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Functional movement screen and Y-Balance test scores across levels of American football players

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ABSTRACT: Few studies have investigated differences in functional movement assessment performance across scholastic levels of competition. This study examined Functional Movement Screen (FMS) performance in middle school (MS), high school (HS) and collegiate (COL) American football players and Y-Balance test (YBT) scores in MS and HS players. Functional movement measurements were collected for MS (N = 29; age = 12.8 ± 0.7 years), HS (N =52; age = 15.7 ± 1.2 years), and COL (N =77; age = 19.9 ± 1.4 years) football players prior to each group's competitive season. Differences in composite FMS and YBT measurements were examined using Welch's ANOVA and Mann-Whitney U-tests, respectively. Chi-square analyses examined normality of score distributions for individual FMS tests. The MS group displayed a lower composite FMS (12.9 ± 1.9) than both HS (14.0 ± 1.7) and COL (14.1 ± 2.1) groups ($p = 0.019$). COL players scored significantly lower on the Shoulder Mobility (SM) but higher on the Deep Squat (DS), In-line Lunge (ILL), Active Straight-Leg Raise (ASLR) and Push-Up (PU) than both HS and MS groups. No differences were found between MS and HS groups for any YBT normalized reach distances and side-to-side reach distance differences. FMS performance varied with football competition level whereas YBT performance did not. The results suggest that football competition levels normative data and injury-risk thresholds should be established when using FMS scores to guide performance and injury prevention programming.

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INTRODUCTION

Football ranks first among all high school and collegiate sports in both participation [1, 2] and injury incidence [3, 4]. The overall injury rate in high school [3] and collegiate [4] football players has been reported to be as high as 4.4 and 9.2 per 1000 athletic-exposures, respectively. Similar rates of injury have also been reported in youth and middle school football players [5, 6]. Roughly 40% of all injuries in football players across all competition levels involve the lower extremities [3, 5, 7], with many resulting from non-contact mechanisms [7]. In response to this high occurrence of injury, researchers have recently focused on developing field-expedient injury risk screening tools to identify potentially modifiable injury risk factors, such as faulty movement patterns and balance deficiencies, from which targeted interventions can be implemented.

The Functional Movement Screen (FMS) and Y-Balance test (YBT) are two injury-risk screening tools used to identify deficiencies in functional movement, neuromuscular control and balance, and core stability. The FMS is comprised of 7 fundamental movement patterns that aim to identify movement deficiencies and asymmetries [8, 9], and the YBT consists of 3 lower extremity reaching tasks used to assess dynamic balance [10]. Both tests require minimal time to administer, have good interrater and intrarater reliability [10-13], and have been shown to be associated with injury risk in various athletic [14-19] and military populations [20, 21]. Prospective studies have reported an association between several FMS measures, such as low composite score (≤14), movement pattern asymmetry, and low individual test scores and elevated injury risk in professional football players [16, 17] and collegiate athletes across various sports [15, 18]. For the YBT, an anterior reach distance difference of ≥4cm has been linked to increased injury risk in collegiate athletes [19] while a normalized composite reach score ≤89.6% has been shown to be predictive of non-contact lower extremity injury in collegiate football players [14]. Prior investigations have also reported normative data for these assessments in numerous populations; however, few studies have described within-sport scores across varying levels of competition and none specific to football. For the FMS, the majority of work to date has focused on the composite score whereas limited data [22-24] exists detailing the distribution of scores for the 7 individual FMS tests, with only one study comparing scores across levels of play [24]. In contrast to FMS research, recent studies on the YBT have described differences in performance within sport and across levels of competition [25, 26].

Field-expedient movement screening tools have become increasingly popular in clinical use and for identification of deficits associated with increased injury risk. From a performance and injury prevention programming standpoint, it is important to know if differences in FMS and YBT scores exist across competition levels so that population specific performance and injury risk thresholds can be established. To the author's knowledge, no studies have examined differences in functional movement and dynamic balance in football players across a range of different ages. Therefore, the objective of this study was to analyze differences in FMS and YBT scores in football players across scholastic competition levels (middle school (MS), high school (HS), college (COL)). Given the results of previous research [16, 25-28], we hypothesized that COL football players would display higher FMS scores than both HS and MS players and that HS players would exhibit greater dynamic balance than MS players.

