09.30  Registration  
Eldon Bldg. Lobby

10.00  Welcome - Professor Joanna Wakefield-Scurr  
Eldon Bldg. Lecture Theatre

10.05  Exhibitors - Introduction  
10.05  Qualisys
10.10  Delsys
10.15  Biosense
10.20  Quintic
10.25  C-Motion

10.30  Podium Presentations – Morning Session  
(Chairs: Dr. Joseph O’Halloran & Michelle Norris)

10.30  Martin Warner (University of Southampton)  
Scapular kinematics during scapular plane humeral elevation in professional wheelchair tennis players

10.45  Elena Seminati (University of Bath)  
Upper body loading in rugby union tackling are affected by tackle direction and impact shoulder

11.00  Barbara Kalkman (Liverpool John Moores University)  
The relationship between medial gastrocnemius lengthening properties and spasticity in cerebral palsy

11.15  Patrick Carden (University of Exeter)  
Influence of rugby surface type and boot stud length on lower limb biomechanical variables associated with Achilles tendinopathy during rugby union specific movements

11.30  Matthias König (London Southbank/ German Sport University Cologne)  
The effect of habitual athletics training on muscle and tendon adaptation in young and older elite athletes

11.45  BASES Communication  
BASES Biomechanics and Motor Control Division Committee  
Adam Hawkey, Dr. Jenny Burbage, Dr. Sandy Wilmott & Dr. Dan Robbins

12.00  Lunch  
Spinnaker Sports Centre

12.45  Poster Presentations

14.00  Keynote Presentation  
(Chair: Professor Joanna Wakefield-Scurr)  
Dr. Neal Smith (Field Leader in Biomechanics - University of Chichester)  
Description or prescription; trying to ensure biomechanics does not try to reinvent the wheel

14.45  Break  
Eldon Bldg. Lobby

15.15  Podium Presentations – Afternoon Session  
(Chairs: Dr. Jenny Burbage & Dr. Tim Exell)

15.15  Mohsen Sayyah (Loughborough University)  
Adjustment in the flight phase of 1M springboard forward pike dives

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How consistently do prospective ACL risk factors classify individuals in different tasks?

16.00  Dario Cazzola (University of Bath)  
Cervical spine loading in misdirected rugby tackles: An integrated in-vitro and in-silico approach

16.15  Student Awards

16.30  Depart
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11.30 Matthias König (London Southbank/ German Sport University Cologne)
The effect of habitual athletics training on muscle and tendon adaptation in young and older elite athletes
INTRODUCTION
Participating in sports like wheelchair tennis increases the demands placed on the shoulder and could increase the risk of developing shoulder pain and injury. Shoulder pain, specifically shoulder impingement, is often associated with a decreased upward rotation, increased internal rotation and increased anterior tilt of the scapula during humeral elevation (Ludewig and Cook, 2000). What is not known is whether participation in wheelchair sport is associated with changes in scapular function. The aim of the study was to examine the presence of shoulder pain and scapular kinematics in professional wheelchair tennis players (WCP) and compare to a group of able-bodied participants with and without shoulder impingement.

METHODS
Eight male and three female professional WCP of average age 26.5±6.7 years were recruited into the study. The presence of shoulder pain within the WCP group was assessed using the Wheelchair Users Shoulder Disability Index (WUSPI) questionnaire and clinical examination, which included Neers, Hawkins Kennedy, Empty can, and painful-arc impingement tests.

Scapular kinematics were obtained using a cluster of retro-reflective markers attached to the acromion (Warner et al. 2012), which were captured using a 10 camera Vicon motion capture system during humeral elevation and lowering in the scapular plane.

Scapular kinematics of 16 able-bodied participants with shoulder impingement (2 out 4 positive tests for impingement) and 16 able-bodied participants without shoulder impingement were obtained through re-analysis of data previously published (Worsley et al., 2013). Data collection protocols were identical and carried out by the same investigator between the impingement, non-impingement and WCP participants.

A one-way ANOVA with Tukey pairwise comparison post-hoc test was used to compare scapular orientation at rest, 90° humeral elevation in the scapular plane and at rest following the lowering phase between groups.

RESULTS
There was an absence of positive signs for impingement in the WCP, with only one participant exhibiting a positive sign on the Hawkins-Kennedy test, and low self-reported pain (average WUSPI score of 28 ± 13.8).

The dominant and non-dominant scapulae of the WCP was significantly (p = 0.032 and p=0.02 respectively) more upwardly rotated by 7° than the participants with impingement. The non-dominant scapula was significantly more internally rotated (6°, p=0.038) and anteriorly tilted (10°, p=0.001) than the non-impingement group.

