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FUNCTIONAL MOVEMENT SCREEN SCORES FOR FASTER AND SLOWER TEAM SPORT ATHLETES

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Abstract This study investigated the Functional Movement Screen scores attained by faster (n = 15) and slower (n = 15) male team sport athletes, as defined by multidirectional speed. Subjects were assessed in the FMS, which included seven actions: deep squat; hurdle step; in-line lunge; shoulder mobility; active straight-leg raise; trunk stability push-up; and rotary stability. Multidirectional speed was assessed by a 20-meter sprint, 505, and a modified T-test; the total time was used to median split the groups. A one-way analysis of variance ($p < 0.05$) determined between-group differences in the speed tests and FMS scores. Faster subjects performed better in the deep squat when compared to slower subjects (2.13 ± 0.74 vs. 1.078 ± 0.081; $p = 0.001$). No other screening assessment differentiated between the groups, and neither did the overall FMS score. The deep squat requires coordination and strength throughout the body, such that ankle dorsiflexion, knee and hip flexion, thoracic spine extension, and shoulder flexion and abduction, can be completed. Specific joint ranges of motion, and muscle recruitment, indicate why the deep squat was performed better by faster subjects. The deep squat could be used to screen for movement deficiencies that would affect team sport-specific multidirectional speed.

Key words: Deep squat, linear speed, change-of-direction speed, movement deficiency, functional mobility

INTRODUCTION

Speed is an essential component of many different team sports. An important consideration for team sport athletes is that they will rarely complete sprints in a linear fashion. As a result, multidirectional speed, which encompasses both linear and change-of-direction speed [19], is an important physical consideration for these athletes. Linear speed involves maximal sprinting in a straight line; change-of-direction speed combines the ability to change direction, accelerate and decelerate rapidly, and is a component of agility [30]. Previous research has established relationships between factors such as strength [19, 26] and power [8] for multidirectional speed in team sport athletes. However, another important part of sprint technique is the ability to express this strength and power through an appropriate range of motion. For example, the range of motion at the hip and knee joints is important for effective sprinting [2], while the actions of the arms help counterbalance momentum within the body during the running gait [13]. Any movement inefficiencies or restrictions within these regions of the body could result in diminished multidirectional sprint performance.

An analysis of movement patterns can provide a practitioner with information about an athlete's ability to move through different planes of motion. Functional movement involves the ability to perform locomotor, manipulative, and stabilizing actions, while maintaining control throughout the kinetic chain [6, 24]. The Functional Movement Screen (FMS) can evaluate these capacities; it is comprised of seven actions, which have been described in detail in previous research literature [6, 7, 10, 16, 23, 24, 25]. The actions include the deep squat; hurdle step; in-line lunge; shoulder mobility; active straight-leg raise; trunk stability push-up; and rotary stability. These movements challenge an individual's ability to facilitate movement in a proximal-to-distal fashion, and subjects are placed in positions where particular muscle or joint limitations and imbalances should be noticeable if appropriate stability and mobility is not present [6]. Any limitations or weaknesses at any position throughout the kinetic chain of these movements could result in a poorer performance.

The FMS has typically been used as a tool to predict injury risk [16, 23]. However, Minick et al [23] have stated that the movement patterns performed within the FMS can be conceptualized in linear running and change-of-direction movements. As a result, the FMS could be used to screen for physical limitations that would influence maximal linear and change-of-direction running speed. However, despite the potential for the movements required in multidirectional sprinting to be seen in the exercises within the FMS [23], the screening exercises may not relate to specific athletic performance. For example, Parchmann and McBride [26] found the FMS scores obtained from the standard 21-point scale did not correlate to 10-meter (m; correlation coefficient, r = -0.136) and 20-m (r = -0.107) sprint time. However, the sample group analyzed by Parchmann and McBride [26], comprising experienced golfers, had little need for running speed in their particular sport. The relationship of the FMS to athletic performance may be different for experienced team sport athletes, as their sports demand the ability to maximally sprint and change direction. Furthermore, even if the overall score may not be expedient, certain exercises from the FMS could be used as an indicator for multidirectional sprint performance.