MATERIALS AND METHODS

Study Design and Participants

This was a cross-sectional study approved by the University's Institutional Review Board (no. 15-A091), with all procedures performed in accordance with the ethical standards of the Helsinki Declaration. Written informed consent was obtained for collegiate participants while parental consent and athlete assent were obtained for HS and MS participants. All participants were tested prior to the start of their competitive seasons. HS and MS players completed both FMS and YBT while collegiate participants underwent FMS only due to time constraints.

Football players were recruited from one private high school and one University to take part in this study. Participants were active members of their college (National Collegiate Athletic Association Division I, n = 77), HS (9^{th} – 12^{th} grade, n = 52), or MS (6^{th} – 8^{th} grade, n = 29) football teams. Participants were included in this study if they were on the official team roster at the start of preseason and medically cleared for all football-related activities. Potential participants were excluded if they had any recent injury and/or musculoskeletal pain that limited their ability to complete the testing as determined by their team's head athletic trainer but not if

TABLE 1. Descriptive statistics for anthropometric data of football players.

	Competition Level (Mean ± SD)			
Variable	**Middle School (n = 29)**	**High School (n = 52)**	**College (n = 77)**	**p-value**
Age (y)	12.8 ± 0.7	15.7 ± 1.2	19.9 ± 1.4	< 0.001
Age range (y)	12 – 14	13 – 17	18 – 22	-
Mass (kg)	54.5 ± 12.4	84.9 ± 16.8	104.2 ± 19.5	< 0.001
Mass range (kg)	35.9 – 83.2	57.2 – 125.6	79.4 – 158.8	-
Height (cm)	166.2 ± 10.2	180.4 ± 6.9	186.8 ± 6.0	< 0.001
Height range (cm)	147.3 – 182.9	165.1 – 195.6	172.7 – 198.1	-
Body mass index	19.5 ± 2.9	25.9 ± 4.2	29.8 ± 4.9	< 0.001
Body mass index range	15.0 – 26.6	17.9 – 36.4	21.9 – 44.9	-

TABLE 2. Composite FMS scores across competition level.

	Competition Level (Mean ± SD)			
Variable	**Middle School (n = 29)**	**High School (n = 51)**	**College (n = 77)**	**p-value**
FMS composite score	12.9 ± 1.9	14.0 ± 1.7	14.1 ± 2.1	0.019
FMS composite score range	8 – 16	9 – 17	9 – 18	-
	%	%	%	
FMS score ≤ 14	79.3	54.3	57.1	0.068

they had prior experience with the FMS or YBT as part of any strength and conditioning programs [26].

Functional Movement Screen

FMS testing was conducted in a station approach for all groups. Examiners included athletic trainers with at least 2 years of experience with the FMS and senior-level athletic training students with FMS level-1 certification. For each group's testing session, the same rater evaluated the same individual component(s) of the FMS for all participants. The FMS is a screening tool comprised of 7 individual tests to assess an individual's overall functional movement capacity. The FMS has been shown to have good interrater and intrarater reliability, even among novice raters [11, 12]. Tests are scored on a 0 – 3 ordinal scale and include the deep squat (DS), hurdle step (HUR), in-line lunge (ILL), shoulder mobility (SM), active straight-leg raise (ASLR), push-up (PU), and rotary stability (RS). A score of 3 indicates the participant was able to perform the movement without compensation and without pain. A score of 2 indicates that the subject could complete the movement without pain but with some level of compensation/imperfection. A score of 1 indicates the subject is unable to complete the movement as instructed and a score of 0 is recorded if the subject experiences pain during the movement. Overall FMS scores can range from 0 to 21. Of the seven tests that comprise the FMS, five (HUR, ILL, SM, ASLR, RS) are scored bilaterally with the lowest score used in calculation of the total score. Detailed methods of FMS testing have been previously described [8, 9, 29].

Y-Balance Test

The YBT is a screening tool used to measure dynamic balance in the Anterior (A), Posteromedial (PM) and Posterolateral (PL) directions. Previous research has shown the YBT to have good interrater and intrarater reliability [10, 13]. Prior to data collection, all examiners received formalized training in the YBT, which included practice testing on college-aged students not involved in this study. Prior to testing, all participants had their anatomical leg length measured in the supine position, and was recorded as the distance from the anterior

TABLE 3. Percentage and absolute number of players who scored the given number of points in FMS tests in the three groups.

