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Original research

A new real-time visual assessment method for faulty movement patterns during a jump-landing task

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ABSTRACT

Objective: Determine the interrater reliability of a new real-time assessment of faulty movement patterns during a jump-landing task.
Design: Interrater reliability study.
Setting: Human movement laboratory.
Participants: 50 healthy females.
Main outcome measures: Assessment included 6 items which were evaluated from a front and a side view. Two Physical Therapy students used a 9-point scale (0–8) to independently rate the quality of movement as good (0–2), moderate (3–5), or poor (6–8). Interrater reliability was expressed by percent agreement and weighted kappa.
Results: One examiner rated the quality of movement of 6 subjects as good, 34 subjects as moderate, and 10 subjects as poor. The second examiner rated the quality of movement of 12 subjects as good, 23 subjects as moderate, and 15 subjects as poor. Percent agreement and weighted kappa (95% confidence interval) were 78% and 0.68 (0.51, 0.85), respectively.
Conclusions: A new real-time assessment of faulty movement patterns during jump-landing demonstrated adequate interrater reliability. Further study is warranted to validate this method against a motion analysis system, as well as to establish its predictive validity for injury.

1. Introduction

Lower extremity movement pattern has been implicated as a risk factor for various knee disorders such as patellofemoral pain (PFP), patellar tendinopathy, and anterior cruciate ligament (ACL) rupture (Bisseling, Hof, Bredeweg, Zwerver, & Mulder, 2008; Boling et al., 2009; Hewett et al., 2005; Mann, Edwards, Drinkwater, & Bird, 2012; Nakagawa, Moriya, Maciel, & Serrao, 2012). It seems essential, therefore, for sports medicine clinicians to possess efficient tools for assessing quality of movement, so that athletes at risk of injury are readily identified and preventive measures are implemented.

Quality of movement can be assessed by various means. Three-dimensional (3D) motion capture (Mizner, Kawaguchi, & Chmielewski, 2008), video analysis (Padua, Marshall, Boling, Thigpen, Garrett, & Beutler, 2009), and real-time visual observation (Padua, Boling, DiStefano, Onate, Beutler, & Marshal, 2011) have all been described previously. Visual observation is particularly useful in the clinical setting, due to its minimal time and equipment requirements. For these reasons, visual observation is also well suited for screening athletes for the presence of potentially hazardous movement patterns, as well as for providing feedback, directing the focus of prevention programs, and assessing the outcome of such programs.

The lateral step down test (Piva et al., 2006; Rabin & Kozol, 2010), overhead squat test (Bell, Padua, & Clark, 2008), one-legged mini squat test (Ageberg, Bennell, Hunt, Simic, Roos, & Creaby, 2010), and the functional movement screen (Teyhen et al., 2012) are all examples of real-time assessments of quality of movement. However, as athletic participation often involves more dynamic activities such running, cutting and jumping, higher level tests may be more appropriate for assessing quality of movement among this population. One such test is jump-landing, which

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typically involves a drop from a 30 cm box followed by an immediate maximal vertical jump (Ekegren, Miller, Celebrini, Eng, & Macintyre, 2009; Mizner et al., 2008; Padua et al., 2009, 2011; Whatman, Hume, & Hing, 2013). Several real-time visual assessment methods have been described to classify the quality of movement during jump-landing (Ekegren et al., 2009; Nilstad et al., 2014; Padua et al., 2011; Whatman et al., 2013). Whatman et al. (2013) described a dichotomous rating based on the position of the patella in relation to the ipsilateral second toe. Although the intrarater reliability of this rating was found to be sufficient, its interrater reliability was only fair, and no differences in 3D knee abduction angle were noted between subjects with differing visual ratings (Whatman et al., 2013). Ekegren et al. (2009) described another dichotomous categorization of knee valgus alignment that demonstrated good to excellent interrater reliability. However, the test's sensitivity in identifying a truly risky valgus alignment as determined by 3D analysis was deemed inadequate (Ekegren et al., 2009). Nilstad et al. (2014) classified quality of movement during jump-landing into 3 levels (good, reduced, or poor) based on the amount of knee valgus as well (Nilstad et al., 2014). Interrater reliability varied from moderate to excellent and this classification has been shown to differentiate between different 3D knee valgus angles during jump-landing (Nilstad et al., 2014).

