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ORIGINAL RESEARCH

AGE DIFFERENCES IN MEASURES OF FUNCTIONAL MOVEMENT AND PERFORMANCE IN HIGHLY TRAINED YOUTH BASKETBALL PLAYERS

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ABSTRACT

Background: There is a lack of information about the influence of age on functional movement tests (FMT) and performance tests as well as in their relationships in young basketball players.

Purpose: The purpose of the present study was to determine the variations in FMT and jump and/or sprint performance scores between age groups (U-14 vs. U-16) in Highly-trained young basketball players. The second purpose was to investigate the relationship between FMT for lower body and jump and/or sprint performance in highly-trained young (U-14 and U-16) male basketball players.

Study Design: Descriptive study.

Methods: Thirty elite young (U-14 to U-16) male basketball players performed several FMT (weight-bearing dorsiflexion test [WB-DF] and a modified Star Excursion Balance test [SEBT]) and performance including unilateral and bilateral countermovement jumps, unilateral horizontal jumping, linear sprinting and performance tests.

Results: All anthropometric and performance tests showed a statistically significant advantage ($p < 0.05$) in the U-16 group, excluding the unilateral jump with left leg ($p = 0.127$). Five out of the eight FMT performed showed a statistically significant advantage ($p < 0.05$) in the U-16 group. The U-14 group did not differ statistically from the U-16 group in WB-DF with left leg and the SEBT anterior right leg and posteromedial left leg reaches. Effect size calculations did show small to moderate effects in favor of U-16. Only two significant correlations ($p < 0.05$) between functional movement and performance measures were identified in the U-16 group for either limb (10-m sprint and $SEBT\text{-}PL_L$, $SEBT\text{-}Composite_L$), while a total of 13 significant correlations ($p < 0.05$) in the U-14 group were found.

Conclusions: The results of this study demonstrated differences in FMT and jump and/or sprint performance test between age groups (U-16 vs U-14). The findings of this study support the idea that the age of the player should be considered when interpreting FMT scores, which could have implications when implementing the FMT for injury risk prediction.

Level of evidence: 2b

Key Words: Functional testing, sports performance, sprinting speed, vertical jump

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Conflict of interest
The last author declared potential conflicts of interest. He has patented the LegMotion system and OctoBalance system.

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INTRODUCTION

The ability to perform high intensity actions (HIA) is an important prerequisite for successful participation in most team-sports.[1,2] Several authors have shown that HIA such as acceleration,[3] maximum running speed,[4] change of direction ability (CODA)[4] and explosive power[5] are related to match performance and competitive level. Specifically, 83% of goals in soccer are preceded by at least one powerful action made by the scoring or the assisting player.[6] Furthermore, international basketball players perform significantly more HIA than their national counterparts.[7] Thus, power and speed abilities seem to be relevant in decisive situations in team-sports.

Functional movement tests (FMT) examine the ability of the body to move through sufficient range of motion (ROM) to perform dynamic tasks and include the weight-bearing dorsiflexion test (WB-DF) and the Star Excursion Balance test (SEBT). It is worth noting that a limited WB-DF score and a substantial between-limbs difference in the anterior direction in the SEBT seem to indicate a greater injury risk in several pathologies.[8-10] For example, limited ankle dorsiflexion has been shown as a risk factor for developing patellar tendinopathy in junior elite basketball.[8] Furthermore, those team-sports players who have suffered an anterior cruciate ligament reconstruction reach lower anterior distances with both limbs (involved and uninvolved) during the SEBT.[9] In addition to this information, the functional asymmetries presented in functional movement or jumping tests are also a predictive measure of lower extremity injuries. In this regard, an individual with a difference greater than 4 cm in the anterior SEBT reach distance is 2.5 times more likely to sustain a lower extremity injury.[10] Additionally, a difference greater than 1.5 cm in the WB-DF can be considered as a cut-off to predict a lower extremity injury.[11] Also, an asymmetry equal to or above 10% during jumping tasks detects players at higher injury risk (i.e., four fold).[12] Thus, it seems that the use of these measures in a physical fitness testing battery might be important in determining risk of injury.

