Assessing movement using a variety of screening tests

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INTRODUCTION

Movement screening is a process that has become widely utilised in both the general and athletic populations, providing practitioners with an indication of joint mobility, motor patterning, muscular equilibrium and stability.[1,7] Although some organisations have their own method of assessing human movement, others have adopted Gray Cook's Functional Movement Screen (FMS), which uses seven tests to gauge an understanding of mobility, stability and movement.[1,7,8,16,18,22,24] These screening methods provide useful information about fundamental movement patterns, thus allowing coaches to interpret the strengths and weaknesses of their athletes, and to make more accurate decisions regarding programme design.

However, one component that the FMS does not address is a screening test at speed. When the seven tests are considered collectively, they are not reflective of dynamic actions involved in many sports, omitting rapid decelerations and high eccentric forces which may be a characteristic of high injury risk.

With this in mind, it seems logical to assess athletes for movement competency using an assessment that has more relevance to injury risk or one that mimics the speed of movement often experienced in sport. This may complement the FMS, thus providing a fuller picture. Velocity-based tests such as the countermovement jump (CMJ), squat jump (SJ) and drop jump (DJ) have long been included in fitness testing batteries,[3,4,35,40] but not always for movement screening purposes. There are a number of similar assessments that have been used for screening purposes, namely to identify athletes at risk of injury.[15,19,30,31,33,37]

For the purpose of this article, these assessments will be grouped under the term 'dynamic stability-based tests'. Therefore, the purpose of this article is to offer the strength and conditioning (S&C) practitioner a brief description of the FMS, to provide evidence of why dynamic stability-based tests are needed to provide a fuller picture, and to review which tests are available for this purpose and make recommendations.

The Functional Movement Screen

In order to understand why we require dynamic stability-based tests in our screening protocols, we must first understand what the FMS consists of and the purpose behind it. The FMS consists of seven tests that aim to identify movement competency for strength, stability and mobility.[1,7] Each test is graded through a 3-point scoring system and then a total score (out of 21) is given at the end. If a test is performed correctly, a score of 3 is given. A 2 is scored if there are compensations in the client's movement and a 1 is given if they are unable to perform the test. Finally a 0 is scored if athletes experience pain during any test.[1,7] Table 1 provides a brief synopsis of the seven tests, their purpose, required physical capacities and common dysfunctions associated with each test.

Why do we need dynamic stability-based tests to support the FMS?

FMS AND SPORT PERFORMANCE

A key limitation of the FMS is the absence of dynamic movements performed at high speed, which are inherent to sporting actions.[1,12] Thus the FMS cannot be expected to fully represent the movement patterns achieved in sport. This is supported by Parchmann and McBride,[34] who compared the FMS and 1RM back squat and their correlation with 10/20m sprint, jump height and agility t-test times, in 25 NCAA division 1 golfers. The results can be seen in Table 2. The lack of correlation between the FMS and these performance tests indicates that the FMS has a poor ability to predict physical performance measures of acceleration, power and agility, especially when compared to maximal lower body strength. Similar

Table 1: The seven FMS tests: purpose, required physical capacities and associated common dysfunctions (adapted from Cook, 2010)

FMS TEST	PURPOSE	REQUIRED PHYSICAL CAPACITIES	COMMON DYSFUNCTIONS
Deep squat	Global mobility and stability in fundamental movement pattern	Talo-crural joint mobility Knee stability Hip mobility Lumbo-pelvic control Thoracic mobility Gleno-humeral joint stability	Tibial external rotation Knee valgus Forward trunk lean Pelvic tucking Arms fall forward
Hurdle step	To identify unilateral asymmetries and deemed an important part of locomotion and acceleration	Ankle/Knee stability Hip mobility Lumbo-pelvic control	Loss of balance Hip hike/drop Lateral flexion of the spine
Inline lunge	Challenges the mobility and stability of the ankle, knee and hip joints	Talo-crural joint mobility Knee stability Hip mobility	Feet flatten Knee valgus Increased hip flexion
Shoulder mobility	Assesses mobility around scapular-thoracic region in an upper body reciprocal movement pattern	Thoracic extension Shoulder adduction/abduction Shoulder flexion/extension Shoulder internal/external rotation	Reduced capacity to meet fists to one another (product of reduced mobility in one or more physical capacities)
Active straight leg raise	Assesses hip flexion and knee extension capacities in an unloaded environment	Hip mobility Lumbo-pelvic stability	Reduced hip flexion range of motion Excessive lumbar extension Femoral external rotation (resting leg) Knee flexion (resting leg)
Trunk stability	View the client's ability to stabilise the trunk region	Gleno-humeral joint stability Lumbo-pelvic stability	Increased lumbar extension Torso rotation Lumbo-pelvic rotation
Rotary stability	Observes multi-planar movement patterns in the pelvis, trunk and scapular-thoracic region	Gleno-humeral joint stability Lumbo-pelvic control Hip mobility	Weight shifting Increased lumbar extension Reduced shoulder flexion