A method in which this could be analyzed is to demonstrate the FMS scores attained by faster team sport athletes when compared to their slower counterparts. This would provide an indication of specific movements within the FMS that can be better performed by an athlete who is quicker in team sport-specific speed tests. Understanding these movement patterns (i.e. the joint ranges of motion, the areas within the body that need to be controlled) required in the FMS screening exercises could then be used to provide technical advice to improve multidirectional speed. Therefore, this research investigated the differences in FMS scores from the individual exercises, in addition to the overall score in the FMS, in faster and slower male team sport athletes. Faster and slower team sport athletes were defined by performance in three tests: a 20-m sprint, 505 change-of-direction speed test, and modified T-test. Subjects were ranked and median split according to the sum of time from each of the speed tests. It was hypothesized that faster subjects would perform better in the tests of functional movements, as scored by the standard 21-point scale, when compared to the slower subjects. This would be particularly true for screening assessments that focus on the lower extremities. This research has importance for team sport coaches, strength and conditioning practitioners, and athletic trainers, as the most appropriate screens for determining physical limitations that could impede multidirectional sprint performance were defined. These screens may then be used to detect and develop the weaknesses in the kinetic chain so as to improve multidirectional speed in team sport athletes.

METHODS AND MATERIALS

SUBJECTS

32 male team sport athletes (age = 22.84 ± 3.90 years; height = 1.79 ± 0.07 m; body mass = 79.37 ± 12.49 kg) volunteered to participate in this study. Subjects were recruited if they: currently participated in a team sport (e.g. soccer, basketball, field hockey, rugby league, rugby union, Australian football); had a team sport training history (≥ two times per week) extending over the previous year; were currently training for a team sport (≥ three hours per week); and did not have any medical conditions or exercise contraindications compromising participation in the study. The study occurred within the competition season for all subjects, who maintained their normal level of physical activity for the duration of the study. The methodology and procedures used in this study were approved by the University of Newcastle ethics committee. All subjects received a clear explanation of the study, including the risks and benefits of participation, and written informed consent was obtained prior to testing.

PROCEDURES

Testing was conducted over three sessions, each separated by one week. The first testing session included the FMS assessment. The second testing session incorporated the 20-m sprint. The third session involved assessing change-of-direction speed via the 505 and modified T-test. Each session lasted for approximately 20-30 minutes. All assessments were conducted in the biomechanics laboratory at the university, with a textured concrete floor. Prior to data collection in the first testing session, the subjects' age, height, and mass were recorded. Height was measured barefoot using a portable stadiometer (Ecomed Trading, Seven Hills, Australia). Body mass was recorded using digital scales (Tanita Corporation, Tokyo, Japan). Subjects were then assessed in the FMS. For the second and third testing sessions, subjects completed a standardized warm-up, which consisted of 10 minutes of jogging on a treadmill at a self-selected pace, 10 minutes of dynamic stretching of the lower limbs, and progressive speed runs over the testing distances. For each sprint test, time was measured to the nearest 0.001 seconds (s), and three minutes recovery time was allocated between trials. Subjects wore their own athletic trainers for all tests; refrained from intensive exercise and any form of stimulant (e.g. caffeine) in the 24-hour period prior to testing; they were tested in the same order across each of the three testing sessions at the same time of day and were permitted to consume water ad libitum throughout each session.

FUNCTIONAL MOVEMENT SCREEN (FMS)