Recently, the relationship between functional asymmetries and performance tests has received some research attention. For example, players displaying greater symmetry during functional testing (assessed via unilateral vertical jump or distance reached during a dynamic balance test) are faster than their asymmetrical counterparts during linear and change of direction (COD) sprint tests.[13] Asymmetries in the WB-DF are also related to decreased performance in COD tasks.[14] As such, it seems that functional asymmetries might play a key role in performance. However, there is scarce information about the age-related differences in FMT and performance in young basketball players.

Thus, the purpose of this study was to determine the variations in FMT and jump and/or sprint performance scores between age groups (U-14 vs. U-16) in highly-trained young basketball players. The second purpose was to investigate the relationship between FMT for lower body and jump and/or sprint performance in highly-trained young (U-14 and U-16) male basketball players. It was hypothesized that: i) U-14 players would have decreased FMT and jump and/or sprint performance scores compared with U-16 and, ii) based on the aforementioned studies, was that the younger age group would have higher correlations between the FMT and performance tests.

METHODS

Experimental approach to the problem

A crossover study design, in which the participants were randomly assigned, was utilized for this study. The season lasted 10 months. The first two months were the pre-season period (August and September). Thereafter, the competitive period comprised eight months (from October to May). The study was conducted during April and May. Several FMT (weight-bearing dorsiflexion test and modified star excursion balance test) and performance tests (jumping, sprinting and changing direction tests) were administered. All players were familiar with the procedures of all tests (they had performed all tests at least six times) and were asked not to perform any strenuous exercise during the day before testing. Players were also asked to follow their normal nutritional habits on the day of the test. FMT were executed the same day and in the same order (WB-DF and modified SEBT) while performance tests were performed another day and also in the same order (jumping, sprinting and COD tests). The first day all players performed all FMT, while the second day they executed all performance tests. All tests were conducted at the same time of the day (18:00 to 20:00) on two different days separated by 72 h.

Subjects

Thirty elite young male basketball players (U-16, n = 15; 15.6 ± 0.6 years; U-14, n = 15; 13.7 ± 0.5 years) volunteered to participate in the present study. Players belonged to a first Spanish basketball division (ACB-Liga Endesa) club academy squad. All players participated in an average of 12 hours of combined basketball (6-7 sessions), strength/power (two sessions) and speed, agility and quickness (SAQ) (one session) training sessions plus two competitive matches per week. At the time of the study, all players were competing at the national level (i.e., Spanish National Basketball League). Furthermore, some players (n = 6) were also competing at the international level (i.e., European and World Basketball Championships). Written informed consent was obtained from both the players and their parents before beginning the investigation. The present study was approved by the institutional research ethics committee, and conformed to the recommendations of the Declaration of Helsinki.

Functional movement tests

Weight-bearing dorsiflexion test

Ankle dorsiflexion was evaluated through the LegMotion system *(LegMotion, your MOtion®, Albacete, Spain)*.[15] Each player started with their hands on their hips, and put the assigned foot on the middle of the longitudinal line just behind the transversal line on the platform (Figure 1). The alternate foot was positioned off the platform with toes at the edge of the platform. Each trial consisted of flexing the ankle as much as possible without raising the heel of the assessed ankle trying to touch a marker, situated just behind the patella, with their knee. The distance achieved was recorded in centimeters. Three trials were allowed with each ankle (i.e., left and right) with 10 seconds of passive recovery between trials. The third value in each ankle was used in subsequent analysis of weight-bearing dorsiflexion (WB-DF).

Modified Star Excursion Balance Test

Dynamic balance was assessed by using the OctoBalance device *(*OctoBalance, Check your MOtion®, Albacete, Spain*)*, a modified version of the SEBT (Figure 2), which analyzed three lower limb excursion directions: anterior (SEBT-A), posteromedial (SEBT-PM) and posterolateral (SEBT-PL).[14] The measurement system is based on an extending measuring tape, which is magnetized to an octagonal platform in each direction, to measure the distance reached. Each trial consisted of pushing the marked point, situated at the top of the measuring tape, with the toes (i.e, big toe) as far as possible in the designated direction. Prior to the commencement of each trial, the measuring tape was established at 30 cm. Each trial was validated by a visual inspection to ensure that each trial was performed without putting the toes on the marked point, and to ensure that their