findings have been reported elsewhere.[11,28] That said, it should be noted that the FMS was not originally intended to be used as a performance screen, rather just a baseline test to assess movement competency. However, due to the increased research on the FMS and its lack of relationship with performance measures,[11,28,34] additional assessments may provide further supporting evidence to complete the screening process.

Furthermore, Frost et al[13] used the FMS to evaluate the effectiveness of training over a twelve-week period. Sixty firefighters were divided into three groups (intervention 1, intervention 2 and control). The first intervention group's training strategies consisted of evidence-based exercises that aimed to reduce injuries, whereas the second intervention group's aim was to simply make the firefighters as 'fit as possible'. It must be noted that no details were offered as to exactly which exercises were chosen for each intervention, making it difficult to critique whether or not the interventions had a significant effect on post-testing. Three 1.5 hour training sessions were performed each week and screening was performed pre and post interventions. Seventeen subjects received the same score when re-tested (intervention 1 = 9, intervention 2 = 5, control = 3), whereas a total of 26 made improvements (intervention 1 = 9, intervention 2 = 9, control = 8) and 17 got worse (intervention 1 = 3, intervention 2 = 5, control = 9).

In conclusion, the total FMS scores were not significantly different between groups after the 12 weeks of training.[13] The authors concluded that the FMS may have its place when identifying pain or asymmetries, but that further information is required (in the form of tests) to guide exercise progression and offer more reliable feedback about the information that can be drawn directly from the FMS alone.[12,13] It was also suggested that screening tasks perhaps be modified to incorporate a speed element,[12] to enhance the conclusions that can be drawn from the process as a whole.

FMS AND INJURY PREDICTION

Although the aforementioned literature suggests that the FMS does not correlate to measures of athletic performance, it is unclear whether or not it can be used to predict injury risk among athletic populations. O'Connor et al[27] used the FMS in an attempt to predict injuries in 874 marine officers. Subjects were divided into either long (68 days, n = 427) or short (38 days, n = 447) training cycles and then followed up with any injuries that occurred during the training cycles. The results of each training cycle were split up into FMS scores of ≤ 14, 15-17 and ≥ 18 and can be seen in Table 3.[27]

The results from O'Connor's study indicate that marine officers who scored ≤ 14 were more likely to get injured when compared to those who scored in the other two categories.

'It is unclear whether or not the FMS can predict injury risk among athletic populations'

Table 2: Table demonstrating the correlations between FMS and 1RM back squat and a range of performance tests (results taken from Parchmann & McBride, 2011)

	10M SPRINT	20M SPRINT	VERTICAL JUMP	AGILITY T-TEST
FMS	-0.136	-0.107	0.249	-0.146
1RM back squat	-0.812*	-0.872*	0.869*	-0.758*

* Significant at $P \leq 0.05$

Table 3: Injury rates by cycle length in marine officers with differing FMS scores (adapted from O'Connor et al, 2011)

CYCLE	SCORE	NO OF SUBJECTS	INJURED (%)	*P* VALUE
Long cycle	≤ 14	36	52.8	0.001*
	15-17	283	29.3	
	≥ 18	108	44.4	
Short cycle	≤ 14	57	40.4	0.015*
	15-17	223	22.2	
	≥ 18	166	28.9	