The FMS used seven actions and three clearing examinations [6, 7, 10, 23, 24, 25]. The screening tests, as illustrated by Frost et al [10], were: (1) Deep squat: a dowel was held overhead with the arms extended, and the subject squatted as low as possible; (2) Hurdle step: a dowel was held horizontally across the shoulders, and the subject stepped over a hurdle in front, level with their tibial tuberosity; (3) In-line lunge: with a dowel held vertically behind the subject so that it contacted the head, back and sacrum, and with the feet aligned, the subject performed a split squat; (4) Shoulder mobility: the subject attempted to touch their fists together behind their back (internal and external shoulder rotation); (5) Active straight-leg raise: lying supine with their head on the ground, the subject actively raised one leg as high as possible; (6) Trunk stability push-up: the subject performed a push-up with their hands shoulder-width apart and placed so that the thumbs were level with the top of the forehead; and (7) Rotary stability: the subject assumed a four-point, quadruped position and attempted to touch their knee and elbow, ipsilaterally and contralaterally. Clearing tests were also used for shoulder mobility, trunk stability push-up, and rotary stability [6, 7]. The shoulder mobility clearing test involved the subject placing their hand on the opposite shoulder and attempting to point the elbow upward. A spinal extension clearing test was used for the trunk stability push-up, whereby the subject performed a press-up from the push-up start position. The rotary stability clearing test involved spinal flexion. From the four-point, quadruped position, subjects rocked back slowly and attempted to touch the buttocks to the heels and chest to the thighs, with the hands remaining as far in front of the body as possible. The reliability of these protocols has been established [12, 23, 25, 28, 29].

Table 1ᵃ. Scoring procedures for the Functional Movement Screen using the standard 21-point scale [6, 7, 10, 24]. R = right; L = left

Functional Movement	Screening Criteria	3	2	1
Deep Squat	Performed without board	X		
Dowel is held overhead with arms extended. Feet shoulder-width apart. Participant squats as low as possible. If score of 3 not attained, subject attempts deep squat with 2x6 inch board placed under heels.	Hips break parallel	X	X	
	Tibia/Torso Parallel	X	X	
	Knees aligned over toes	X	X	
	Symmetrical and weight bearing	X	X	
	Dowel behind toes	X	X	
	No lumbar flexion		X	
	Feet do not externally rotate	X	X	
	Heels do not come off floor	X		
	Performs without pain	X	X	X
	Score			
Hurdle Step	Clears hurdle	X	X	
Subject starts by facing hurdle. Hurdle adjusted to height of subject's tibial tuberosity. A dowel is held across shoulders. Subject steps over hurdle, touches heel on ground in front of hurdle, while keeping stance leg extended. Moving leg then returned to start position. Moving leg is side being scored.	Hip/knee/ankle aligned	X		
	No lumbar flexion	X		
	Dowel stays parallel to ground	X		
	Ankle remains dorsi-flexed	X		
	No contact between foot and	X	X	
	hurdle	X	X	
	Balance maintained	X	X	X
	Performs without pain			
	Score	R:	L:	
In-line Lunge	Dowel contacts	X		
Measure subject's tibia length (floor to tibial tuberosity). Subject stands with toes at zero-point of tape measure, and mark placed at distance equivalent to tibia length. Subject holds dowel vertically behind body so it contacts head, back and sacrum. Opposite hand to front foot should grasp dowel at cervical spine; other hand grasps at lumbar spine. With feet aligned, the subject performs a lunge placing heel at mark; back knee should touch ground behind front foot. Front leg is side being scored.	head/back/sacrum	X		
	Dowel remains in sagittal plane	X		
	No torso movement	X		
	Knee contacts ground behind	X		
	heel	X		
	Rear foot does not externally	X		
	rotate	X	X	
	Lumbar spine remains neutral	X	X	
	No forward lean	X		
	Balance maintained	X	X	X
	Places hands appropriately			
	Front heel remains on ground			
	Performs without pain			
	Score	R:	L:	

Table 1a and 1b display the scoring checklist used in this study. Three repetitions of each task were completed, and the best performed repetition was graded [6, 7]. Approximately five seconds of rest were provided between trials, one minute of rest between tests, and subjects were instructed to return to the starting position between each trial [24]. Two video camcorders (Sony Electronics Inc., Tokyo, Japan), positioned anteriorly and laterally [10, 12, 23], recorded the screens. Two qualified exercise scientists who were experienced with the use of the FMS analyzed the subjects live and after viewing the video footage, scoring each subject individually. If there was any discrepancy between the two scores, the two investigators then discussed the results for each subject until a resolution was reached. A final score for each subject in each movement was recorded, before the final overall score was tallied.