DISCUSSION
Despite the increased demands placed on the shoulder though sport participation there was an absence of shoulder pain and impingement signs in WCP. This may be attributable to the greater upward rotation observed in the dominant shoulder, which is thought to allow the acromion to lift away from the humeral head and avoid impingement. This difference in scapular kinematics may be a result of the functional requirements of wheelchair tennis and shoulder specific training regimes undertaken by the players.

CONCLUSION
The studied cohort of wheelchair tennis players exhibited an absence of shoulder pain, signs of impingement and exhibit alterations in scapular function. These results suggest sport participation and training may have protective benefits for the shoulder in wheelchair tennis athletes.

REFERENCES
Upper Body Loading in Rugby Union Tackling Are Affected by Tackle Direction and Impact Shoulder

Elena Seminati, Dario Cazzola, Grant Trewartha and Ezio Preatoni
Department for Health, University of Bath, Bath, UK
e-mail: e.seminati@bath.ac.uk

Introduction
Approximately 25% of Rugby Union injuries occur to players executing a tackle and they mostly involve upper-body regions. Tackles are typically unpredictable, and very difficult to analyse from a biomechanical perspective. We designed a novel tackle simulator to investigate tackling biomechanics in a more ecologically valid laboratory setup, and we measured upper-body loading under different tackling conditions.

Methods
In a repeated-measures study design 6 male Rugby Union players, all right-side dominant (26.7 ± 7.6 years; 1.82 ± 0.09; 95.7 ± 14.0 kg) performed full tackling trials against a bespoke tackle simulator (Fig. 1) starting from a 3-step run up. Participant executed tackles with dominant and non-dominant shoulder and from 3 different directions (frontal [0°], 45° and 90° to the travel direction of the tackle bag).

Figure 1: Example of experimental set-up during the 90° non-dominant shoulder tackle using the tackle simulator.

Four pressure sensors (VersaTek XL, Tekscan Inc, USA) were placed onto the punch bag and allowed the estimation of tackle impact forces (500 Hz). Participant and punch bag motion were captured at 250 Hz through a 16-camera motion capture system (Oqus, Qualisys, Sweden) with eight reflective markers on the punch bag and a 74-landmarks total-body marker-set (Seminati et al., 2016). An inertial measurement unit (IMU) (MTw, Xsens Technology B.V. NL) measured 3D accelerations and angular velocities (100 Hz) on the participant’s forehead. Linear mixed models and magnitude-based inferences were used to assess the effect of different tackling conditions on the selected biomechanical variables (Hopkins, 2010). Bag velocity at impact was included as a covariate.

Results
Dominant shoulder tackles in the frontal direction generated the highest impact forces, 5.3 ±1.0 kN (15% higher than non-dominant shoulder tackles). Impact load decreased going from frontal to diagonal (-3%) and lateral tackling (-10%). The lowest peak head accelerations (substantially lower [-5%] compared to frontal tackles) were recorded during diagonal tackles, with the dominant shoulder (9.1 ± 3.5 g). Resultant head angular velocity was substantially lower when tackling from 45° and 90° than from a frontal position and the lowest head angular velocities (13.5 ± 5.2 rad/s) were recorded when tackling with the non-dominant shoulder at 90°. Mean neck flexion angles at impact were substantially greater (by 20%) for non-dominant than for dominant shoulder in each of the three tackling directions evaluated. Also, the lowest neck flexion angles (-13 ± 7°) were recorded when players tackled from 45°, with the left shoulder.

Discussion
The results are in line with the outcomes obtained in previous studies on tackling without a run-up phase (Seminati et al., 2016): both laterality and tackle direction have a substantial effect on the loads applied to the upper-body of the tackler. Overall, a more ‘passive’ behaviour (i.e. lower peaks and longer breaking phase) during non-dominant shoulder tackles. From a kinematic perspective, players employed a more ‘head-up’ technique during dominant shoulder tackles, which is in line with BokSmart and RugbySafe guidelines. This evidence supports the technique suggested by the guidelines for safe and effective rugby techniques (i.e. BokSmart and RugbySafe), which recommend tackling at an angle between 15-45° to the running direction of the ball carrier. This approach can reduce the tackle impact force, while maintaining tackle effectiveness.

Conclusion
Where feasible, the tackler should control tackling technique as it may have important implications for injury prevention. Coaching should aim to reduce the deficiencies in tackling technique on the non-dominant side, including encouraging better head-neck control.

