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Review Article

Developing A Multi-Directional Single-Leg Jumping Assessment which Incorporates Technical, Physical and Perceptual Components of Performance

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Abstract

Developing a comprehensive athlete profile can provide coaches and clinicians with a variety of valuable information regarding individual players' performance and capabilities. Creating an assessment that is not only reliable, but also addresses the three primary components of agility (technical, physical and perceptual) is needed to better assess individual player strengths and weaknesses. Unilateral performance measures across multiple directions can be used to detect directional-specific asymmetries which may provide valuable information regarding those players that are at an increased risk of injury or that may not be ready to return to play following a lower limb injury. A percent difference in performance measures between legs that exceeds 15% in any of the three directions is thought to place the athlete at greater risk of injury. Additional characteristics associated with alignment, muscle activation patterns and relative joint angles throughout the movement can also be indicative of high risk movement patterns. Further research is needed to assess the reliability and develop normative data for such an assessment.

Keywords: Leg Power; Lower Limb Injury; Asymmetry; Single-Leg Jumping; Agility

Abbreviations: ASI- Average Symmetry Index

Introduction

Identifying strengths and weaknesses within individual players' performances often provides valuable information for coaches and clinicians. As such, a variety of different functional performance tests are often used as diagnostic tools when determining a player's 1) player potential; 2) potential for injury; 3) strength and conditioning programming; 4) injury prevention programming; and 5) gathering baseline data for progress assessments and 6) assessing readiness to return to play following an injury. As many movements performed in sport reflect the agility of the athlete (e.g., responding to opponents movements, accelerating and decelerating efficiently, maintaining balance and control throughout the competition, etc.). Agility can be defined as a rapid whole-body movement requiring changes in velocity and/or direction in response to a sport-specific stimulus [1-3]. From this working definition, it is clear that there are technical, physical and perceptual components involved. However, many tests of agility and sports performance do not measure all three components (with most eliminating the reactive element). Creating a comprehensive player profile requires not only performance measures pertinent to the sport and tasks regularly performed, but must also include aspects of decision-making, technique