One common limitation of the aforementioned visual classification systems is their sole reliance on frontal-plane knee alignment in determining quality of movement and/or risk of injury. Although greater knee valgus during jump-landing has been previously shown to predict ACL injury (Hewett et al., 2005), other movement deviations have also been associated with injury (Table 1). For example, decreased knee flexion excursion during landing has been associated with the risk of sustaining an ACL injury (Hewett et al., 2005; Myer, Ford, Khoury, Succop, & Hewett, 2010), as well as the risk of developing PFP (Boling et al., 2009). Similarly, decreased knee and hip flexion during landing have been associated with patellar tendon abnormality and patellar tendinopathy (Bisseling et al., 2008; Edwards, Steele, McGhee, Beattie, Purdam, & Cook, 2010; Mann et al., 2012). Consequently, relying solely on frontal-plane knee motion during jump-landing may not fully capture the level of risk associated with this functional task.

The Landing Error Scoring System – Real time (LESS-RT) (Padua et al., 2011), which is a derivative of the original video-based LESS (Padua et al., 2009), is a real-time assessment method that does rate motion at several joints around 3 planes of motion (Padua et al., 2011). However, the LESS-RT possesses several limitations. First, the test's reliability has only been established using expert clinicians with extensive training in rating video performance of jump-landing (Padua et al., 2011). In addition, the reliability of the LESS-RT has been described using the intraclass correlation coefficient (ICC) which does not account for agreement due to chance, and as such, potentially inflates the level of agreement. As the LESS-RT uses an ordinal scoring scale, the appropriate measure for assessing its reliability is the kappa coefficient, which is a chance-corrected measure of agreement (Sim & Wright, 2005). Finally, the LESS-RT includes 10 items that are assessed over 4 trials (Padua et al., 2011). This requires simultaneous assessment of 2–3 items, sometimes pertaining to movement at different joints (i.e. knee and foot) (Padua et al., 2011). As the jump-landing task occurs rapidly, it may be difficult to accurately judge the alignment and/or movement at several joints simultaneously, which may hinder reliability and validity.

The tuck jump assessment tool is another visual assessment method that includes other potentially useful items such as the level of noise associated with landing, as well as the amount of in-flight motion (Myer, Ford, & Hewett, 2008). However, this test does not include assessment of sagittal-plane joint motion, and studies assessing its reliability have resulted in mixed results (Dudley, Smith, Olson, Chimera, Schmitz, & Warren, 2013; Herrington, Myer, & Munro, 2013).

In an attempt to overcome some of the limitations of existing real-time visual assessment methods, we have devised a new scale that combines the assessment of frontal- and sagittal-plane motion, as well as rating of the amount of noise associated with landing and the amount of in-flight movement during jumping. The purpose of this study was to assess the interrater reliability of this visual assessment scale.

Table 1
Knee and hip kinematics previously associated with knee injury.

Kinematic variable	Disorder	Reference
Increased knee valgus	ACL tear	Hewett et al. (2005)
Decreased knee flexion	ACL tear	Hewett et al. (2005)
		Myer et al. (2010)
	PFP	Boling et al. (2009)
	Patellar tendinopathy	Mann et al. (2012)
		Bisseling et al. (2008)
Decreased hip flexion	ACL tear	Sheehan et al.
	Patellar tendinopathy	Mann et al. (2012)
		Edwards et al. (2010)
Increased hip internal rotation	PFP	Boling et al. (2009)

Abbreviations: ACL, anterior cruciate ligament; PFP, patellofemoral pain.

2. Methods

The study was approved by the ethics committee of Ariel University, and all participants gave informed consent prior to participation.

2.1. Participants

Fifty female undergraduate students at Ariel University volunteered to participate in the study. Participants had to be 18–40 years old. Exclusion criteria were a history of knee pain, previous lower extremity surgery, current complaint of pain in the low back or lower extremities, and pregnancy.

2.2. Procedures

Following informed consent, demographic information including age, height, weight and level of physical activity was collected. Physical activity was quantified by multiplying the number of weekly sessions by the number of minutes of every session, resulting in units of minutes/week.

2.2.1. Jump-landing test

The setup of the jump-landing area is presented in Fig. 1. Subjects stood on a 30-cm box. Two 1-m long parallel lines were marked on the floor in front of the box (one line was 10 cm in front of the box, while the other was 60 cm in front of the box). Subjects were instructed to drop off the box, land inside the area bordered by the 2 floor lines and then immediately jump straight up as high as possible. The test was repeated 5 times. No restrictions were imposed on arm position and/or movement during the task. No feedback was given regarding the landing technique. Participants performed the jump-landing while wearing shorts that fully exposed their knees, as well as their own sneakers. Following instruction, each participant was given 6 trial repetitions in an attempt to minimize performance variability during the test itself.

2.2.2. Raters and training

Two physical therapy students, within less than 2 weeks from graduation, performed all ratings for this study. These students have already completed all didactic and clinical education,