* Statistically significant at $P < 0.01$

'Movement quality must be considered and each individual test analysed in order to gain practical usage from the screening process'

However, it must be noted that the identified imbalances (as measured by the scores of ≤ 14) were not 'treated' within the respective training cycles; therefore, once again it is impossible to know whether these injuries could have been prevented.[27]

In agreement with this study, Butler et al[5] investigated whether performance in physical fitness tests and the FMS were predictors of injury in 108 firefighters. The performance tests consisted of a sit and reach test, push up test (maximum number performed in two minutes), pull up test (until failure), 1.5 mile run and a firefighter-specific 'tower test'. Once again, a cut-off point had to be obtained for statistical analysis and it was deemed that scores of ≤ 14 were able to discriminate against those who were at a greater risk of injury. However, when the seven tests were assessed individually by way of regression analysis, the deep squat and push up test were the only two tests that were able to moderately predict injury (R = 0.330); the sit and reach test was the only physiological variable that was a moderate predictor injury (R = 0.218).[5]

With this in mind, these results should be interpreted with care, as the sit and reach does not challenge joint mobility in specific areas of the kinetic chain.[36] More recent methods, as described above in the deep squat, have been considered more appropriate examples to challenge mobility and global movement patterning.

Further support could be drawn from a study by Li et al,[21] which highlighted by exploratory factor analysis that the seven tasks of the FMS had low internal consistency and were not good indicators of any single factor. Furthermore, it was concluded that greater attention should be paid to the score of each individual test, rather than the sum score when interpreting FMS results. This highlights the limitations in interpreting the total score and the necessity to look at specific movement patterns or skills that are relevant to the context, thus addressing each individual score. For example, multiple studies have used a cut-off point for statistical analysis (<14)[5,6,27] and suggested that there is an association between those who score below 14 and injury risk. However, it is feasible for a subject to score perfectly on six tests (sum total of 18) and poorly on the seventh (scoring a 1), which would provide a sum score of 19. If the sum score is used for analysis without further investigation, this would be considered an excellent score with the poor test score being overlooked. Therefore, movement quality must be considered and each individual test analysed in order to gain practical usage from the screening process.

Similarly, Chorba et al[6] assessed the ability of the FMS to determine injury risk, this time in 38 female collegiate athletes. Seven of these reported prior reconstructive surgery on their anterior cruciate ligament (ACL). It was noted that 69% of subjects that scored ≤ 14 sustained an injury during the intervention period (pre-season). In addition to this, a correlation (R = 0.76) existed between low-scoring subjects on the FMS and injury rates. However, what is perhaps more important, is that the FMS was unable to differentiate between subjects who had not experienced any ACL trauma versus those who had.[6]

In addition, ACL injuries have been shown to alter movement patterns[39] and a screening process that is unable to differentiate between subjects that have or have not had this type of trauma may increase the risk of re-injury to an athlete, as this aspect of the screening process could be missed. Specifically, the predominance of static tasks performed during the FMS may not have been provocative enough to determine functional limitations in athletes with a previous injury. This point further highlights the need for more dynamic forms of assessment that are reflective of speeds and forces experienced during sporting movements.

More recently, McCall et al[23] published an article on risk factors, testing and preventative strategies for non-contact injuries in professional football. A total of 93 international premier league clubs were surveyed on what were perceived to be important risk factors for non-contact injuries and the tests used to identify them. Of the 93 surveys, 44 (47%) were successfully completed and returned. There was a wide variety in the response regarding perceived risk factors for non-contact injuries, highlighting the multi-factorial nature of this area. The five most common risk factors reported were previous injury, fatigue, muscle imbalance, fitness and movement efficiency.[23] However, what is perhaps the most important finding of this study is that the most common method by which teams aimed to test for injury risk was the FMS (29 out of 44). The ability of the FMS to predict injury still seems very unclear. With this in mind, and given the inconclusive relationship between the FMS score and its ability to screen for injury risk, further testing is important to complement the capacity of the FMS to fulfil this role.