Table 1^b. Scoring procedures for the Functional Movement Screen using the standard 21-point scale [6, 7, 10, 24]. R: right; L: left

Functional Movement	**Screening Criteria**	**3**	**2**	**1**
Shoulder Mobility *Measure hand length (distance from distal wrist crease to tip of third digit). Subject makes fists, tucking thumbs, and attempts to touch fists together behind back in one motion. Tester measures distance between two closest boney prominences. Flexed shoulder is side being scored.*	Fists are within 1 hand length	X		
	Fists are within 1.5 hand lengths		X	
	Fists are not within 1.5 hand lengths			X
	Performs without pain	X	X	X
	No pain with impingement test	X	X	X
	Score	R:	L:	
Active Straight-Leg Raise *Subject lies supine with head on ground; board placed under knees. Tester identifies midpoint between superior anterior iliac spine (ASIS) and midpoint of patella; dowel placed here ⊥ to ground. Subject actively raises test leg (ankle dorsi-flexed and knee extended) as high as possible. Opposite leg, head, should remain in contact with ground. Leg with flexed hip is side being scored.*	Malleolus between midthigh and ASIS	X		
	Malleolus between midthigh and knee		X	
	Malleolus below knee			X
	Opposite hip remains neutral	X	X	
	Toes remain pointed up	X	X	
	Knee maintains contact with board	X	X	
	Performs without pain	X	X	X
	Score	R:	L:	
Trunk Stability Push-up *Subject assumes prone position with hands shoulder-width apart, positioned per criteria. Subject performs a push-up with knees extended and ankles dorsi-flexed; body lifted as one unit.*	Performs with thumbs aligned at chin	X		
	Performs with thumbs aligned at clavicle		X	
	Body lifted as one unit	X	X	
	Ankles remain dorsi-flexed	X	X	
	Performs without pain	X	X	X
	No pain with extension test	X	X	X
	Score			
Rotary Stability *Subject assumes a four-point, quadruped position; shoulders and hips at 90°. Subject then flexes one shoulder and extends ipsilateral hip; shoulder then extends and knees flexes to touch elbow and knee. If score of 3 not attained, subject performs diagonal pattern with shoulder and contralateral hip. The shoulder that moves is side of body being scored.*	Balanced ipsilateral	X		
	Balanced contralateral		X	
	Spine parallel	X	X	
	Knee/elbow in line	X	X	
	Knee and elbow touch	X	X	
	Minimal trunk flexion		X	
	Performs without pain	X	X	X
	No pain with flexion test	X	X	X
	Score	R:	L:	
	Final Score:			(21)

With the exception of the deep squat and trunk stability push-up, both sides of the body were assessed within the FMS movements. Each movement was scored from 0-3 (Table 1). According to relevant criteria, scores of 3, 2, 1, and 0, represented: ‘performed without compensation’, ‘performed with compensation’, ‘could not perform’, and ‘pain’, respectively [6, 7, 10]. Using guidelines by Frost et al. [10], a movement completed with a single compensation scored a 2; more than one compensation resulted in a score of 1. An overall cumulative score of 21 was the highest a subject could attain. For tasks that required assessments of both sides of the body, the lowest score contributed to the overall score [6, 7, 10]. For the purpose of this research, individual scores for each side of the body were considered in the final analysis.

20-METER SPRINT

20-m sprint time was recorded by a timing lights system (Fusion Sports, Coopers Plains, Australia). Gates were positioned at 0 m, 5 m, 10 m, and 20 m, at a height of 1.2 m. Sprints over 5 m [11, 20], 10 m [11, 20], and 20 m [9, 11] have been used in the assessment of team sport athletes. Subjects began the sprint from a standing start 30 cm behind the start line to trigger the first gate, and were instructed to accelerate from the starting line and sprint through all timing gates. When ready, subjects started in their own time, and were instructed to run maximally once they initiated their sprint. If the subject rocked backwards or forwards prior to starting, the trial was disregarded and repeated, following the required rest interval. Subjects completed three trials, and the fastest trial was used for analysis.

