Assessment of Single Leg Landing Severity in Gaelic Athletic Association Football

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I. INTRODUCTION

The Irish Gaelic Athletic Association (GAA) has over half a million registered players [1], with 2,200 clubs in Ireland and over 700 clubs worldwide [2]. Football is a major component, containing aspects of soccer, rugby and basketball. A general match-play injury incidence of 62 per 1000 hours was reported [3]. Lower extremity injuries dominate (76%), especially hamstring and ACL injuries through non-contact mechanisms [4]. The most common non-contact injury mechanisms include landings (26.7%) and pivots (40.0%) [5].

While strength and conditioning programmes have been assessed for their effectiveness in reducing non-contact injuries in GAA sports (eg [6]), and there has been an analysis of potential concussive events in GAA hurling [6], little is known about the biomechanics of non-contact lower limb injuries in GAA football.

One aspect of GAA football is that players compete for the ball in the air. To do this, they attempt to out-jump their opponent to catch the ball, and then frequently execute a single leg landing, potentially exposing the landing knee to buckling forces. So far, there appears to have been no investigation of this common event. Accordingly, the goal of this short communication was to preliminarily characterize the landing severity of typical single leg landings in GAA football as well as the stiffness of the lower limb complex for different single leg landing strategies. This was achieved by a combination of video analysis and fundamental impact modelling.

II. METHODS

A. Video Analysis

Eight representative matches from the elite men's game were assessed, using freely available broadcast video (25-30 fps), accessed via Youtube. The focus was on non-contact cases, in particular single-leg landing following a jump (eg. to compete for the ball). Cases for which there was an uninterrupted video view were considered further. There were no injuries evident in the cases assessed. Neglecting cases involving rotation about the player's vertical axis, it is assumed the severity of the landing is mainly influenced by the jump height (which determines the vertical landing velocity) and the ankle, knee and hip flexion (which collectively determine the lower limb stiffness). Intrinsic factors such as knee valgus were not considered at this stage.

B. Fundamental impact model

A simplified estimate of the landing stiffness of the lower limb complex was made using a 1-DOF spring mass model. A mass (m) of 80 kg was assumed for all athletes, as individual masses were unknown. Two different approaches were applied to estimate landing stiffness:

1. The jump height (h) was estimated from the number of frames in which the athlete was airborne, using the equations of uniform acceleration under gravity. The downward displacement (x) of the athlete's mass centre (hips) from initial contact to the end of the landing event was estimated using Kinovea. A balance between kinetic and potential energy was then used to estimate the lower limb landing stiffness using $k = 2mgh/x^2$.
2. The time taken from initial contact to the end of the landing event was estimated and then used to compute the natural frequency (ω_n) of the lower limb complex, using a method similar to [8]. From this, an estimate of the lower limb stiffness in the landing event was computed using $k = \omega_n^2 m$.

The low frame rate and the varied view angle of the video introduce considerable uncertainty into these calculations. This was partially accounted for by estimating the earliest/latest frame for consideration of initial landing and end of the landing event, as well as allowing for a nominal 1cm variation on the measured downward displacement (x) of the mass centre during landing.

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III. INITIAL FINDINGS

There were 32 single leg landings in the eight matches assessed which had sufficient image clarity to apply the method outlined above. Figure 1 shows a typical landing event (yellow player, number 9). Figure 2 shows the resulting single leg lower limb stiffness versus jump height results, showing mean and uncertainty estimations.

Figure 1. Representative single leg landing case

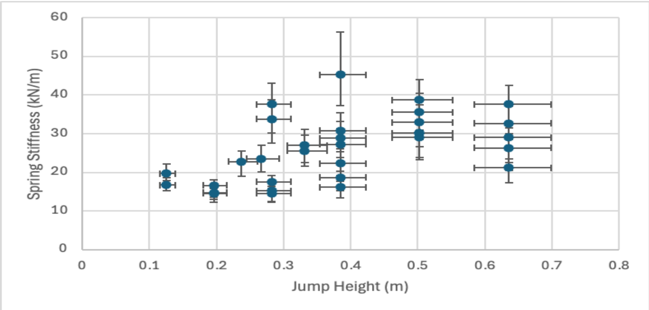

Figure 2. Preliminary findings for lower limb landing stiffness as a function of jump height.

IV. DISCUSSION

Elite male GAA football players frequently land on a single leg from heights of around $40 - 65cm$, corresponding to estimated landing speeds of $2.8 - 3.6\ m/s$. Female athletes are at higher risk of ACL injury (4x rate compared to males) [10] and should be a focus in future, but broadcast video footage of the women's game is much less prevalent. The measured effective leg stiffness in the men's landings varied substantially depending on the landing strategy employed by the athlete. For more intense jumps ($> 0.5\ m$), the stiffness varies by a factor of 1.8 (ca. $38{,}000\ N/m$ versus ca. $21{,}000\ N/m$), depending on strategy. High jump heights combined with high stiffness are likely higher risk events. The peak force in a spring mass model with an initial impact speed of v can be estimated from $F = mv\omega_n$. This suggests peak single leg landing forces of around $6000\ N$ for a stiff landing from a jump height of $65cm$. For a lateral offset of $5\ cm$ from the hip to the knee joint, this corresponds to a lateral bending moment of ca. $300\ Nm$, close to knee injury thresholds in the literature [9], though this likely overestimates risk as it neglects muscle activity.

Although no injuries were observed in the cases assessed, landings have been identified as a frequent cause of knee injury [5] and single leg landings generally induce higher knee loading than two legged landings. Current strength and conditioning protocols for GAA include single-leg drop jumps and countermovement jumps, but the effective jump height is then much lower. It is therefore unclear whether existing strength and conditioning protocols adequately prepare players for the landing mechanics regularly experienced in matches.

V. REFERENCES

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