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The effect of videotape augmented feedback on drop jump landing strategy: Implications for anterior cruciate ligament and patellofemoral joint injury prevention

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ABSTRACT

Background: Modification of high-risk movement strategies such as dynamic knee valgus is key to the reduction of anterior cruciate ligament (ACL) and patellofemoral joint (PFJ) injuries. Augmented feedback, which includes video and verbal feedback, could offer a quick, simple and effective alternative to training programs for altering high-risk movement patterns. It is not clear whether feedback can reduce dynamic knee valgus measured using frontal plane projection angle (FPPA).
Methods: Vertical ground reaction force (vGRF), two-dimensional FPPA of the knee, contact time and jump height of 20 recreationally active university students were measured during a drop jump task pre- and post- an augmented feedback intervention. A control group of eight recreationally active university students were also studied at baseline and repeat test.
Results: There was a significant reduction in vGRF ($p = 0.033$), FPPA ($p < 0.001$) and jump height ($p < 0.001$) and an increase in contact time ($p < 0.001$) post feedback in the intervention group. No changes were evident in the control group.
Conclusion: Augmented feedback leads to significant decreases in vGRF, FPPA and contact time which may help to reduce ACL and PFJ injury risk. However, these changes may result in decreased performance.
Clinical relevance: Augmented feedback reduces dynamic knee valgus, as measured via FPPA, and forces experienced during the drop jump task and therefore could be used as a tool for helping decrease ACL and PFJ injury risk prior to, or as part of, the implementation of injury prevention training programs.

1. Introduction

Poor neuromuscular control during landing as demonstrated by increased dynamic knee valgus during the drop jump task has been prospectively linked to anterior cruciate ligament (ACL) and patellofemoral joint (PFJ) injury [1,2], and to secondary ACL injury following ACL reconstructive surgery [3]. There are potentially a multitude of reasons why the individual demonstrates poor control on loading the limb during landing including poor proprioception (understanding of the position of the limb), strength of muscles such as the Quadriceps, Gluteus Medius and Maximus [4] and inadequate range of movement at joints such as the ankle [5] resulting in compensatory movement patterns being adopted. But perhaps one of the simplest reasons for poor control may be a lack of understanding of what is a good or bad movement pattern.

Feedback is a fundamental tool for learning and performing of motor skills and may be the quickest and simplest form of training available; indeed the use of additional feedback has long been shown to be a vital part of motor skill learning associated with optimising lower limb movements [6–10]. The use of simple verbal feedback decreases ground reaction force (GRF) and knee valgus angles and moments during landing tasks [6–10]. Furthermore, the use of video to supplement verbal instructions given to participants can decrease GRF and improve frontal and sagittal plane landing mechanics during both simple and more complex sporting movements [11–14]. A combination of analysis-of-self and analysis-of-expert has been shown to be the most effective type of video feedback for reducing GRF and increasing knee flexion displacement during vertical jump landing [14]. These improvements were also retained 1 week later, suggesting that motor patterns may have changed and the improvements would endure, therefore decreasing injury risk in the long-term [14].

Herman et al. [11] found that augmented feedback, based on the Onate [14] expert and self-combination protocol, resulted in decreased GRF and increased knee flexion and hip abduction angles. However, no changes were noted in other variables relating to dynamic knee valgus,

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such as hip internal rotation, knee valgus or tibial rotation angles. No other studies based on Onate et al.'s [14] protocol have evaluated such measures. In addition, the Onate protocol is based on criteria which have been theorised to reduce injury risk. Greater improvements may be seen using feedback criteria based on identification of high-risk movement patterns such as the Landing Error Scoring System (LESS) [15].

