ASSESSING LATERAL ANKLE SPRAIN RISK USING LOWER LIMB ANTHROPOMETRICS

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The purpose of this study was to identify clinical measures, that could be used to recognise individuals at an increased risk of ankle sprain based upon lateral centre of pressure (COP) patterns during running gait. A convenience sample of young healthy males (n=32) were recruited and assessed using basic anthropometric measures and questionnaires. Treadmill running COP patterns were collected using Novel pressure insoles. This study identified a model based upon the Cumberland Ankle Instability Tool, external rotation at the knee, and height, could predict an individual's COP distribution with an 84.4% accuracy. The outcome from the study could be used as a quick measure to identify individuals at potential increased risk of lateral ankle sprain.

KEYWORDS: plantar pressure, injury, inversion, gait.

INTRODUCTION: Participation in regular physical activity reduces the risk of many health problems including, hypertension, heart disease and stroke; sport however is recognised as a risk factor for a range of different musculoskeletal injuries (Bahr and Krosshaug, 2005; Haskell *et al.*, 2007). Ankle inversion injuries account for between 10-30% of all sports injuries, and can be as high as 82% in sports such as volleyball (Fong *et al.*, 2007). There are 1.0-1.5 million emergency department visits due to sprained ankles each year in the United Kingdom, a frequency of 5,600 incidences per day (Cooke *et al.*, 2009; Lamb *et al.*, 2009). The medical cost for one injury, including healthcare and sick leave in the UK, ranges from £940 to £1,314, which is £1-2 billion annually, though this figure only accounts for individuals who have sought help from a hospital emergency department and not those who have self-managed or other received other forms of care (Cooke *et al.*, 2009).

When an injury is not managed effectively it can impact on joint structure and movement patterns, which in turn continually stress the injured ligaments (Wikstrom *et al.*,2013). An inhibited sensorimotor system could result in a "continuum of disability", including development of chronic ankle instability (CAI) (Wikstrom *et al.*, 2013). Recurrent ankle sprains, caused by lateral ankle instability are known as CAI (Hertel, 2002). CAI can result in pain, reduced function and decreased quality of life. Up to 70% of patients suffering ankle sprains report residual problems and recurrence of sprains (Konradsen and Voigt, 2002; Anandacoomarasamy, 2005). The financial and quality of life costs are therefore high.

In 85% of lateral ankle sprain (LAS) cases the injury occurs due to excessive inversion at a high velocity, predominantly in sports involving running on variable surfaces, repetitive jumping or frequent changes in direction (Kalirathinam *et al.*, 2016; DiStefano *et al.*, 2008; Gross P, 2009). LAS typically are caused by a combination of increased inversion and externally rotating the lower leg at foot strike (Hertel, 2002; Dubin *et al.*, 2011). To avoid injury during forced inversion, the peroneals (peroneus longus and peroneus brevis) contract, thereby causing a protective eversion of the foot. The tibialis anterior with adjacent musculature then eccentrically contract, decelerating the plantar flexion (Dubin *et al.*, 2011). If the mechanics of the joint are not working correctly then the individual is at risk of injury.

Research has shown that those individuals with a laterally deviated centre of pressure (COP) during either running or walking have an increased risk of LAS (Kobayashi *et al.*,). Assessing an individual's COP can be both time consuming and expensive, therefore the purpose of this study is to identify standard clinical measures which could be used to develop a quick and economical assessment tool to identify those with increased risk of LAS based on lateral COP. Prevention programmes could then be targeted at people with this identified biomechanical risk factor; with the aim of allowing these people to enjoy sport with a reduced risk of injury.

METHODS: Thirty-two healthy males were recruited from Loughborough University, Loughborough Rugby Football Club, Loughborough University physiotherapy department, Loughborough University Rugby club, and the surrounding area. All participants gave consent to participate in the study which was approved by Loughborough University Ethical Advisory Committee. Those included in the study were healthy males (identified using Loughborough University's standard health screen questionnaire), white European, aged 18-45 years, and able to run for 30 minutes (self-reported). Genetics was considered as a factor because it can influence an individual's risk of Osteoarthritis, for example; as we do not know the influence of genetics on LAS it has been controlled for (Felson *et al*, 2000). Excluded were individuals with medical conditions preventing participation in physical activity, heart conditions including medication-controlled blood pressure, or those who had a history of previous surgery or fracture requiring realignment to either lower limb.

Participants completed three questionnaires including a basic health questionnaire, the Cumberland Ankle Instability Tool (CAIT) (Hiller *et al*., 2006), and the Tegner Activity Scale (Tegner and Lysholm, 1985). Anthropometric measures were taken as listed below. Range of movement was measured using a hand-held goniometer by a single qualified physiotherapist with experience and specific training on the equipment to reduce risk of inter-observer error.