505 CHANGE-OF-DIRECTION SPEED TEST

The methodology for the 505 was used as per established methods [11], with one timing gate (Fusion Sports, Coopers Plains, Australia) used to record time. The set-up is shown in Figure 1. During the warm-up, subjects were allowed to familiarize themselves with the movement patterns required for the 505. Subjects used a standing start with the same body position as per the 20-m sprint, with their front foot 30 cm behind the start line. The subjects sprinted through the timing gate to the turning point, indicated by a line marked on the laboratory floor between markers. Subjects were to place either the left or right foot, depending on the trial, on or behind the turning line, before sprinting back through the gate. Three trials were recorded for turns off the left and right foot, the order of which was randomized amongst the subjects. If the subject changed direction before hitting the turning point, or turned off the incorrect foot, the trial was disregarded and the subject completed another trial after the required rest period. The fastest overall trial for the 505 was used for analysis.

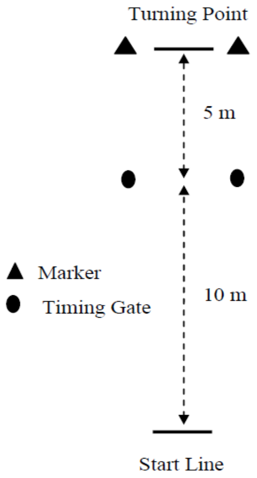

Figure 1: 505 test design and layout

MODIFIED T-TEST

A modified T-test was used for this study [27]. The smaller distances between markers within the modified T-test make it more specific to field and court sport athletes, which has been found to be a reliable assessment of change-of-direction speed [27]. Markers were positioned as shown in Figure 2, with a start line clearly indicated by tape positioned on the laboratory floor, and one timing gate was utilized (Fusion Sports, Coopers Plains, Australia). Subjects started 30 cm behind the start line, and were required to face forwards at all times during the test. To start the test, subjects sprinted forwards 5 m to touch the top of the middle marker. They then side-shuffled 2.5 m to the left or right, depending on the trial, to touch the next marker, side-shuffled 5 m in the opposite direction to touch the next marker, side-shuffled 2.5 m back to touch the middle marker again, before back-pedaling past the start line to finish the test. The hand that was on the same side as the shuffle direction (i.e. the right hand when shuffling to the right, and the left hand when shuffling to the left) was used to touch the marker. Subjects were not to cross their feet when side-shuffling; if they did, the trial was stopped and another attempted after the required rest period. Six trials were completed in total; three with movement initiation at the middle marker to the left, and three with movement initiation to the right. The order of trials was randomized amongst the subject group. The fastest overall trial was analyzed.