Which dynamic stability-based assessments should we use?

Physical testing batteries commonly use a range of high-load movements including the 1RM or 3RM power clean/snatch/back squat and high-velocity jumps: such as drop jump, countermovement jump or squat jumps to assess the strength/power abilities of their athletes.[3,4,35,36] However, for the purpose of this article, these tests will not be analysed as a tool for complementing a physical testing battery. Instead, the focus will be on an overview of which assessments could be used to assess movement competency at velocity, thus complementing screening protocols that lack this component.

LANDING ERROR SCORING SYSTEM (LESS) TEST

The LESS test is a clinical screening tool that aims to assess an individual's risk of suffering a non-contact ACL injury through the evaluation of landing mechanics from a drop vertical jump.[31,32,33,38] Using two video cameras (sagittal and frontal plane views) to analyse potentially high-risk movement patterns that have been used as predictors of future ACL risk,[33] it is graded on a 17-point scale for assessing different landing mechanics. However, it has been deemed too time-consuming for coaches to use practically and the use of video cameras has meant it cannot be used in 'real-time'.[33] Padua et al[31] created a modified version of the test, which was reduced to a 10-point grading criteria and could score clients subjectively, without the use of video cameras. The score-sheet and definitions can be seen in Table 4 and Table 5.

Padua et al[31] investigated the reliability of this modified version of the LESS test using 43 subjects from a US military academy (24 female, 19 male). A total of two sessions

Table 4: The Landing Error Scoring System (LESS) Score Sheet for the modified version of the LESS test (Padua et al, 2011)

OBSERVING FROM THE FRONT VIEW	OBSERVING FROM THE SIDE VIEW
1. Stance width o Normal (0) o Wide (1) o Narrow (1)	6. Initial landing of feet o Toe-to-heel (0) o Heel-to-toe (1) o Flat feet (1)
2. Maximum foot rotation position o Normal (0) o Moderately externally rotated (1) o Slightly internally rotated (1)	7. Amount of knee flexion displacement o Large (0) o Average (1) o Small (2)
3. Initial foot contact o Symmetric (0) o Not symmetric (1)	8. Amount of trunk flexion displacement o Large (0) o Average (1) o Small (2)
4. Maximum knee valgus angle o None (0) o Small (1) o Large (2)	9. Total joint displacement in the sagittal plane o Soft (0) o Average (1) o Stiff (2)
5. Amount of trunk lateral flexion o None (0) o Small to moderate (1)	10. Overall impression o Excellent (0) o Average (1) o Poor (2)
Total =	

Table 5: Operational definitions on the modified LESS test sheet (adapted from Padua et al, 2011)

LESS CRITERIA	OPERATIONAL DEFINITION	RATER VIEW
Stance width	Abnormally wide or narrow stance during landing, they receive an error (+1)	Front
Foot-rotation position	Moderate amount of external rotation or internal rotation, they receive an error (+1)	Front
Initial foot-contact symmetry	If 1 foot lands before the other or there is alternating heel-to-toe/toe-to-heel landing mechanics, they receive an error (+1)	Front
Knee valgus	Small amount of knee valgus (+1) Large amount of knee valgus (+2)	Front
Lateral trunk flexion	If trunk is not perfectly vertical in frontal plane, they receive an error (+1)	Front
Initial landing of feet	If subject lands heel-to-toe or flat-footed, they receive an error (+1)	Side
Amount of knee flexion	Small amount of knee flexion displacement (+1) Average amount of knee flexion displacement (+2)	Side
Amount of trunk flexion	Small amount of trunk flexion displacement (+1) Average amount of trunk flexion displacement (+2)	Side
Total joint displacement in sagittal plane	Large displacement of trunk & knees = 'soft' (0) Average displacement of trunk & knees = 'average' (1) Small displacement of trunk & knees = 'stiff' (2)	Side
Overall impression	Soft landing with no frontal plane motion at the knee = 'excellent' (0) Stiff landing with large frontal plane motion at the knee = 'poor' (+2) All other criteria rates 'average' (+1)	N/A

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were performed, using three raters. Inter-rater reliability was reported by an intraclass correlation (ICC) of between 0.72-0.81.[31] These results were similar to a previous study by Padua et al,[33] who assessed the reliability of the original LESS test, reporting an ICC of 0.84. This offered supporting evidence that the modified LESS test would be an acceptable version of the test to use.