References
THE RELATIONSHIP BETWEEN MEDIAL GASTROCNEMIUS LENGHTENING PROPERTIES AND SPASTICITY IN CEREBRAL PALSY

Barbara M. Kalkman¹, Lynn Bar-On², Francesco Cenni², Constantinos N. Maganaris¹, Alfie Bass³, Gill Holmes³, Gabor J. Barton¹, Kaat Desloovere², Thomas D. O’Brien¹
¹Research Institute of Sport Exercise Sciences, Liverpool John Moores University, Liverpool, UK
²Department of rehabilitation Sciences, KU Leuven, Leuven, Belgium
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INTRODUCTION
Children with cerebral palsy (CPC) typically present with ankle joint hyper-resistance and a reduced range of motion (ROM). This clinical presentation can be underpinned by spasticity and/or an increased muscle stiffness and contracture. It was long thought that spasticity causes contractual in CPC, but recent studies suggest muscle stiffness to play a more detrimental role (Willerslev-Olsen et al., 2013). Furthermore, muscle and tendon properties seem to be altered such that measurements at the joint level do not adequately reflect muscle properties (Kalkman et al., 2016). Therefore, to better understand the differential contributions of stiffness and spasticity to joint hyper-resistance, we studied muscle and tendon properties during slow and fast stretches in CPC. We hypothesized that muscle properties modulate behaviour during stretch which triggers spasticity.

METHODS
Twelve CPC (age: 12±3y, 6 hemiplegic 6 diplegic) participated. Children lay prone with 20° knee flexion while their ankle was passively rotated through the full ROM, slowly and as fast as possible. Ultrasound, synchronized with 3D motion analysis and surface electromyography (EMG) was used to record muscle and tendon excursion and muscle activity of the medial gastrocnemius. The average root-mean-square (RMS) of the EMG data in fast stretches was calculated to represent EMG intensity. EMG<sub>slow</sub> was calculated as the increase in EMG-RMS during slow stretch. Stretch repetitions were categorised in 3 groups (Table 1) according to muscle behaviour. Maximal muscle lengthening relative to muscle-tendon-unit lengthening was determined during slow stretch. Angular velocity and muscle lengthening velocity were determined during fast stretch at the stretch reflex threshold (SRT), 30ms prior to EMG onset, and compared between groups using Kruskal Wallis and Mann Whitney U tests.

Table 1: Categorization of stretch repetitions.

<table>
<thead>
<tr>
<th>Stiff</th>
<th>Spastic</th>
<th>Stiff and spastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lengthening during slow stretch</td>
<td>M≤T</td>
<td>M &gt; T</td>
</tr>
<tr>
<td>EMG intensity during fast stretch</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

M: muscle, T: tendon

Figure 1: Angular and lengthening velocity at the stretch reflex threshold (SRT)

RESULTS
At the SRT, angular velocity did not differ between groups, but muscle lengthening velocity was significantly higher in muscles categorized only with spasticity (p=0.005). During slow stretch, we found a negative correlation between relative muscle lengthening and EMG<sub>slow</sub> (r=-.73)

DISCUSSION
Muscle lengthening velocity prior to EMG onset is higher in muscles with spasticity only than in muscles that are also stiff, and can differentiate between muscles, while angular velocity cannot. Stiff muscles, coupled with a relatively more extensible tendon, results in lower muscle lengthening velocities and may indicate possible adaptations that can minimize a spastic response. Interestingly the biggest group of children (n=6) showed both increased stiffness and spasticity. In this group, we saw an increase in the level of length dependent muscle activation with increasing levels of stiffness. Similar presence of a length, rather than velocity, dependent activation in neuromuscular disorders has been reported previously (Bar-On et al. 2014).

CONCLUSION
Treatment aiming to decrease ankle joint hyper-resistance should ideally be based on examination at the tissue, rather than joint, level and should account for the amount of spasticity and stiffness present.

REFERENCES
INTRODUCTION

Achilles tendinopathy poses a challenge to medical practitioners within Rugby Union, especially during the competitive season (Cook & Purdam, 2013). Reported biomechanical variables associated with an increased risk of developing Achilles tendinopathy include large magnitudes of rearfoot movement and tibial rotation (Lorimer and Hume, 2014). Changes in sports playing surfaces and footwear are also cited as a contributory risk factor (Knobloch et al, 2008).