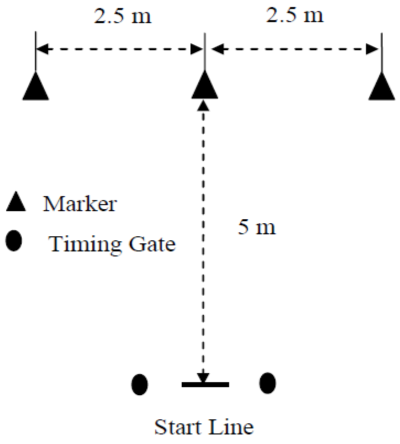

Figure 2: Modified T-Test design and layout

STATISTICAL ANALYSIS

Descriptive statistics (mean ± standard deviation) were used to provide the profile for each measured parameter (i.e. speed test times and FMS scores). As stated, subjects were ranked according to total time from the speed tests (i.e. fastest 20-m time intervals + 505 time + modified T-test time). The Levene statistic determined homogeneity of variance of the data. Subjects were then median split into two groups – faster and slower – according to their total time across the speed tests. As there is a tendency for dichotomized data to regress towards the mean, the subjects ranked 16 and 17 were eliminated from the study. This was done to ensure each group comprised subjects of different multidirectional speed capabilities. Thus, subjects ranked 1-15 were in the faster group; subjects ranked 18-32 were placed in the slower group. A one-way analysis of variance determined whether there were significant ($p < 0.05$) differences between the sprint times, and the FMS screening scores, of the faster and slower groups. Effect sizes (ES) were also used to describe the magnitude of the selected differences between the groups. ES were calculated according to the methods of Cohen [5], where the difference between the means was divided by the pooled standard deviations. For the purpose of this research, less than or equal to 0.20 was considered a trivial effect; 0.21 to 0.59 a small effect; 0.60 to 1.20 a moderate effect; 1.21 to 2.00 a large effect; 2.01 to 4.00 a very large effect; and 4.01 and above an extremely large effect [14]. All statistical analyses were processed using the Statistics Package for Social Sciences (Version 20.0; IBM, Armonk, United States of America).

RESULTS

After the median split, there were no significant differences in age (faster = 23.33 ± 3.52 years; slower = 22.60 ± 4.52 years; p = 0.624; ES = 0.18), height (faster = 1.80 ± 0.06 m; slower = 1.79 ± 0.07 m; p = 0.733; ES = 0.15), or body mass (faster = 78.01 ± 11.14 kg; slower = 79.25 ± 13.92 kg; p = 0.791; ES = 0.10) between the groups. The descriptive data for the speed tests are shown in Table 2. The faster group was significantly quicker in all the speed tests when compared to the slower group. This was by 8%, 7%, and 6% in the 0-5 m, 0-10 m, and 0-20 m intervals respectively; 3% in the 505; and 9% in the modified T-test.

Table 2: Descriptive data for the 0-5 meter (m), 0-10 m, and 0-20 m intervals of a 20-m sprint, and 505 and modified T-test times, for the faster and slower groups in male team sport athletes. p = significance; ES = effect size; s = seconds

	Faster (n = 15)	***Slower (n = 15)***	***p value***	***ES***
0-5 m (s)	0.990 ± 0.040	1.078 ± 0.081*	0.001	1.38
0-10 m (s)	1.702 ± 0.054	1.828 ± 0.080*	0.001	1.85
0-20 m (s)	2.951 ± 0.085	3.147 ± 0.206*	0.002	1.24
505 (s)	2.339 ± 0.071	2.421 ± 0.104*	0.018	0.92
Modified T-test (s)	5.979 ± 0.227	6.584 ± 0.273*	<0.001	2.41

* Significantly ($p < 0.05$) slower than the faster group

The individual screening scores, in addition to the overall FMS score, are displayed in Table 3. As there were no differences in the rotary stability scores for either side of the body, only one score is shown. The faster group scored significantly higher in the deep squat screening exercise. The 45% greater deep squat score had a moderate effect (ES = 0.95). There were no other significant differences in individual screening scores. The 13% higher overall FMS attained by the faster group had a moderate effect when compared to the slower group (ES = 0.55), but the difference was non-significant (p = 0.114).

Table 3: Descriptive data for the Functional Movement Screen assessments (ASLR = active straight-leg raise) for the faster and slower groups in male team sport athletes. *p* = significance; ES = effect size

	Faster (n = 15)	***Slower (n = 15)***	***p value***	***ES***
Deep Squat	2.13 ± 0.74	1.47 ± 0.64*	0.014	0.95
Hurdle Step Left	1.60 ± 0.83	1.33 ± 0.49	0.292	0.40
Hurdle Step Right	1.73 ± 0.89	1.53 ± 0.64	0.484	0.26
In-Line Lunge Left	2.53 ± 0.64	2.20 ± 0.86	0.239	0.44
In-Line Lunge Right	2.40 ± 0.74	2.07 ± 0.88	0.271	0.41
Shoulder Mobility Left	2.33 ± 0.90	2.33 ± 0.90	1.000	0.00
Shoulder Mobility Right	2.80 ± 0.41	2.60 ± 0.83	0.410	0.30
ASLR Left	2.33 ± 0.90	2.20 ± 0.78	0.667	0.15
ASLR Right	2.40 ± 0.74	2.20 ± 0.86	0.500	0.25
Trunk Stability Push-up	2.40 ± 0.63	2.13 ± 0.74	0.299	0.39
Rotary Stability	1.53 ± 0.52	1.40 ± 0.51	0.481	0.25
Overall Score	14.40 ± 2.92	12.73 ± 3.15	0.114	0.55