In this study the anthropometric variables were chosen that were identified as having a possible impact upon risk of LAS. Both high body mass index (BMI) and reduced ankle range of movement (ROM) have been seen to potentially increase an individual's risk of LAS and therefore were included as measures in the study (Willems *et al.*, 2005; Gribble et al, 2016).

Anthropometric measures that were taken were: Height (m), mass (kg), BMI (kg/m^2), ankle (ROM) (active and passive): dorsiflexion, plantarflexion, inversion, eversion, knee ROM (active and passive): internal and external rotation, bi-malleolar width, foot length, foot width, and calf circumference.

Each participant was fitted with pressure insoles Pedar (Novel gmbh) in their normal running shoes and ran on the treadmill (TechnoGym Excite Med) for 2 minutes at 11 km/h. The insole pressure system measures provided pressure distribution through participants feet including their COP. Prior to any data collection participants were introduced to the equipment and invited to practice. All running tests were recorded using a Basler high-speed digital camera (Balser AG, Ahrensburg, Germany) camera and data from the Novel system, the synchronised data was collected at 100Hz. Data was collected from the pressure insoles in 30 s durations and repeated 4 times. Each participant was requested to focus on running normally, to look ahead and to not talk whilst the data collection process was active.

Based upon the method of Morrison (2010), the COP was categorised as lateral or medial by splitting the foot in two using the width measure (for example, left foot 90/2 = 45mm). Adding up the medial data points and the lateral data points and subtracting them from each other, gave a value of any medial or lateral displacement of COP at that point (positive was medial: negative was lateral). The sum of the resultant differences gives an overall number which if positive defines a medial tendency or if negative would define lateral tendency. No previous study of this type has used an in-shoe pressure system therefore the method of analysis is different when compared to studies using force plates.

T-tests were carried out to identify which independent variables differed significantly between individuals with medial or lateral COPs. The variables that were identified as being significantly different between individuals with lateral or medial COP were then entered into a Binary Logistic regression.

RESULTS: Multiple Independent variables identified as being significantly different between medial or lateral COP individuals were: external rotation at knee both active and passive, question 8 from the CAIT ("Typically, when I start to roll over (or "twist") on my ankle, I can stop it – immediately/often/sometimes/never/I have never rolled over on my ankle")) and individual's height. When combined in a Binary logistic regression χ^2 (6, 32) =17.68, p<0.01. It was found that between 42.4% and 58.6% of the variance in the dependent variables could be explained by the model. Hosmer and Lemeshow's test (χ^2 (8,32) =12.093, p=0.147)) gave a percentage accuracy and classification of 84.4% meaning 84.4% of the time the prediction will be correct. Each independent variable was insufficient to predict risk on its own (table 1), though range of movement on passive external rotation at knee (ROM R Pass EXT) did approach statistical significance (p=0.067) as shown in Table 1.

Table 1. Significance and confidence intervals for Independent variables in model

	Mean (SD) Lateral COP	Mean (SD) Medial COP	Sig.	95% C.I.for EXP(B) Lower	Upper
Cumb control R	2.19 (0.93)	2.82 (0.41)	0.881	<0.001	<0.001
ROM R Act EXT	27.29 (8.96)	35.73 (8.21)	0.289	0.799	1.008
ROM R Pass EXT	31.10 (10.72)	43.18(10.20)	0.067	0.882	1.267
Height	181.11(6.72)	175.13(5.94)	0.548		

DISCUSSION: The independent variables used in the model provided a high level of accuracy when identifying individuals at risk of a lateral COP, despite the individual measures not being significant as identified in the binary logistic regression, though they had been statistically significant when compared using T-Tests. This model needs to be considered with caution when approximately two thirds of participants had a lateral distribution of pressure. Another point to highlight is that two of the variables included in the model concerned the knee range of movement and not the ankle, this could raise questions for further research as to whether we need to incorporate more joints when assessing injury risk of lateral ankle sprains. This is contradictory as to what was found in previous research (Willems *et al.*, 2005; Kobayashi *et al.*, 2015). It should be considered that height was an influential part of the model whereas previous research has identified BMI, though height is a component of BMI. (Willems *et al.*, 2005; Kobayashi *et al.*, 2015). There is potential that the BMI data has been swayed by the participants in the research as it was based on the local population of Loughborough which has a strong sporting background and therefore may influence the results.

CONCLUSION: This study has identified several independent variables that could be used as a model to identify individuals with a lateral COP, a risk factor LAS. Overall it was found that a model based upon the Cumerland Ankle Instability Tool, external rotation at the knee, and height, could predict an individuals COP distribution with an 84.4% accuracy.

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