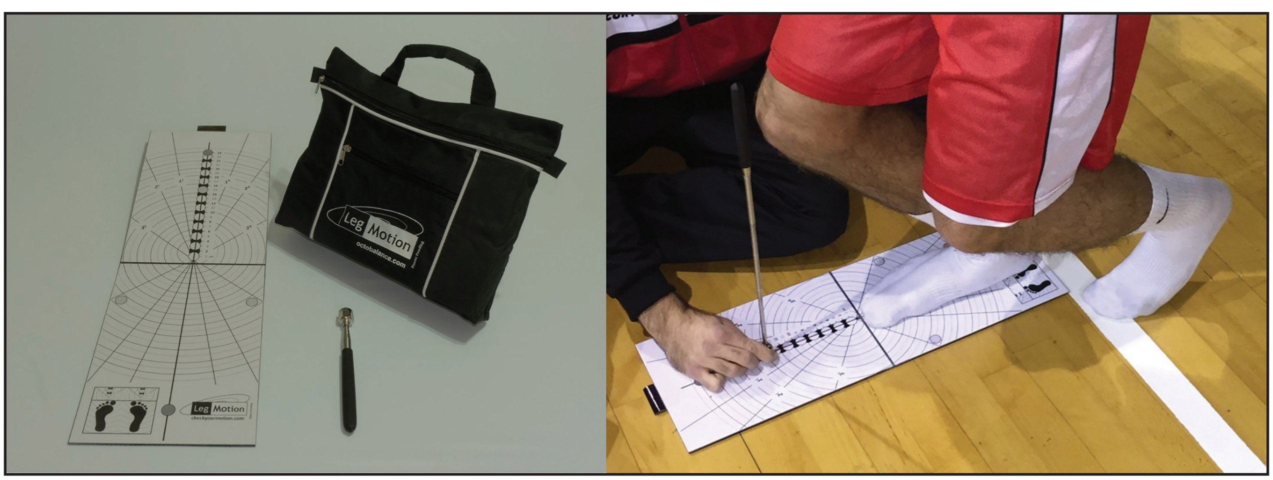

Figure 1.

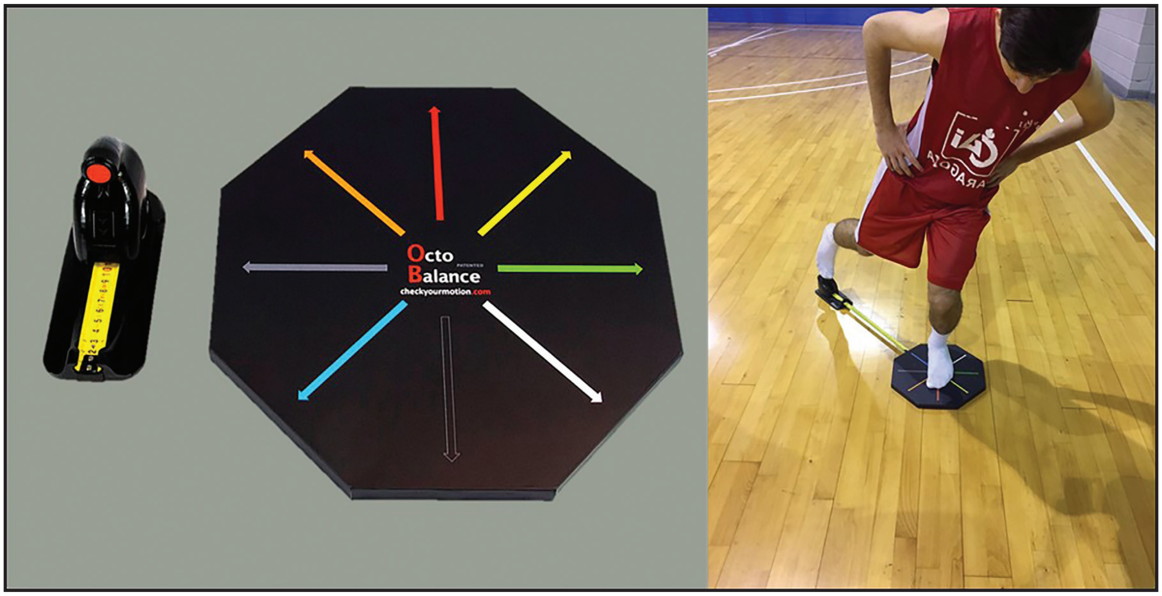

Figure 2.