* Significantly ($p < 0.05$) lower than the faster group

DISCUSSION

To the authors' knowledge, this is the first study to examine which FMS assessments may differentiate between athletes with different multidirectional speed capabilities, by median splitting male team sport athletes into faster and slower groups according to 20-m sprint, 505, and modified T-test performance. The faster subjects in this study were quicker over each of the 20-m sprint intervals when compared to experienced Australian football players [20]; faster in the 505 when compared to experienced rugby league players [11]; and quicker in the modified T-test when compared to male athletes from sports such as football, basketball, volleyball, and handball [27]. This shows that the faster group would have physical characteristics typical of quicker team sport athletes when considering established means in the literature, and provides an indication of the validity of the study results. Overall, six out of seven FMS screening exercises were no different when performed by the faster or slower groups. The overall FMS score was also not significantly different between the groups, although the higher score attained by the faster group did have a moderate effect. However, faster subjects did score significantly higher in the deep squat. The mechanics of the deep squat performance provides some rationale as to why faster team sport athletes may perform better in this test. As a result, the deep squat could be a useful screening assessment of functional limitations that could influence multidirectional speed in team sport athletes.

As stated, the deep squat was the only screening exercise that differentiated between the faster and slower groups (Table 3). The deep squat is a complex movement requiring dorsi-flexion of the ankles, flexion of the knees and hips, extension of the thoracic spine, and flexion and abduction of the shoulders [4, 6]. Greater range of motion, strength, and coordination through these areas of the body provides some evidence of functional mobility [4, 16], allows for greater squat depth, and results in a better FMS score. Even though it is a bilateral exercise, previous research has shown that strength-based bilateral squat movements can relate to unilateral activities such as maximal sprinting [26]. The value of the deep squat as a screening tool has been demonstrated in previous research. For example, a poor score in the deep squat was the primary predictor for a lower FMS total in professional American football players [17]. There are several mechanical reasons as to why faster team sport athletes would also perform better in the deep squat. These relate to technique, in particular the range of movement of particular joints, and muscle recruitment.

Neuromuscular control of the lower-limb joints is needed in the deep squat [4]. This is also true for multidirectional sprinting [21]. For example, the range of dorsi-flexion at the ankles, as controlled by the tibialis anterior, is important within the closed kinematic chain of the deep squat [4]. This muscle is also important for multidirectional sprinting, as ankle dorsi-flexion facilitates clearing the foot from the ground, as well as preparing the foot for impact [15]. Limited quadriceps activation has been linked to poorer performance in the deep squat [4]. The quadriceps contribute to hip flexion and knee extension during the running gait, and the hip flexors and knee extensors have been suggested as the primary muscle groups accountable for increases in step frequency and running speed [21]. The deep squat could be used as an indicator of functional range of motion of the lower extremity joints, in addition to quadriceps strength in male team sport athletes. Those athletes with a restricted lower-limb joint range of motion as defined by the deep squat, in conjunction with weaker leg muscles, may experience detriments to multidirectional sprint performance.

Lumbo-pelvic stability is also needed for a better score in the deep squat [6, 10, 24]. Stability about the low back and pelvic region has been stated to be important for better stability and body positioning when changing direction, as well as enhancing the ability to provide succinct braking forces during the running gait [1]. Moreover, the upper body must also be controlled in the deep squat, with glenohumeral and thoracic spine mobility necessary for successful performance [6]. Mobility at the shoulder joint is needed during maximal multidirectional sprinting, in order to drive the arms and counterbalance leg movements [22], as well as to assist with rotating the body during a cutting action [3]. Deceleration of the arms during a maximal cut would be controlled in part by the muscles about the thoracic spine (e.g. trapezius, rhomboids, serratus anterior, latissimus dorsi, and teres minor) [18]. The stability provided by the lumbo-pelvic region, in conjunction with a degree of upper-body mobility, could also have contributed to the better performance by faster team sport athletes in the deep squat. Nonetheless, further analysis is needed to ascertain whether deficiencies in specific regions of the body, as detected by the deep squat screen, then relate to faster or slower team sport-specific multidirectional speed.