FMS Test	Group	FMS Test Score			
		3	2	1	0
Deep Squat	College	10.4% (8)	72.7% (56)	16.9% (13)	0.0% (0)
	High School	2.0% (1)	54.8% (28)	41.2% (21)	2.0% (1)
	Middle School	6.9% (2)	51.7% (15)	41.4% (12)	0.0% (0)
Inline Lunge	College	26.0% (20)	64.9% (50)	7.8% (6)	1.3% (1)
	High School	5.8% (3)	82.7% (43)	9.6% (5)	1.9% (1)
	Middle School	0.0% (0)	69.0% (20)	31.0% (9)	0.0% (0)
Hurdle Step	College	1.3% (1)	90.9% (70)	7.8% (6)	0.0% (0)
	High School	5.9% (3)	72.5% (37)	21.6% (11)	0.0% (0)
	Middle School	0.0% (0)	89.7% (26)	6.9% (2)	3.4% (1)
Shoulder Mobility	College	28.5% (22)	35.1% (27)	31.2% (24)	5.2% (4)
	High School	66.7% (34)	27.5% (14)	3.9% (2)	1.9% (1)
	Middle School	69.0% (20)	17.2% (5)	13.8% (4)	0.0% (0)
ASLR	College	39.0% (30)	41.5% (32)	19.5% (15)	0.0% (0)
	High School	15.4% (8)	75.0% (39)	9.6% (5)	0.0% (0)
	Middle School	17.3% (5)	55.2% (16)	24.1% (7)	3.4% (1)
Push-Up	College	37.7% (29)	54.5% (42)	5.2% (4)	2.6% (2)
	High School	28.8% (15)	48.1% (25)	23.1% (12)	0.0% (0)
	Middle School	6.9% (2)	27.6% (8)	58.6% (17)	6.9% (2)
Rotary Stability	College	0.0% (0)	77.9% (60)	20.8% (16)	1.3% (1)
	High School	0.0% (0)	98.1% (51)	1.9% (1)	0.0% (0)
	Middle School	0.0% (0)	96.6% (28)	3.4% (1)	0.0% (0)

Note: ASLR = active straight-leg raise.

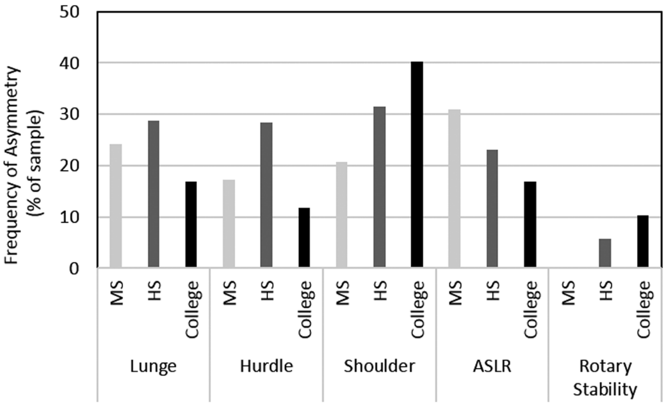

Fig. 1. Frequency of individual FMS test pattern asymmetry. Abbreviations: ASLR, active straight leg raise; MS, middle school; HS, high school.

superior iliac spine to the distal tip of the ipsilateral medial malleolus. This measurement was used to normalize reach distance to leg length for analysis [10]. Testing procedures followed those described by Plisky et al. [30]. In short, participants began with their test leg on the center foot plate, toes aligned behind a starting line, and were given directions to slide the reach indicator out as far as possible in the indicated reach direction, while maintaining their balance on the stance leg [10, 13]. Trials were discarded and repeated if the participant: 1) failed to maintain single-leg balance on the foot plate during the trial, 2) failed to maintain foot contact with the reach indicator during the trial, 3) used the reach indicator for support or to regain balance during the trial, and 4) failed to return the reach leg back to the center foot plate following achievement of maximal reach distance [10]. Prior to data-collection trials, participants performed 3 practice trials for each direction on each leg, following which, they moved to a separate station allowing for approximately 5 minutes of recovery before being tested for 3 maximum reaches in each of the A, PM and PL reach directions on the right and left legs [31].

Reach distances were normalized to anatomical leg length and expressed as a percentage of leg length (reach distance/limb length) X 100. Composite normalized reach distance was calculated for each leg as (ANT + PM + PL) / (3 X limb length) X 100. Right-to-left side reach distance difference were calculated in cm (reach distance difference = [maximum right reach distance – maximum left reach difference]), and overall reach asymmetry was calculated as the sum of all three reach direction differences [10, 31].