heel remained on the anterior-posterior line on the platform (the whole foot must be on the platform and with the heel on the border line of the octagon). Players were instructed to maintain their hands on their hips throughout the test. Warm-up consisted of two trials with each leg (i.e., two with left stance and two with right stance). Thereafter, three trials were allowed with each leg with 10 seconds of passive recovery between trials. The mean result of the three trials for each leg was used for subsequent analysis.[14]

Performance tests

Bilateral countermovement jump (CMJ) test

Lower limb bilateral explosive power was assessed using a vertical countermovement jump (CMJ) (centimeters) with flight time measured by the Optojump (Optojump, Microgate, Bolzano, Italy) to calculate jump height.[16,17] Each trial was validated by a visual inspection to ensure that each jump was without any leg flexion, each landing was without any leg flexion on the first contact time and, thereafter, the subject was allowed to flex the hip, knee and ankle for better absorption of forces. Subjects were instructed to maintain their hands on their hips during CMJ. The depth of the CMJ was self-selected. Each test was performed three times, separated by 45 seconds of passive recovery, and the best jump was recorded and used for analysis.

Unilateral countermovement jump (CMJ) test

Each subject started by standing solely on the designated leg, maintaining their hands on their hips during unilateral CMJ and the alternate leg flexed to 90° at the hip and knee. Players were asked to jump as high as possible and to land on the assessed leg (Optojump, Microgate, Bolzano, Italy). Leg swing of the alternate leg was not allowed. Failure to maintain proper technique resulted in an invalid jump (i.e., loss of hands on hips, 90° flexion, or use of leg swing). Each test was performed twice, separated by 45 seconds of passive recovery, and the best jump for each leg was recorded. The variables used for analyses were: 1-legged left CMJ (CMJ_L) and 1-legged right CMJ (CMJ_R).

Unilateral horizontal jump (HJ) test

Unilateral horizontal jump test was measured using a regular measuring tape. Each subject stood with the toes of the designated leg positioned just behind a starting line (marked with tape), hands placed behind the back and the alternate leg flexed to 90° at the hip and knee. When ready, each subject flexed then rapidly extended the assessed leg and jumped as far as possible (forward distance). The subjects were instructed to perform a controlled, balanced landing and to stick the landing for 2-3 s until the tester registered the landing position. No extra hops were allowed during testing. Failure to hold the landing position for 2-3 s resulted in a disqualified hop. The point of the shoe closest to the starting line upon landing was used to determine the distance jumped. Leg swing of the alternate leg was allowed. Each test (left and right) was performed twice, separated by at least 45 seconds of passive recovery, and the best jump for each leg was recorded. The variables used in analyses were: 1-legged left HJ (HJ_L) and 1-legged right HJ (HJ_R).

Speed tests

Running speed was evaluated by 25-m sprint times (standing start) with 5-m, 10-m and 20-m split times. The front foot was placed 0.5 m before the first timing gate. Time was recorded with photoelectric cells *(Witty, Microgate, Bolzano, Italy)*. The 25-m sprint was performed twice, separated by at least three minutes of passive recovery. The best time was recorded for analysis.

180° Change of direction test

A 10-m sprint test was performed. The front foot was placed 0.5 m before the first timing gate (Witty, Microgate, Bolzano, Italy). Each player sprinted from the start/finish line, completely crossed the 5-m line with either right or left foot, and turned 180° to sprint back to the start/finish line. Players executed two valid trials with each foot, separated by at least two minutes, with the fastest retained for calculations. The variables used in analyses were COD 180° with left ($COD180_L$) and right leg ($COD180_R$).

V-cut test

In the V-cut test, players performed a 25-m sprint with 4 CODs of 45° each 5 m.[18] The front foot was placed 0.5 m before the first timing gate *(Witty, Microgate, Bolzano, Italy)*. For the trial to be valid, players had to pass the line, placed on the floor, with one foot completely at every turn. If the trial was considered a failed attempt, a new trial was allowed. The distance between each pair of cones was 0.7 m. Players performed two trials separated by at least three minutes. Time of the fastest trial was recorded.

Data analysis

Data are presented as mean ± SD. The distribution of each variable was examined with the Shapiro-Wilk normality test. The magnitude of between-session differences was also expressed as standardized mean difference (Cohen effect sizes, ES). The criteria to interpret the magnitude of the ES were as follows: < 0.2 trivial, > 0.2 to 0.6 small, > 0.6 to 1.2 moderate, > 1.2 large.[19] Relationships between variables were determined using Pearson´s correlations. The significance level was set at $p \leq 0.05$. Data were analyzed using PASW/SPSS Statistics 20.0 (SPSS Inc, Chicago, IL, USA).