The LESS is a movement assessment tool which takes into account frontal and sagittal plane motion of the trunk, hip, knee and ankle [15]. Higher scores on the LESS, which indicates poor movement patterns, correlate to 3D movement patterns which potentially increase injury risk [15]. For example, those with high (poor) LESS scores demonstrate increased hip adduction and knee valgus angles and moments. Therefore, the use of a scoring system such as the LESS as a basis for feedback is likely to improve frontal plane projection angle (FPPA) scores during landing tasks, the FPPA being a composite measure of the 3D motions contributing to dynamic knee valgus [16,17]. This indicates that individuals who exhibit high FPPA also demonstrate movement patterns which place increased stress on the ACL and PFJ, increasing risk of injury. Therefore, this study aims to combine the expert and self-combination feedback protocol used by Onate et al. [14] with the LESS to determine whether this will reduce FPPA during the drop jump (DJ) task.

2. Methods

2.1. Participants

An intervention group of 20 recreationally active participants, eight men (age 24.3 ± 4.7 years, height 178.1 ± 6.8 cm, weight 81.1 ± 7.7 kg) and 12 women (age 22.6 ± 3.8 years, height 166.9 ± 6.3 cm, weight 67.2 ± 10.9 kg), and a control group consisting of eight recreationally active participants, four men (age 23.0 ± 4.2 years, height 181.3 ± 7.19 cm, weight 76.5 ± 12.4 kg) and four women (age 20.0 ± 4.0 years, height 164.9 ± 2.7 cm, weight 57.8 ± 9.2 kg) volunteered for the study. Participants were required to be free from lower extremity injury for at least six months prior to testing, and have no history of lower extremity surgery. Injury was defined as any musculoskeletal complaint which stopped the participant from undertaking their normal exercise routine. The study was approved by the University Research and Ethics Committee and all participants gave written informed consent prior to participation.

2.2. Protocol

Prior to testing, markers were placed on the lower extremity for the measurement of FPPA. The marker placement was undertaken as previously described by Munro et al. [18]

2.2.1. Drop jump (DJ) task

Subjects undertook the DJ task as previously described by Munro et al. [18]. The initial landing from the step was used for analysis purposes [19].

2.2.2. FPPA

FPPA of the knee was determined from digital images using Quintic software package (9.03 version 17) and was measured as previously described by Munro et al. [18] as shown in Fig. 1. Positive FPPA values reflected dynamic knee valgus, excursion of the knee towards the midline of the body so that the knee marker was medial to the line between the ankle and thigh markers. Negative FPPA values reflected excursion of the knee away from the midline of the body. The average FPPA from three trials was used for analysis. Within-session and between-session reliability of this method has been established [18].

Fig. 1. Frontal plane projection angle during drop jump task.

2.2.3. Feedback group protocol

Each participant first completed baseline testing, during which they performed three test trials of the DJ task. Participants then undertook the feedback session, followed by post-feedback testing, which included a further three test trials. This process was then repeated for the second task. Both legs were tested and analysed After completion of baseline testing participants underwent a video-assisted summary feedback programme based on the 'expert plus self' combination used by Onate et al. [14]. The expert model was trained in proper landing technique by the principal investigator (AM); this landing was based on the criteria for the highest possible score on the LESS [15] where the model demonstrated:

- At initial contact: trunk and hip flexion, a minimum of 30° knee flexion, no evidence of knee valgus or sideways trunk lean, both feet simultaneously contacting with toes first;

- After initial contact: further trunk and hip flexion, a minimum of a further 45° knee flexion, no evidence of knee valgus, feet shoulder width apart with no more than 30° rotation and overall impression of a soft landing.

Participants first viewed two trials of the expert video, followed by their own three trials. In each case the sagittal plane video was viewed first. Each trial was viewed twice, first at normal speed and second in slow motion, controlled by the principal investigator. To help review the technique on display in each trial, participants were required to complete a checklist. The checklist was based on the best possible score on the LESS and expert technique to provide a focus on technique parameters that would bring a performance improvement (Appendix 1). The principal investigator explained the criteria and reviewed the video with the participant to ensure their understanding. This included identification of errors in their performance and how each could be improved. Where participants already performed a specific criterion correctly they were instructed to maintain this technique, for example if there was no evidence of knee valgus they were instructed to maintain this rather than to land with further knee varus.

Each feedback session lasted 3 min on average. Immediately following the feedback session participants performed a further three trials of