However, in the first study by Padua et al,[33] the authors assessed the reliability of the original LESS test on 2691 subjects from three large US military academies. 3-D motion analysis was used to assess kinematics of the jump off the box (again from 30cm height, positioned at a distance of 50% of their height away from the force platforms). Scores were rated excellent if they scored ≤ 4 and poor if they scored > 6 on the test.[33] Interestingly, 29% of male subjects scored in the excellent category versus 14% of females, whereas 36% of female subjects were rated poor versus 23% of male subjects. Poor scores were associated with higher levels of knee valgus, hip adduction and increased hip/knee internal rotation. Further to this, the results demonstrated that the LESS test was able to distinguish between subjects who had suffered previous ACL injuries and those who had not,[33] and similar results have been seen elsewhere.[2] In the light of this evidence, it would appear that the LESS test is a useful screening tool for assessing those at risk from non-contact ACL trauma. In addition, this was an aspect that was highlighted as 'un-achievable' by Chorba et al[6] when assessing the ability of the FMS to predict injury risk.

THE SINGLE LEG LANDING ASSESSMENT

One of the potential disadvantages in the LESS test was that it only focused on one type of landing mechanics (bilateral). It was noted that injuries occur in a multitude of ways (cutting, side-stepping, reacting to an opponent), all of which were not looked at in the methodology.[15] However, in a recent study by Jones et al,[15] the authors examined the relationship between landing, cutting, pivoting and knee valgus in female soccer players. Each subject performed six trials of a 'single leg landing' (SLL) from a 30cm box. Results showed that peak knee abduction moments moderately correlated (R = 0.63; P < 0.01) with SLL and horizontal change of direction (in cutting) time.[15] It was suggested that utilising a landing assessment to screen for non-contact ACL risk may have its limitations, especially in sports where other movement patterns such as cutting or changing direction are more frequent (such as soccer).[15] In the same study, subjects who performed poor landing mechanics also showed poor COD mechanics as identified by increased knee valgus. When combined with the correlation between the SLL and cutting, it would suggest that using a landing assessment for the purpose of identifying 'high risk athletes' may have its place in screening methodologies.

However, a single leg landing from a 30cm height may not be an appropriate assessment for all athletes, due to the unilateral eccentric demand placed on each limb. A primary purpose of this test is to assess the level of knee valgus experienced from a single leg landing task. If it is deemed by coaches that this assessment can provide useful information regarding knee mechanics, but it is too advanced, then modifying the test to reduce the impact may offer a potential alternative, and not put the athlete at risk. Lowering the height at which the test is performed may provide coaches with an idea of what athletes are able to cope with during a single leg landing task.

This alteration in box height was investigated by Ford et al,[9] who looked at trunk motion between 11 female and 11 male collegiate athletes during the single leg landing task, this time from a 13.5cm height. It was hypothesised that reduced trunk control would affect the distal joints, specifically the knee joint.[9] Results showed that the female athletes demonstrated significantly greater trunk flexion (F: -13.9 ± 8.0° vs M: -8.5 ± 6.6°) and lateral trunk tilt compared to males (F: 3.8 ± 1.9° vs M: 2.8 ± 1.3°) and these were suggested to contribute to female athletes' increased risk of knee valgus.[9] Similarly, in another study by Ford et al,[10] the authors examined gender differences during a single leg landing task from either a medial or frontal plane direction. Once again, female athletes had higher levels of knee valgus compared to males, but also increased hip adduction, which was deemed an additional contributor to the increased valgus that females experienced[10] and has been shown also in previous research.[20]

