limb Length (cm)	73.8 ± 6.1	80.1 ± 11.6	85.8 ± 7.8	87.9 ± 6.5	**<0.001***
Female (%)	33 (63.5)	92 (66.7)	200 (63.9)	335 (56.8)	

[a] Significant ANOVA results noted in bold with an asterisk (*). Missing patients for weight: one in 8-10, two in 11-12, three in 13-14, eleven in 15-17.

Table 2. Mean ± Standard Deviation of YBT Metrics by Age Group

Y-Balance Metric	8-10	11-12	13-14	15-17	ANOVA p-value
Affected Limb	**(58)**	**(156)**	**(349)**	**(646)**	**(1209)**
Anterior	72.7 ± 7.4	73.3 ± 19.2	71.3 ± 14.3 [X]	69.4 ± 8.4 [X]	**0.004***
Posteromedial	114.3 ± 8.9	118.7 ± 34.1	115.4 ± 20.1	114.7 ± 10.5 [Y]	0.150
Posterolateral	110.8 ± 10.9	116.2 ± 32.0	112.4 ± 21.4	111.1 ± 11.0	0.947
Composite	99.4 ± 7.6	102.9 ± 28.5	99.8 ± 18.2	98.5 ± 9.0	0.742
Unaffected Limb	**(46)**	**(120)**	**(277)**	**(534)**	**(977)**
Anterior	74.4 ± 7.2	77.0 ± 23.3	71.6 ± 11.4 [X,Y]	70.6 ± 8.5 [X,Y]	**<0.001***
Posteromedial	113.0 ± 19.2	122.4 ± 39.5	115.3 ± 17.9	115.1 ± 10.8	0.825
Posterolateral	112.1 ± 10.2	117.9 ± 37.4	112.2 ± 19.3	111.8 ± 11.5	0.953
Composite	100.0 ± 10.1	106.0 ± 33.3	99.8 ± 15.8	99.2 ± 9.2	0.553
Between-Limb Difference (Δ)	**(46)**	**(120)**	**(277)**	**(534)**	**(977)**
Anterior	1.9 ± 1.4	2.9 ± 2.8	2.1 ± 2.1 [Y]	2.6 ± 2.8 [Z]	**0.014***
Posteromedial	3.9 ± 10.3	2.8 ± 2.8	2.4 ± 2.1	2.7 ± 2.9	0.723
Posterolateral	3.2 ± 2.4	3.8 ± 9.6	2.7 ± 2.4	2.7 ± 2.5	0.116
Composite	2.6 ± 4.1	3.1 ± 4.2	1.9 ± 1.8 [Y]	2.1 ± 2.2 [Y]	**0.024***

[a] Significant ANOVA results noted in bold with an asterisk (*). Superscripts denote statistical significance between age groups. Differences with the 8-10-year, 11-12-year, and 13-14-year groups are noted by the superscripts X, Y, and Z, respectively. Bilateral patients grouped with Affected Limb on both sides and excluded from Between-Limb Difference. Total patients (N) listed for each group. Reach distances normalized by limb length. Y-Balance Test (YBT).

aged 11 to 12 years, with a decline in younger and older age groups. As YBT scores were normalized by leg length, the decrease suggests that, as maturity progresses, leg length increases more than dynamic stability improves over time despite an increase in raw scores with age. Furthermore, dynamic stability is highly dependent on flexibility, which decreases with age.[29] While studies in youth athletes that compare the YBT across age have previously demonstrated increased scores with age rather than the observed decrease, these studies have compared youth to collegiate athletes[17] or studied an extremely homogenous cohort.[9] The large, heterogenous cohort of various lower-extremity conditions and sports observed in the current study may provide a more accurate view of the total youth athlete population than prior research. Thus, the inconsistency in YBT scores across the cohort highlights that premature athletes may not follow the same progression as maturing athletes and emphasizes the need for future studies to provide additional normative data on YBT scores at return-to-play for the 8 to 10-year-old group.

The importance of establishing YBT normative data for younger ages is underscored by the general agreement that the YBT can be predictive of injury given the positive relationship between adolescent growth and injury risk,[12,13,30] though agreement is not unanimous.[14] The anterior direction has been identified as especially useful for injury risk, both in reach distance[15,16] and in the difference between limbs.[17] One possible explanation is suggested by Earl and Hertel, who put forth that the greater knee flexion observed in anterior reach results in greater vastus medialis obliquus and vastus lateralis activity for a more demanding overall task than the posterior direction.[31] As anterior reach was the only direction consistently significant in this study, the results exhibit additional evidence that anterior reach may not only be predictive of return-to-play outcomes, but abnormal values for each age are also more readily identifiable given more stark age differences. Therefore, future studies should aim to corroborate these age-specific anterior reach distances, specifically in ages 8 to 10, as their predictive ability may be clinically useful.

SEX COMPARISON

The differences observed by sex serve to bolster the interpretation that the average onset of pubertal growth around 11 and peak growth at 13 years is a significant determinant of YBT metrics.[28] Prior to the female growth spurt at 8 to 10 years, no differences were identified between sexes. However, there was a significant difference in nearly every category in 11 to 12-year-olds where growth stage is most sex-dependent, with less difference in the older groups as growth leveled off. As such, future validation of 8 to 10-year-old YBT scores may not necessarily require stratification by sex; however, these results do emphasize that the YBT at 8 to 10 years cannot be considered equivalent to scores at 11 to 12 years for practitioners examining return-to-sport readiness.

LIMITATIONS

Limitations to the current study include data collection involving a single pediatric sports medicine practice and risk of data specific to the region. Smaller sample size in the youngest age group and variability in sample size across all age groups presents complications when trying to make between-group comparisons. Furthermore, patients included in the current study were presumably cleared for sport after this YBT and were expected to show YBT scores similar to a healthy population, limiting the utility of the current study's data for injury risk prediction. Finally, the YBT is not yet validated in the 8 to 10-year-old population. However, this only serves to emphasize that future work should compare YBT performance to functional outcome measures to successfully validate the YBT for younger ages.

CONCLUSION

This study presents YBT scores in a large cohort of lower-extremity patients aged 8 to 17 with age group comparisons. Anterior reach scores were observed to rise from 8 to 10 years to 11 to 12 years then significantly decrease with age. Both posterior directions and composite YBT scores also displayed a nominal peak at 11 to 12 years with a decrease at younger and older ages. Differences by sex were observed in the three older groups, with all eight reach distances significant at 11 to 12-years-old, but differences were not seen at 8 to 10 years. Therefore, patients aged 8 to 10 years were not consistent within the trends observed in the validated 11 to 17 year-old population. Given the importance of YBT scores in predicting injury risk, specifically anterior reach, it is necessary that the YBT is studied for validation in this age group and normative values are established in future studies to avoid inaccurately generalizing trends observed in older populations to pre-mature children.

DECLARATION OF CONFLICTING INTERESTS

The Authors declare that there are no conflicts of interest.

Submitted: March 19, 2024 CDT, Accepted: June 26, 2024 CDT

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SUPPLEMENTARY MATERIALS

Supplementary Material

Download: https://ijspt.scholasticahq.com/article/120898-lower-quarter-y-balance-test-differs-by-age-younger-athletes-may-not-be-generalized-to-high-school-aged-counterparts/attachment/235399.pdf