A score of 14 has been set as a threshold for injury risk for American football players [17]. The faster group was above this threshold (14.40 ± 2.92), while the slower group was below (12.73 ± 3.15). Although the faster team sport athletes scored 13% higher in the overall FMS score out of 21 with a moderate effect, it was not significantly greater than that for the slower group (Table 3). Observation of the individual assessment scores shows a trend that faster athletes performed the FMS movements better; nevertheless, no other individual screening exercise differentiated between the faster and slower groups, which is in line with previous research that suggested there were minimal relationships between the FMS and athletic performance [24, 26]. This was true even for tests that placed greater emphasis on lower extremity mobility, which were the in-line lunge, hurdle step, and active straight-leg raise (Table 3). The in-line lunge and hurdle step both require control of the ankle, knee, and hip of each leg, concurrent with hip abduction and adduction, during a stepping action [6]. Even though the stepping action would be specific to sprinting, the actual speed of movement of these screening assessments, which are slow and controlled [6], may limit their use as delineation tools between faster and slower athletes. Furthermore, the in-line lunge and hurdle step have some limitations with assessing mid-range performance [23], and the reliability of the hurdle step has been questioned, because of the difficulty in scoring all aspects of the movement [25, 29]. The active straight-leg raise assesses hamstring, gastrocnemius, and soleus flexibility [7]; greater compliance in these muscles has actually been linked to slower 20-m sprint performance in rugby union players [9]. From the results for the current study, faster team sport athletes do not perform significantly better in the in-line lunge, hurdle step, or active straight-leg raise, when compared to slower athletes.

Screening exercises that predominantly stressed the upper body and trunk (shoulder mobility, trunk stability push-up, rotary stability) [25], also did not differentiate between faster and slower team sport athletes (Table 3). Shoulder mobility is specific to glenohumeral range of motion [7], and as a result it is not unexpected that the faster multidirectional speed was not differentiated by this screening exercise. The trunk stability push-up requires a stable trunk during the performance of a symmetric upper body movement [7]. As the arm actions during running are asymmetrical [13], this provides some indication as to why performance in this test was not significantly better in faster team sport athletes. Rotary stability, which assesses multi-plane trunk stability [7], also did not differentiate between faster and slower athletes. Schneiders et al. [28] has queried the value of rotary stability as a screening assessment, due the difficulty in achieving a high score. The results from this study support these assertions, in that this test could not differentiate between faster and slower athletes. When considering screening exercises for diagnosing potential limitations specific to multidirectional sprint performance, tests that focus on the upper extremities do not appear to have great value for team sport athletes.

CONCLUSION

In order for a screening assessment to identify characteristics of faster team sport athletes, it must involve specific movement patterns and muscle recruitment. The results from this study indicate that the deep squat was the only FMS exercise that differentiated between faster and slower male team sport athletes as assessed by multidirectional speed (20 m sprint, 505, and modified T-test). This is not to discount the potential value of the other six screening exercises used in the FMS. However, if there is a focus on finding a movement deficiency that delineates between faster or slower team sport athletes, the deep squat appears to be the only exercise that incorporates functional movement, and stresses both the upper and lower extremities appropriately.

PRACTICAL APPLICATION

The practical application of this research is that team sport coaches, strength and conditioning professionals, and athletic trainers, could consider using the deep squat as a method to assess joint restrictions or muscle weakness that may affect multidirectional sprinting in their athletes. Identification of these functional limitations could then inform specific conditioning programs for team sport athletes. However, further research is required to confirm whether limitations identified by the deep squat can be corrected, such that linear and change-of-direction speed can be improved.

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