RESULTS

Descriptive values for anthropometric data are reported in Table 1. All data were found to be normally distributed. As would be expected based on maturation, U-16 players were taller, heavier, and had a larger wingspan compared to U-14 players.

Performance tests

Performance tests are reported in Table 2. All performance tests showed a significant advantage ($p < 0.05$) in the U-16 group excluding the CMJ_L ($p = 0.127$).

Functional movement tests

Descriptive values for FMT are provided in Table 3 and Figure 3. Five out of the eight FMT performed showed a statistical advantage ($p < 0.05$) in the U-16 group. While the U-14 group did not differ statistically from the U-16 group in $WB\text{-}DF_L$, $SEBT\text{-}A_R$, and $SEBT\text{-}PM_L$, ES calculations did show small to moderate effects in favor of U-16.

Correlations

The correlations between the FMT and performance tests are reported in Table 4 and Table 5. Only two moderate significant correlations ($r = 0.547$ to 0.561; $p < 0.05$) between functional movement and performance measures were identified in the U-16 group for either limb (0-10m and $SEBT\text{-}PL_L$, $SEBT\text{-}Composite_L$).

Table 1. *Anthropometric data and between-group comparisons for U-14 and U-16 basketball players. Bolded values represent statistically significant differences.*

		Mean		SD	*p*	*ES*
Weight (kg)	U_16	76.5	±	11.1	**.001**	*1.42*
	U_14	59.5	±	12.9		
Height (cm)	U_16	188.8	±	7.6	**.000**	*2.12*
	U_14	170.7	±	9.5		
Wingspan (cm)	U_16	194.3	±	7.4	**.000**	*2.13*
	U_14	174.5	±	11.2		

Table 2. *Performance test data and between-group comparisons for U-14 and U-16 basketball players. Bolded values represent statistically significant differences.*

		Mean		SD	*p*	*ES*
CMJ_L (cm)	U_16	14.242	±	2.695	.127	*0.62*
	U_14	12.381	±	3.349		
CMJ_R (cm)	U_16	14.542	±	2.738	**.010**	*1.05*
	U_14	11.819	±	2.457		
HJ_L (cm)	U_16	163.333	±	12.999	**.008**	*1.17*
	U_14	142.059	±	23.271		
HJ_R (cm)	U_16	161.667	±	13.640	**.009**	*1.11*
	U_14	143.118	±	19.662		
5-m sprint (s)	U_16	1.082	±	0.063	**.027**	*-0.85*
	U_14	1.135	±	0.061		
10-m sprint (s)	U_16	1.835	±	0.073	**.007**	*-1.08*
	U_14	1.919	±	0.083		
20-m sprint (s)	U_16	3.159	±	0.112	**.002**	*-1.41*
	U_14	3.352	±	0.161		
25-m sprint (s)	U_16	3.811	±	0.149	**.003**	*-1.23*
	U_14	4.024	±	0.198		
$COD180_L$ (s)	U_16	2.634	±	0.105	**.001**	*-1.41*
	U_14	2.793	±	0.120		
$COD180_R$ (s)	U_16	2.630	±	0.115	**.019**	*-0.96*
	U_14	2.766	±	0.168		
V-Cut	U_16	6.902	±	0.251	**.000**	*-1.50*
	U_14	7.328	±	0.317		

R= Right; L= Left; CMJ= one-legged vertical jump; HJ= one-legged horizontal jump; COD180= 5+5 m sprint test with a 180° change of direction; V-cut= 25-m sprint test with 4 x 45° changes of direction

In the U-14 group, a total of 13 significant correlations ($p < 0.05$) were found. Pearson correlations in the U-14 group ranged from 0.498 to 0.723 and reflect moderate relationships (both positive and negative).