Statistical Analyses

Data for continuous variables were tested for normality with the Shapiro-Wilk test before statistical analysis. Since FMS composite scores and YBT variables were not normally distributed and group sizes were unequal, non-parametric methods were used. Differences in composite FMS score between MS, HS, and COL football players were examined using a one-way Welch's ANOVA test. Post-hoc testing was completed using the Games-Howell test. Mann-Whitney U tests were used to examine differences in YBT normalized reach distances and right-to-left reach distance differences between MS and HS players. Pearson's χ^2 tests for independence were evaluated to determine differences between the distribution of scores for the individual FMS tests, right-to-left side asymmetries on individual

TABLE 4. Comparison of Y-Balance reach distances and differences between high school and middle school football players.

Variable	Competition Level (Mean ± SD)		
	Middle School (n = 29)	High School (n = 52)	p-value
Normalized scores (% leg length)			
Anterior	64.1 ± 5.6	63.4 ± 5.8	0.545
Posteromedial	101.2 ± 12.2	102.9 ± 10.7	0.386
Posterolateral	99.5 ± 10.9	95.3 ± 10.4	0.120
Composite	88.3 ± 8.5	87.2 ± 8.0	0.595
Reach Differences (cm)			
Anterior	3.2 ± 2.4	4.1 ± 3.2	0.262
Posteromedial	5.2 ± 4.1	5.1 ± 3.7	0.871
Posterolateral	5.4 ± 3.3	4.2 ± 3.6	0.070
Composite	13.7 ± 5.3	13.5 ± 7.7	0.416

FMS tests, and percentage of composite scores ≤14, across the three groups. Additionally, standardized effect size statistics were used to determine the clinical relevance of all statistically significant findings ($p < 0.05$). For Welch's ANOVA test results, eta-squared effect sizes were calculated and categorized as large (≥ 0.14), medium (0.06 – 0.13), or small (0.01 – 0.05). For Mann-Whitney U tests, *abs(r)* effect sizes were calculated and categorized as large (≥ 0.5), medium (0.3 – 0.4), or small (0.1 – 0.2). Cramer's V effect sizes were calculated for χ^2 tests and categorized as large (≥ 0.5), medium (0.3 – 0.4), or small (0.1 – 0.2). Data analyses were performed using Statistical package for the Social Sciences version 20.0 (SPSS, Inc., Chicago, IL).

RESULTS

Group specific demographic and anthropometric data of football players are presented in Table 1. Table 2 presents mean FMS composite scores and the percentage of players scoring ≤ 14 for all 3 groups. MS players exhibited lower FMS composite scores than both HS and COL players (both, $p = 0.019$; eta-squared = 0.050).

Table 3 presents the distribution of scores for the individual FMS tests. The DS ($\chi^2 = 15.41$, $p = 0.017$, Cramer's V = 0.222), ILL ($\chi^2 = 25.38$, $p < 0.001$, Cramer's V = 0.283), HUR ($\chi^2 = 14.78$, $p = .022$, Cramer's V = 0.217), SM ($\chi^2 = 29.26$, $p < 0.001$, Cramer's V = 0.305), ASLR ($\chi^2 = 21.19$, $p = 0.002$, Cramer's V = 0.259), PU ($\chi^2 = 42.55$, $p < 0.001$, Cramer's V = 0.367) and RS ($^2 = 14.44$, $p = 0.006$, Cramer's V = 0.214) tests all demonstrated different patterns of scoring across levels of competition. Figure 1 presents the percentage of players exhibiting right-to-left side asymmetries on individual FMS tests. Over 30% of HS and 40% of COL athletes had some type of shoulder asymmetry, whereas 31% of MS demonstrated ASLR asymmetries. However, no Chi-squared test reached statistical significance.

Table 4 presents the normalized reach distances and right-to-left side reach differences for the YBT for MS and HS football players. As shown, no differences existed between MS and HS football players for either YBT measurement.

DISCUSSION

The FMS and YBT are two functional movement assessments that have been used to identify movement dysfunction in athletic and military populations and to help guide injury prevention strategies [10, 15, 19, 21, 32-34]. From a performance and injury prevention programming standpoint, it is important to understand if FMS and YBT measures differ between sports and across age-specific competition levels within a specific sport. Therefore, our primary objective was to evaluate FMS and YBT performance in football players across various levels of competition. Overall, we found that HS and COL players displayed a higher composite FMS score than MS players and that differences between groups were found for all of the individual FMS tests. In contrast, we found no difference in any YBT measurement between HS and MS players.