It would appear that the single leg landing may provide coaches with the ability to differentiate between male and female athletes at risk of ACL trauma, through the assessment of knee valgus as one of the key contributors to ACL injury. Also, when combined with increased hip adduction (as identified in Ford's study),[10] reduced gluteal muscle activation may play a part in this aforementioned hip adduction. With this in mind, coaches should consider exercises that aim to target gluteal strengthening at high velocity to challenge the stabilisation of the knee that athletes may experience in sporting actions. This provides a rationale for a progressive plyometric programme, which if designed with a logical progression focusing on landing mechanics, may assist in reducing un-wanted knee valgus mechanics. However, no specific grading criteria was reported (as portrayed above in the LESS test), which may limit the practicality of this test to the use of video cameras (which not all coaches will have access to) or sight, but if no grading criteria has been created for this test, then its validity and reliability must be questioned.

THE TUCK JUMP ASSESSMENT

The majority of ACL injuries occur from non-contact events such as deceleration and faulty landing mechanics.[26] The tuck jump assessment requires subjects to perform continuous, repeated tuck jumps on the spot for 10 seconds.[25] But where the LESS test allows coaches to observe landing mechanics, the tuck jump may offer coaches the opportunity to observe flaws in landing mechanics during a higher intensity plyometric exercise.[25] Subjects are observed for flaws in technique over 10 different criteria on technique, foot, knee, and thigh motion and are given a '1' if faulty mechanics are visible.[25] The grading criteria can be viewed in Table 6 (below).

TESTING THE TUCK JUMP ASSESSMENT

One of the first priorities when using any testing protocol is to assess its reliability in order to understand whether it can be repeatedly utilised. Herrington et al[14] assessed the intra and inter-tester reliability of the tuck jump assessment. Ten subjects (5 male, 5 female) were videoed from 2 metres away in the sagittal and frontal plane during the tuck jump assessment while two testers independently viewed and scored them. Results showed that the average agreement between the two testers across the assessment protocol was 93%, with 100% agreement on 5 of the 10 tests.[14] The results demonstrated excellent reliability between the testers, although only two testers were used. The authors also suggested that a possible advantage this test has is the increased load that the athlete is exposed to compared to the drop land, increasing the requirement for neuro-muscular control during landing. However, the very nature of the increased load and heightened neuro-muscular control may prove to be too advanced for some athletes and its use must be implemented with caution, depending on the experience, age and health of the athlete

Table 6: Grading criteria for the Tuck Jump Assessment (adapted from Myer et al, 2011)

TUCK JUMP ASSESSMENT	PRE	MID	POST	COMMENTS
Knee and thigh motion				
1. Lower extremity valgus at landing				
2. Thighs do not reach parallel (peak of jump)				
3. Thighs not equal side-to-side (during flight)				
Foot position during landing				
4. Foot placement not shoulder width apart				
5. Foot placement not parallel (front to back)				
6. Foot contact timing not equal				
7. Excessive landing contact noise				
Plyometric technique				
8. Pause between jumps				
9. Technique declines prior to 10 seconds				
10. Does not land in same footprint (excessive in-flight motion)				
Total score				

'When looking at tuck jump assessment, it is important to understand that there will be multiple underlying factors relating to ACL injury risk'

in question. In addition, it has also been acknowledged that the test's practicality could be expanded if it could be utilised in real time. Modern video cameras, along with modern mobile technology, provide a cost-effective alternative to the 3D motion cameras used in the full version of the LESS test, by which this could be achieved. Additionally, the skilled coach's eye should not end up overlooked as a valuable tool to assess performance. Clearly, more research is needed in this area.

Klugman et al[17] investigated whether a 10-week plyometric programme minimised flaws in technique, as identified by the tuck jump assessment. A group of 49 female high school soccer athletes with a mean age of 14 took part in the study; 15 athletes were included in the 10-week intervention programme (34 in the control group), but it was not specified how many sessions were conducted each week. The only details provided were that subjects in the intervention group attended 95% of the sessions that were offered to them.