DISCUSSION

The primary finding of the present study is that the older group (U-16) had higher FMT and jump and/or sprint performance scores compared with younger group (U-14), a finding that is not unexpected given the normal maturation of young athletes. However, these results may have unique applications for clearing players for sport participation based on requirements to return to a norm-referenced score. Another significant finding of this study was that moderate to strong correlations were detected between certain functional movement and performance tests with the greatest number of correlations identified in the U-14 group. Based on the results of this study, FMT and jump and/or sprint performance test scores should be evaluated based on normative data that are specific to the individual's age and a greater

Table 3. *Functional movement tests data and between-group comparisons for U-14 and U-16 basketball players. Bolded values represent statistically significant differences.*

		Mean		SD	*p*	*ES*
WB-DF$_L$ (cm)	U_16	11.5	±	3.1	.258	*.42*
	U_14	10.4	±	2.4		
WB-DF$_R$ (cm)	U_16	12.5	±	3.0	**.033**	*0.82*
	U_14	10.1	±	2.7		
SEBT-A$_L$ (cm)	U_16	62.8	±	4.5	**.000**	*1.72*
	U_14	53.5	±	6.3		
SEBT-A$_R$ (cm)	U_16	60.5	±	5.3	.182	*1.39*
	U_14	53.1	±	5.4		
SEBT-PM$_L$ (cm)	U_16	82.1	±	6.4	.066	*.71*
	U_14	77.4	±	6.9		
SEBT-PM$_R$ (cm)	U_16	82.1	±	7.3	**.046**	*.77*
	U_14	76.3	±	7.7		
SEBT-PL$_L$ (cm)	U_16	76.9	±	8.0	**.028**	*.86*
	U_14	70.1	±	8.0		
SEBT-PL$_R$ (cm)	U_16	78.0	±	8.4	**.019**	*.93*
	U_14	69.5	±	10.0		

R= Right; L= Left; WB-DF= weight-bearing dorsiflexion; SEBT-A= Star excursion balance test-anterior direction; SEBT-PM= Star excursion balance test-posteromedial direction; SEBT-PL= Star excursion balance test-posterolateral direction

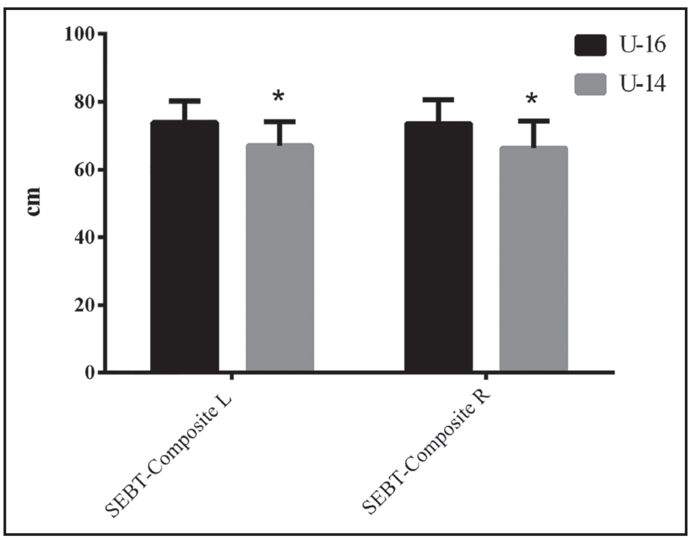

Figure 3.

focus on functional movement development among younger athletes is warranted.

A review of the literature[20] has suggested that differences in balance ability (i.e., static [the timed unipedal stance and monitoring the centre of pressure motion in a force platform unipedal or bipedal, eyes open or eyes shut] and dynamic [SEBT] balance) are apparent both across sports and across performance levels within a given sport. Individual differences in balance ability may relate to individual variations in performance among athletes of differing levels of competitive achievement or the maturation. While such differences, or relationships, cannot infer causation, greater focus on balance training at specific times in athletic development may contribute to successful performance.

The 10-m sprint time (i.e., split time in a 25-m sprint) recorded among basketball players in the current study is similar to professional basketball players aged between 27 to 31 years old as measured in other studies.[21,22] According to Schiltz et al.[21] professional and junior-level basketball players displayed similar isokinetic knee profiles and functional performances (i.e., bilateral CMJ, bilateral CMJ with arm swing, a 10-m sprint, single-leg drop jump, and

Table 4. *Correlations between functional movement and performance for left limb. Bolded values indicate statistically significant correlations.*