The COL and HS groups displayed nearly identical FMS composite scores, both of which were significantly greater than the MS group. The COL and HS groups displayed a composite score similar to those reported in other collegiate athletic populations [15, 28, 35] but lower than NFL football players [16] and Gaelic games players [36]. Notably, only Warren et al. [28] reported FMS composite scores for a collegiate population that included football players but their cohort was comprised predominantly of athletes from other sports, which limits any direct comparison with our results. However, the finding that the COL group's composite FMS score measured here is similar to the sample recruited by Warren et al. [28] is not surprising since both studies were comprised of athletes from the highest division of collegiate athletics. Furthermore, it is commonplace for Division I athletes to undergo year-round training programs guided by strength and conditioning specialists. It is reasonable to suggest that exposure to year-round structured training programs, albeit with varying goals specific to the sport of play, was influential in producing comparable levels of neuromuscular control identified by the similar scores. Similarly, the composite score for our HS group was roughly 1 point higher than that reported in a large cohort of high school athletes comprised of roughly 25% football players [27]. To our knowledge, we are the first to report FMS scores in a group of MS football players. In a recent study of adolescent soccer players [37], authors reported a median score of 12 for the under-13 age group, which is the closest age-specific comparison to our MS group. The current study found similar results with the previous study. Specifically, FMS composite scores in younger athletes were lower than that reported in groups comprised of HS, collegiate, and professional athletes [15, 16, 27, 28]. It can be likely explained by the expected differences in physical maturity-related neuromuscular control and coordination between groups. Although we found no association between level of competition and percentage of players with an FMS score ≤14, more than half of HS and COL and 75% of MS players had a composite score ≤14, which, based upon previously published findings, suggests associations with higher risk of injury [15, 16, 20, 21]. However, it should be noted that the sensitivity and specificity of these investigations using the ≤ 14 cutoff is low and thus current evidence does not support the use of the FMS composite score as an injury prediction tool [38, 39]. Future research to investigate associations between FMS composite score and performance on individual subtests, and injury incidence in adolescent athletes is warranted.

A primary aim of this study was to explore potential differences in individual test scores across these 3 levels of competition and several noteworthy findings emerged. The DS and ILL tests are used to assess functional mobility of the lower extremities as well as overall neuromuscular control and balance. Notably, 40% of MS and HS players scored a "1" on the DS in comparison to 17% of COL players. Our findings are similar to Portas et al. [37] who reported better performance of mobility-categorized FMS tests (DS, ILL, HUR) amongst adolescent soccer players of higher levels of physical maturity. Similar to our findings with FMS composite scores, it is reasonable to suggest that age-related maturational influences in neuromuscular control and coordination may have partially explained the low scores in the MS group. Likewise, resistance training experience may have contributed to the low scores seen in both MS and HS groups. FMS developers have noted that both tests mirror the traditional squat and lunge exercises commonly performed in most athlete strength and conditioning programs, though the starting positions and directions are distinct, which allow for functional deficiencies to be observed [8, 9]. Given the role of ankle and hip mobility on squat depth and performance [40], lack of resistance training in general or training which did not address limitations in these areas may have impacted scores. A limitation of our study is that we did not collect data on prior resistance training experience and therefore cannot determine any direct relationship. Future researchers may want to longitudinally track functional movement scores in players as they progress through levels of competition and investigate the influence of various training regimens on scores.

Interestingly, COL players scored better in the ASLR than HS and MS players while the younger groups both scored significantly better than COL players in the SM test. Notably, more than two-thirds of all MS and HS players scored a "3" on the SM in comparison to only 30% of COL players. Portas and colleagues [37] computed a FMS-flexibility score from the SM and ASLR tests and found that performance was positively influenced by increasing level of physical maturity in adolescent soccer players. Prior studies have reported there is no association between age and sexual maturation levels, and flexibility in the lower extremities, as determined by sit-and-reach test performance, in adolescent boys [41, 42]. Previous investigators have also reported that full-range resistance training can improve hamstring flexibility but not shoulder extension ROM in college-aged participants; notably, authors found no change (positive or negative) in shoulder ROM [43]. Although this latter finding may partially explain why COL players did not score better in the SM than HS and MS groups, it does not support the finding that increased level of competition was associated with significantly lower scores on this test. Future researchers may want to investigate the influence of potential contributing factors, such as participation in various resistance training and flexibility programs and history of prior injury, on SM performance.