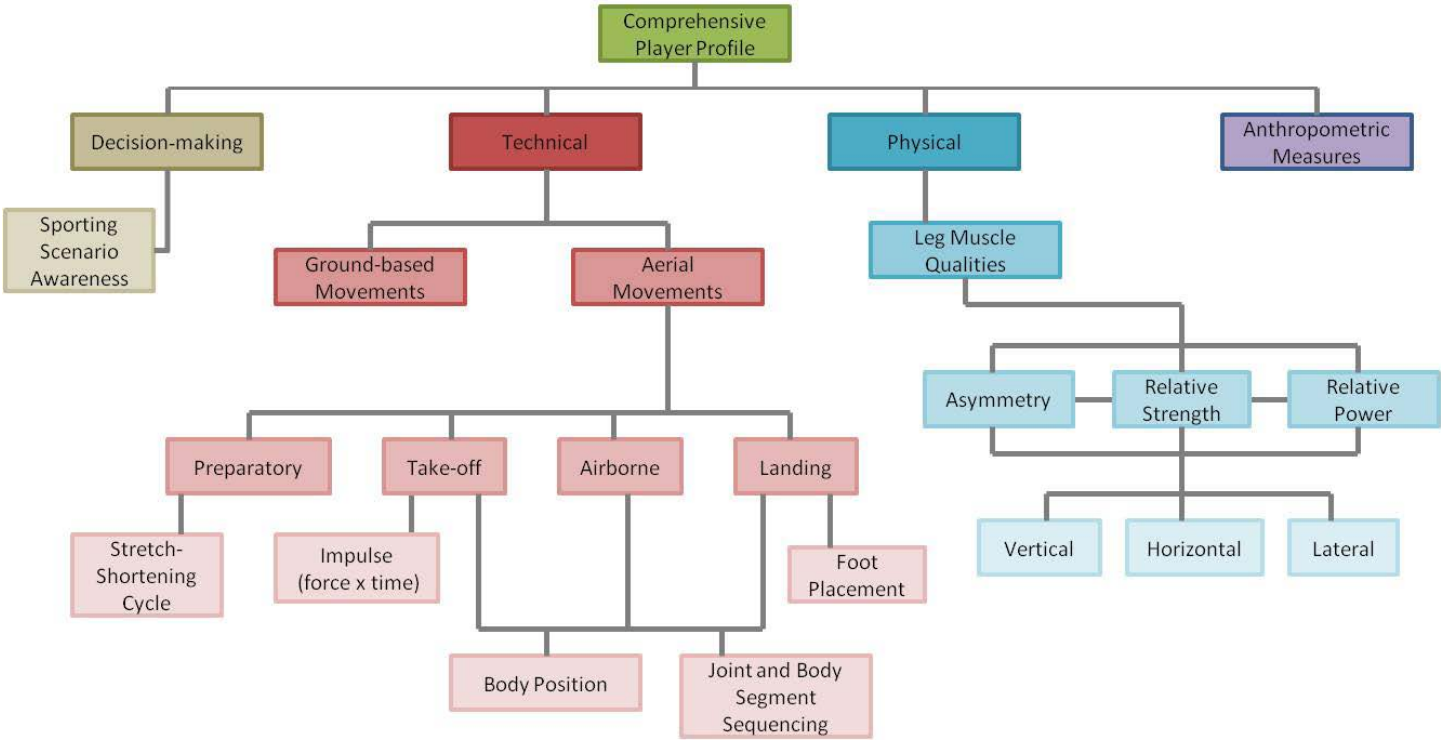

Figure 1. Deterministic model of agility (modified from [4])

proficiency, physical strengths and anthropometric characteristics (see Figure 1).

Of interest in this article is the development of a single-leg jumping assessment across multiple directions that is able to detect differences in performance through a variety of technical, physical and reactive elements. When these variables are excessively high or differ substantially between limbs, the athlete is considered to be at an increased risk of lower limb injury [5-16]. Therefore, an easily administered and reliable assessment that is able to identify such characteristics when performing sport-specific tasks would seem to be of great value to coaches and clinicians.

Multi-directional Performance

A common measure of leg strength and power in sport is the vertical jump assessment. This is primarily due to its relatively simple testing procedures and high reliability of performance results [17]. However, in sport, a player's movements are not confined to a single direction (e.g. vertical) but are performed across multiple directions throughout the entirety of the competition. Additionally, it has been shown in recent research that a player's leg strength capabilities are not uniform across these various directions [8,17-19]. Therefore, using only the maximum vertical jump assessment as a means of developing a player profile for those athletes that perform multi-directional movements (vertical, horizontal and lateral) in their sport creates an inaccurate representation of the player's strength and power capabilities [18]. An assessment of leg power that can be performed across multiple directions can provide coaches and clinicians with valuable information regarding baseline values, minimum standard values (e.g. performance indicators), and a means of monitoring player progress (whether injured or not) [17]. Additionally, shared variances (ranging from 13 – 62%) reported in 3 separate studies [18,20,21] investigating multi-directional jumping have indicated that each direction measures relatively independent leg qualities of each other; further supporting the inclusion of horizontal and lateral hopping into the standard vertical jump assessment.

Unilateral Performance

Dynamic movements in sport are not always performed on both legs simultaneously (i.e. bilaterally). Players are often required to jump, land, change direction, accelerate, etc. using only one leg at a time (i.e. unilaterally). As such, the legs may differ substantially in strength, power and technical characteristics. When a single leg is used to generate or absorb large ground reaction forces (characterized in particular by jump take-off and landing, respectively), any muscular imbalances will increase the strain placed on the single leg and may detrimentally affect the performance [5,7,17,22]. By isolating one leg at a time during the movement task, a measure of symme-

try (ASI = average symmetry index) between limbs can easily be calculated using the following equation [17].

ASI = [1 – (dominant limb/non-dominant limb)] x 100

OR

ASI = [1 – un-injured limb/injured limb)] x 100

It is important to note that some researchers use the absolute value of the ASI measure which masks valuable information regarding which leg is actually performing better. By eliminating the absolute value component of the equation (as shown above), a positive ASI value will be representative of the dominant/un-injured limb having superior strength while a negative ASI value will indicate that the non-dominant/injured limb had superior strength and power [17].