			CMJL	HJL	0-5m	0-10m	0-20m	0-25m	COD180L	V_cut
U_16	WB-DF$_L$	*Pearson*	.270	.443	.368	.172	.041	-.041	.070	.169
		p	.396	.150	.216	.575	.894	.894	.821	.581
	SEBT-A$_L$	*Pearson*	.004	.114	.313	.232	.101	-.020	.469	.396
		p	.989	.725	.298	.447	.743	.949	.106	.181
	SEBT-PM$_L$	*Pearson*	.070	.390	.358	.453	.396	.352	.350	.262
		p	.828	.210	.230	.120	.180	.238	.241	.388
	SEBT-PL$_L$	*Pearson*	-.026	.269	.400	**.547***	.491	.430	.495	.314
		p	.936	.398	.175	.053	.088	.143	.086	.297
	SEBT-Composite$_L$	*Pearson*	.005	.308	.534	**.561***	.449	.355	.523	.403
		p	.989	.330	.060	.046	.124	.234	.067	.172
U_14	WB-DF$_L$	*Pearson*	**.498***	.353	-.385	-.205	-.410	-.194	-.408	-.447
		p	.050	.165	.127	.429	.164	.455	.104	.072
	SEBT-A$_L$	*Pearson*	**.502***	**.644****	**-.628****	**-.587***	**-.723****	**-.698****	-.210	-.202
		p	.048	.005	.007	.013	.005	.002	.418	.437
	SEBT-PM$_L$	*Pearson*	.321	.480	-.235	-.201	-.429	-.361	.277	.024
		p	.226	.051	.364	.440	.143	.154	.281	.927
	SEBT-PL$_L$	*Pearson*	.280	.379	-.124	-.067	-.418	-.326	.095	.077
		p	.294	.134	.636	.797	.156	.202	.718	.769
	SEBT-Composite$_L$	*Pearson*	.419	**.570***	-.451	-.383	**-.655***	**-.572***	.026	-.063
		p	.106	.017	.069	.129	.015	.016	.922	.810

L: Left; WB-DF: weight-bearing dorsiflexion; SEBT-A: anterior direction, SEBT-PM: posteromedial direction, and SEBT-PL: posterolateral direction; SEBT-Composite: composite of all directions; CMJR: one-legged vertical right jump; CMJL: one-legged vertical left jump; HJR: one-legged horizontal right jump; HJL: one-legged horizontal left jump; COD180R: 5+5 m sprint test with a 180° change of direction with right leg; COD180L: 5+5 m sprint test with a 180° change of direction with right leg; V-cut: 25-m sprint test with 4 x 45° changes of direction.
Note: *= p <0.05; **= p <0.01.

Table 5. *Correlations between functional movement and performance for right limb.*

			CMJ$_R$	HJ$_R$	0-5m	0-10m	0-20m	0-25m	COD180$_R$	V_cut
U_16	WB-DF$_R$	*Pearson*	.065	.135	.419	.166	-.052	-.124	.135	.055
		P	.840	.676	.154	.589	.866	.686	.660	.860
	SEBT-A$_R$	*Pearson*	.086	-.380	.175	.377	.334	.272	.106	.340
		P	.790	.224	.567	.204	.265	.370	.731	.255
	SEBT-PM$_R$	*Pearson*	.250	.379	.166	.317	.253	.176	.057	.082
		P	.433	.224	.589	.291	.405	.565	.853	.789
	SEBT-PL$_R$	*Pearson*	.349	.322	.197	.406	.385	.316	.186	.089
		P	.266	.308	.519	.169	.194	.293	.544	.773
	SEBT-Composite$_R$	*Pearson*	.128	.030	.369	.505	.467	.396	.236	.256
		P	.692	.925	.215	.079	.108	.181	.439	.399
U_14	WB-DF$_R$	*Pearson*	-.089	-.257	-.099	.077	-.517	-.002	-.281	-.116
		P	.743	.319	.707	.769	.070	.995	.274	.658
	SEBT-A$_R$	*Pearson*	.289	.367	-.472	-.430	**-.653***	**-.553***	.011	-.026
		P	.278	.148	.055	.085	**.016**	**.021**	.965	.921
	SEBT-PM$_R$	*Pearson*	.241	.394	-.139	-.012	-.249	-.214	.269	.280
		P	.369	.118	.595	.963	.412	.410	.297	.276
	SEBT-PL$_R$	*Pearson*	.173	.340	-.189	-.112	-.476	-.370	-.020	.002
		P	.521	.182	.467	.668	.100	.143	.939	.993
	SEBT-Composite$_R$	*Pearson*	.247	.426	-.318	-.240	**-.563***	-.466	.141	.136
		P	.357	.088	.214	.354	**.045**	.059	.589	.603

