PREPARATORY TRUNK ANGULAR MOMENTUM PREDICTS PEAK KNEE VALGUS MOMENTS

[1]**Jonathan M D Staynor,** [1]Jacqueline A Alderson, [2]Jeffrey A Reinbolt, [1]Marcel Rossi and [1]Cyril J Donnelly
[1]University of Western Australia
[2]University of Tennessee

INTRODUCTION

Simulation research has identified lateral positioning of the whole body center of mass (COM) as an important factor influencing peak knee valgus moments (PKVM) and associated anterior cruciate ligament (ACL) injury risk, during the weight acceptance (WA) phase of change of direction (CoD) movements [1]. As the trunk is the heaviest body segment, it is has the greatest individual-segment impact on whole body COM. Experimental research has observed associations between WA trunk kinematics and ACL injury risk [2], which is important given an athletes peak ACL injury risk occurs during WA [1]. However, there is at least a 25ms electromechanical delay in muscle force production [3], limiting the opportunity for the neuromuscular system to execute movement which will alter trunk or whole body COM position within the WA time period. It is probable that trunk segment preparatory mechanics during flight phase prior to WA, influences subsequent WA kinematics and ACL injury risk.

The aim of the current study was to investigate the influence of preparatory trunk angular momentum (H_T) on PKVM during the WA phase of unplanned sidestepping (UPSS). It is hypothesized that multi-planar preparatory H_T will predict PKVM during the WA of UPSS.

METHODS

Twelve male participants (x±yyrs, 1.85±0.07m, 79.89±11.50kg) completed a previously published sidestepping protocol [1]. Retro-reflective markers were recorded at 250Hz using a 12 camera Vicon MX motion analysis system (Vicon, Oxford, UK) and ground reaction forces (GRF) were recorded at 2,000Hz from a 1.2m by 1.2m force plate (Advanced Mechanical Technology Inc., Watertown, USA). Kinematic and GRF data were both low pass filtered at 15Hz. A participant specific skeletal model [1] and anthropometric segment inertial parameters [4] were used to estimate 16 body segments, which were required to calculate whole body COM position. Angular momentum of the head, thorax, middle torso and lower torso segments were calculated about the whole body COM (Eq 1) during the preparatory phase (toe-off to one frame prior to landing) of UPSS. H_T was calculated by summing the angular momentum of the head, thorax, middle torso and lower torso segments and normalized to participant mass, height and approach velocity ($kg.m^2.s$). PKVM were calculated via inverse dynamic procedures during WA [2] and normalized to participant mass and height (kg.m).

$$H_i = (COM_i - COM_{body}) \times m_i (V_i - V_{body}) + I_i w_i \quad (1)$$

Using 80% of the trials (n=34) a linear mixed model was run to predict PKVM from three dimensional preparatory H_T. Participants were modelled as random factors to account for within-subject variability. Mean single plane H_T (frontal, sagittal and transverse) were input as independent variables, and were removed from the model manually in order of highest *p* value until all remaining independent variables were significant (α = 0.05). The regression model was externally validated against the remaining 20% of the trials (n=9) by using a paired samples t-test and Cohen's d effect size to compare predicted vs measured PKVM.

RESULTS AND DISCUSSION

Sagittal plane H_T did not significantly correlate with PKVM ($p \geq 0.05$), and was removed from the model. Significant correlations were found between frontal and transverse plane H_T with PKVM (Table 1). The regression equation was deemed to sufficiently predict PKVM as there was no significant difference ($p \geq 0.05$) between predicted (0.49±0.20) and measured (0.43±0.22) values, with difference between the predicted and measured moments shown to be small in effect size (d = 0.29). This observation suggests that multi-planar H_T were capable of predicting PKVM and ACL injury risk during UPSS.

Parameters	**β**	**SE**	***p***
Intercept	0.55	0.05	<.001
Frontal H_T	-136.90	52.75	.014
Transverse H_T	618.34	160.80	.001

Table 1: Parameter coefficients (β) and standard error (SE) for significant H_T predictors of PKVM and ACL injury risk.

Increases in frontal H_T (e.g. momentum acting to laterally flex the trunk towards CoD) were negatively correlated with PKVM. This is in agreement with previous research which reported increased PKVM with increased peak lateral trunk flexion away from the CoD during WA [2]. Increases in transverse H_T (e.g. momentum acting to rotate the trunk towards the intended CoD) are positively associated with PKVM. It is possible that preparatory H_T in the transverse plane requires an athlete to adopt kinematic postures, such as a wide lateral foot placement [2], during WA that are associated with high PKVM. This rationale is currently speculative and is being investigated within a larger sample size (n=40).

CONCLUSIONS

The current study has established a link between preparatory H_T about the whole body COM and ACL injury risk during WA. These finding provide a rationale to investigate an athlete's preparatory mechanics during non-contact CoD movements.

REFERENCES

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