When an ASI is calculated for a given movement performance, the magnitude of the imbalance can be an indicator of an increased potential for injury. This is of particular interest when clearing a player to return to their respective sport following an injury. There is no solid threshold of ASI magnitude that separates injured players from non-injured; however a magnitude that exceeds 15% is often associated with players who have recently sustained an injury to their lower limb, while normative data for various un-injured populations of athletes tend to present ASI values below 10% [5,6,8-14]. Therefore, the grading scale outlined in Table 1 can be used as a general guide for determining the severity of an ASI magnitude. It is important to note, however, that these classifications are not an absolute. For example, an athlete presenting an ASI measure of 17 in one direction may not necessarily incur a lower limb injury, while a player presenting an ASI measure of 6 in one direction may. This scale is designed to identify those players that are at a greater risk of injury due to their increased imbalances between limbs in one or more movement directions.
Insert Table 1 here.

ASI range (% difference between limbs)	Risk Potential
0-9.9	Minimal to low
10-15	Moderate
≥ 15.1	High

Table 1. Classification of average symmetry index (ASI) thresholds.

Multi-directional Unilateral Assessment

Performing a single-leg countermovement jump into the vertical, horizontal and lateral directions can provide highly reliable data (ICCs ranging from 0.82-0.96, CV% < 7.2 [9,21,22]) and a more comprehensive profile regarding a player's leg strength and power output. Additionally, depending on the resources available, such a comprehensive assessment can reflect more sensitive measures of force and power (derived from force plate analysis) or less sensitive measures of jump distance/height (via manual measurement or video analysis). Regardless of the resources available, the single-leg countermovement assessment will provide valuable feedback on the current status of each individual player with relatively high reliability.

Technical Performance Indicators

The strategies used to successfully complete a given task will often vary across players and genders. There are, however, various body positions and techniques that are thought to be associated with an increased incidence of injury to the lower extremities (see Table 2). A kinematic analysis of the movement patterns used when performing the multi-directional leg assessment may provide further insight into specific movement patterns that predispose an athlete to injury or a subsequent injury following recovery and medical clearance.

Characteristic	Study
Single leg landing	Chaudhari et al (23), Pappas et al (13)
Time to stabilization	Ross et al (15)
Landing kinematics (various)	Ross et al (15), Wickstrom et al (16), Myer et al (26), Myer et al (27), Ireland (25)
Near full knee extension at impact	Chaudhari et al (23), Pappas et al (13), Myer et al (26), Myer et al (27), Ireland (25), Swartz et al (28)
Anterior tibial displacement	Chaudhari et al (23), Ireland (25)
Internal rotation of femur, external rotation of tibia	Chaudhari et al (23), Ireland (25), Swartz et al (28)
Knee Valgus	Chaudhari et al (23), Myer et al (26), Myer et al (27), Ireland (25), Swartz et al (28)
Increased quadriceps activity and decreased hamstring activity at impact	Colby et al (24), Pappas et al (13), Myer et al (26), Myer et al (27),
Increased maximum knee flexion through ground contact	Wickstrom et al (16), Myer et al (27)

Table 2. Characteristics of movement performances identified as possible mechanisms for lower extremity injury.

A 3-D video analysis of the multi-directional single-leg assessment should be used in order to analyze the movement patterns being performed. When comparing previously injured athletes to un-injured athletes, those athletes that have more recently sustained a lower limb injury will likely present additional altered techniques to compensate for the lack of strength, coordination and confidence in the injured limb [14]. As that limb becomes stronger, those previously identified characteristics will likely dissipate. However, if they fail to diminish over time, the athlete will be at an even greater risk for injury (in either limb).

Decision-making Element

Creating a comprehensive player profile must take into account as many components of agility as possible. However, many assessments of this nature do not measure all three components. Therefore, to create a complete profile of the athlete's abilities, it is important to include a sport-specific reactive element to the assessment. In the multi-directional single-leg jumping assessment that this paper has been centered around, a reactive element can easily be included by having the athlete react to a signal (auditory or visual) by jumping into the designated direction. Another option is to have the athlete per-

form multiple jumps into one direction, stopping immediately on the researcher's command. This would provide additional information concerning balance and control as well as time to stabilization (a factor identified in Table 2).

Conclusion

Player's movements in sport are not confined to only one direction and are commonly performed off of a single leg. To create a complete profile of athletes' performance proficiencies, a reliable assessment is needed that incorporates not only single-leg multi-directional movements, but also kinematic analysis of movement techniques as well as a reactive component. Highly valuable information gathered from such a comprehensive assessment includes: direction-specific performances, asymmetry magnitudes, alignments upon landing, contact time (if consecutive jumps are performed), time to stabilization, muscle activation patterns, and reaction time/accuracy. Reliability of such an assessment is needed, as well as normative measures for both genders and across various sports and performance levels.

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