Almost two-thirds of MS players scored a "1" on the PU test in comparison to roughly 37 and 8% of HS and COL players, respectively. The PU is an assessment of reflexive core stability [8, 9]; however, it does require an adequate level of upper body strength. Given that the mean age of MS players was 12.8, it would be expected that many players had not yet physically matured in comparison to older athletes. Puberty-associated hormonal and growth changes impact both skeletal muscle mass and strength [44]; therefore, low scores may partially be explained by the lack of physical maturity seen in this group. Notably, our findings are similar to others who reported decreased PU scores in soccer players of lower levels of physical maturity [37]. Consequently, clinicians may want to exert caution when using the PU test in adolescent athletes since lower scores, in particular a score of "1", may be due to limited upper body strength and not a lack of core stability.

The finding that there was no difference in all three YBT reach directions between the MS and HS players was unexpected since we hypothesized that older players would perform better than their younger counterparts due to age-related higher levels of strength, balance, and overall movement competency. Notably, our findings are not consistent with previous research. Butler et al. reported that COL and professional male soccer players achieved greater PM and PL but decreased ANT reach distances in comparison to HS players [26] while Bullock et al. [25] reported similar findings with MS, HS, and COL male basketball players all achieving greater ANT reach distances than professional players. Moreover, the authors of the latter study found that HS players attained greater ANT reach distances than the MS group. Previous investigators have proposed that the anterior reach direction requires the greatest amount of closed chain ankle dorsiflexion [45]. As we noted previously, this motion may also play a role in deep squat performance and was postulated as being a potential influence in the differences found between COL and both MS and HS groups. As with ANT reach distance, we found no difference in deep squat performance between the HS and MS groups. It is plausible that our HS and MS groups had comparable closed chain ankle dorsiflexion ROM and that this similarity influenced performance in these YBT and FMS measures. However, we did not directly measure closed chain ankle dorsiflexion and therefore cannot determine any direct relationship.

We also found no statistically significant difference in reach direction asymmetry between MS and HS football players although HS players displayed roughly 28% greater reach distance difference in the ANT direction and 22% less reach distance difference in the PL direction than MS players. This finding is in contrast to a recent study that reported greater PM and PL reach direction asymmetries in athletes between 10 and 12 years of age in comparison to 16 to 18-yr olds while controlling for sex, BMI, and history of injury [46]. It is reasonable to suggest that the greater difference in age between groups in the previous study versus that seen in our MS and HS groups was influential in these contrasting results.

This study has several limitations. First, our study is limited by the unequal sample sizes in the 3 groups, in particular the small number of MS players. Second, previous history of injury would have assisted in potentially explaining the differences seen in individual FMS test performance. Third, our comparison of YBT performance was limited to MS and HS players as time limitations on the day of test administration did not permit assessment of COL players. Fourth, time constraints in the screening process also prohibited ascertainment of reliability measurements. Lastly, a potential influence on FMS and YBT performance in all 3 groups was prior experience with these tests. Familiarity with a test could have led to an adapted strategy or "improved" performance. Though prior experience may have aided in explaining the results, it would not have negated the finding that there were several distinct patterns in individual FMS test performance across levels of competition.

CONCLUSIONS

Functional movement capacity and dynamic balance are potentially modifiable factors associated with injuries. The FMS and YBT are two screening tests that are routinely used to identify deficits associated with increased injury risk and guide injury prevention strategies [10, 15, 19, 21, 33, 34]. Past research has suggested that performance on these tests differ across sport and levels of competition [16, 25-28]. To our knowledge, however, we are the first to compare performance in these measures across levels of American football competition. In the present study, COL and HS football players displayed slightly greater composite FMS scores than MS players and several distinct patterns in individual FMS test scores were found indicating different functional movement limitations exist across varying scholastic levels of competition. In contrast, no differences were found in YBT performance between HS and MS football players. These findings have practical applications for clinicians and other personnel responsible for the development and implementation of injury prevention programs in athletic populations. Our results support the notion that population specific normative data and injury risk thresholds should be established when implementing performance and injury prevention programming across sport levels of competition.

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