R: Right; WB-DF: weight-bearing dorsiflexion; SEBT-A: anterior direction, SEBT-PM: posteromedial direction, and SEBT-PL: posterolateral direction; SEBT-Composite: composite of all directions; CMJR: one-legged vertical right jump; CMJL: one-legged vertical left jump; HJR: one-legged horizontal right jump; HJL: one-legged horizontal left jump; COD180R: 5+5 m sprint test with a 180° change of direction with right leg; COD180L: 5+5 m sprint test with a 180° change of direction with right leg; V-cut: 25-m sprint test with 4 x 45° changes of direction.* p <0.05; ** p <0.01

single-leg 10 s continuous jumping). In the present study, in general, U-16 players demonstrated increased jump and/or sprint performance scores compared with U-14 players. It seems that some abilities such as sprinting performance (i.e., 10-m sprint time) might be different at younger stages (U-14 vs. U-16), though when the age at peak height velocity (APHV) is achieved and the adolescents are in a post-pubertal stage (approximately at 15-16 years) no significant sprinting differences are found. This statement is supported in young soccer players where greater differences are presented between U-14 and U-16 in comparison to U-16 to U-18 in 10-m sprint time.[23] However, it is important to note that these differences disappeared when the biological age (APHV) was used as a covariate in the between-group comparisons. Thus, sprinting differences might be related to maturational status.

In the current study, age appears to be an important factor that may have an impact on associations between FMT and jump and/or sprint performance scores. Anterior excursion data demonstrated various significant relationships to performance measures, primarily in 0-5m, 0-10m, and 0-20m sprint times and horizontal jump. Faster subjects had greater anterior reach. Both left and right excursion scores related to better performance times, demonstrating that greater dynamic ROM relates to increased quickness and acceleration among these elite basketball athletes (U-14). Similarly, Lockie et al.[24] found a significant relationship between dynamic stability, as measured by functional reaching, and multidirectional speed (i.e., linear and change of direction speed) in field sport athletes. However, in that study, posterior-lateral and composite excursion data related to slower performance times, demonstrating that greater dynamic ROM was related to decreased acceleration (0-10 m) among these elite basketball athletes (U-16). Gonzalo-Skok et al.[14] reported similar results in a similar sample of basketball players. Differences in body size and proportions between U-14 and U-16 could explain the differences in correlations between groups. According to Gribble et al.[25] performance on the SEBT varies depending on sport, sex, and age. In addition, the effect of competition level (i.e., high school, collegiate, and professional) on Y-Balance test scores, a variation of the SEBT, in soccer players has been established. In general, professional soccer players exhibited greater dynamic balance during the Y Balance test than did high school soccer players.[26] Endo et al.[27] reported that lower extremity tightness and balance were significantly correlated in young baseball players. Hoch et al.[11] demonstrated a significant proportion of the variance within the anterior reach distance in this direction of the SEBT may be a good clinical test to assess the effects of dorsiflexion ROM restrictions on dynamic balance.

The results from the current study suggest that the better performance in all tests for the U-16 group are based on the maturational status and skill level of these players compared to the younger ones. The lack of significant difference in the CMJ-l might be due to different functional use of left leg (i.e., almost all players were right leg dominant) during basketball skills such as the layup.

Furthermore, limitations of the current study should be recognized. The study is inherently limited because it only assessed a small number of elite players in each group and future researchers should determine if similar relationships exist in a larger sample. Data should also be collected on various sports to examine the generalizability of these findings to other athletes beyond basketball. Finally, a greater range in age among study participants would provide more detail regarding the changes in functional movement and performance relationships at different stages of athletic development. In spite of these limitations, the current data suggest that both FMT and performance testing are age-sensitive and can provide the practitioner with useful information regarding performance limitations.

CONCLUSIONS

The results of this study demonstrated differences in FMT and jump and/or sprint performance test between age groups (U-16 vs U-14). The findings of this study support the idea that the age of the player should be considered when interpreting FMT scores, which could have implications when implementing the FMT for injury risk prediction.

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