Subjects who took part in the 10-week training programme demonstrated improved mean scores in the tuck jump assessment of 5.4 from 4.9. However, the control group also improved their mean scores from 5.8 to 5.0, with no additional training focus other than standard soccer practice.[17] The authors suggested that there may be a dose-response relationship where a specific amount of time or sessions are required before they have a greater effect on the tuck jump assessment. However, without knowing the number or duration of sessions, it is impossible to draw accurate conclusions regarding the methodology. As it stands, what can be suggested is that soccer training in this study proved to be just as successful at improving flaws in technique when measured by the tuck jump assessment.[17]

When collating this literature concerning the tuck jump assessment, it is important to understand that there will be multiple underlying factors relating to ACL injury risk. Myer et al[26] suggested that one of the most important considerations was an athlete's neuro-muscular control and that the tuck jump assessment posed the ability to repeatedly assess this by monitoring for improvement during re-testing. However, in the light of the evidence from Herrington et al[14] and Klugman et al,[17] further research is required on its reliability in real-time and whether or not specific plyometric interventions can bring about significant improvements in an athlete's capacity to perform the test. Further to this, it would be useful to know whether the tuck jump assessment has the capacity to differentiate between athletes who have had previous ACL trauma and those who have not, as this has been demonstrated for the LESS test.

Practical application

When deciding on which test should be used to complement movement screening, each of the three aforementioned tests have their advantages and disadvantages. Each of them has been used with an emphasis on outlining those at risk of injury, particularly ACL trauma. However, to the author's knowledge, the LESS test is the only one that has successfully been able to detect these differences.[31] The single leg landing assessment, whether performed from a 30cm height[15] or 13.5cm height,[9] will challenge an athlete's neuro-muscular control to a greater extent than a bilateral drop landing (as per the LESS test). Therefore, it may be prudent to use the single leg landing assessment as a progression from the LESS test if coaches deem that the bilateral landing is being performed perfectly or that it does not sufficiently challenge the athlete's neuro-muscular control. One of the advantages of the single leg landing assessment is the unilateral nature of the test, which may better represent the demands athletes are required to cope with compared to the bilateral assessment. Further to this, the tuck jump assessment will increase the requirement for neuro-muscular control even further and may be considered for assessment purposes as a progression from the single leg landing test. The repeated nature of the test places increased eccentric demands on the athlete, as well as the potential to assess under fatigue during a high intensity plyometric activity.

Coaches may consider using these three dynamic stability-based assessments to complement the movement screening process for their athletes. There is a progression in terms of eccentric demand and neuro-muscular control through each of the aforementioned tests, which allows coaches to utilise an enhanced velocity-based assessment if their athletes continually perfect the grading criteria in one or need to be challenged further.

The 'coach's eye'

An additional consideration for the S&C practitioner is the validity of some of the aforementioned screening tests. The literature has highlighted the reliability of these additional screening tools, but no validity statistics have been reported to the authors' knowledge. Therefore, until any of these assessments are thoroughly validated (either across a large subject base or for a homogenous group), coaches should continue to screen their athletes to ensure we gain the best possible picture of an athlete's movement. This can be done as specific testing sessions (as outlined in the assessments above) or during training sessions (both in the weight room and on the field/court/track). For example, a coach may program an athlete to perform both strength and power in the form of complex training during a weight room session. Such examples of this may be a CMJ performed after a rest period of heavy back squats. With this in mind, the coach could use the CMJ exercise as a method of monitoring knee valgus during landing mechanics, as opposed to purely trying to enhance vertical power. Ultimately, it is the coach's responsibility to ensure optimal technique is being adhered to during training sessions, and this concept of on-going screening should be a fundamental aspect of the S&C practitioner's coaching ability.

Conclusion

The FMS allows practitioners to gauge an understanding of motor patterning, stability and mobility. Although this may provide useful feedback on issues surrounding specific movement patterns, the predictive value of these tests for athletic performance and likelihood of future injury is not profound. Utilising the LESS test, single leg landing assessment and/or tuck jump assessment may offer coaches additional screening tools in predicting those athletes at higher risk of potential injury, namely knee trauma. These tests may provide a more detailed picture of how an athlete moves, enabling coaches to make more concise decisions regarding programme design, injury prevention techniques and long-term athlete sustainability.

AUTHORS' BIOGRAPHIES

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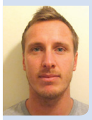

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