Three playing surfaces are used in Rugby Union: natural turf (NAT), third generation artificial turf (3G) and more recently combination pitches comprised of natural turf augmented with artificial fibres (AUG). Players will often alter Rugby boot stud/cleat length in an attempt to mitigate the mechanical characteristics of the different playing surfaces.

AIMS: To determine if biomechanical risk factors for Achilles tendinopathy are influenced by playing surface and footwear when running and performing rugby-specific movements.

METHODS

Fourteen senior academy players from an Aviva Premiership Rugby Union team participated in the study (97.43 ± 6.80 kg, 1.83 ± 0.04 m, 20.87 ± 1.07 years). Participants were standardized footwear with a six forefoot and two heel stud configuration (Waitangi, Mizuno). Three-dimensional motion of the lower limbs was recorded using an active marker motion capture system (200 Hz, Coda, Charnwood Dynamics, UK).

Plantar pressure data were synchronously collected using pressure insoles (100 Hz, Pedar, Novel GmbH). Straight line running (RUN), ninety degree change of direction (90CoD) and 95 kg resisted sled pushing tasks were performed (PUSH, Figure 1), over three surface conditions (NAT, 3G and AUG) and three stud length conditions (13 mm, 16 mm and 21 mm length studs). Statistical comparisons of the left leg (change of direction leg) were made using a two-way (Surface x Stud Length) ANOVA with repeated measures (alpha = 0.05).

RESULTS

Figure 1. PUSH task.
THE EFFECT OF HABITUAL ATHLETICS TRAINING ON MUSCLE AND TENDON ADAPTATION IN YOUNG AND OLDER ELITE ATHLETES

König, M.1,2, Epro, G.1,2,3, McCrum, C.2,4, Bädorf, M.2, Schade, F.5 & Karamanidis, K.1

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INTRODUCTION
Muscles and tendons adapt in response to mechanical loading (Arampatzis et al., 2007). However, different time courses of muscle and tendon adaptation in response to training (Mersmann et al., 2016) may cause discordance within the muscle-tendon unit (MTU), increasing injury risk. We analysed the triceps surae (TS) muscle strength and Achilles tendon (AT) stiffness in young adult elite athletes over one season, in order to detect potential training-induced discordance between muscle and tendon adaptation. Following this, we examined the effect of habitual athletics training on young and older athletes’ TS MTU mechanical properties, using a cross-sectional design.

METHODS
Triceps surae muscle strength and AT stiffness of both legs were assessed during maximal isometric voluntary ankle plantarflexion contractions using dynamometry and ultrasonography in 11 healthy younger adult elite sprinters and jumpers (23±3y), 12 master sprinters (66±7y), 12 recreationally active young controls (26±3y), as well as one young adult elite athlete, 10 months after unilateral Achilles tendon reconstruction. In our longitudinal investigation, all young adult elite athletes (11 healthy, one AT reconstruction patient) underwent regular (every 2–4 weeks) MTU measurements over one season at their respective Olympic training centres using a custom-made mobile dynamometer (TEMULAB®, Protendornt, Aachen, Germany).

RESULTS
Healthy young elite athletes showed higher (p<.05) ankle joint moments (4.0±0.5Nm/kg) and AT stiffness (687.2±115.1N/mm) than both other groups and there were no differences in the parameters between master athletes and the young recreationally active controls (2.7±0.6Nm/kg and 574.2±93.2N/mm vs. 3.2±0.3Nm/kg and 557±70.2N/mm). Concerning our cross-sectional investigation over one year of athletics training, similar patterns of relative changes in TS muscle strength and AT stiffness were seen for both legs in the young elite athletes (coefficient of variation: 8.7±2.3% vs. 12.7±4.8%) over all analysed data points (on average, 16 per athlete). There were no observable increases in TS muscle strength or AT stiffness in the post tendon reconstruction athlete’s affected leg over one season, which showed remarkably lower strength, but similar stiffness, compared to the non-affected leg (average value over all analysed data points: 1.8±0.2Nm/kg and 503.7±90.7N/mm vs. 3.4±0.2Nm/kg and 496.8±33.1N/mm).

DISCUSSION
Our longitudinal investigation illustrates concordant muscle and tendon adaptation in response to athletics training within our analysed sample of healthy young elite athletes. The lower muscle strength and similar AT stiffness in the affected, compared to the non-affected leg after AT reconstruction remained unchanged over one season, despite intense athletics training, indicating that AT rupture and reconstruction may lead to irreversible discordance within TS MTU. Finally, habitual athletics training over the lifespan may effectively counteract the age-related deterioration of MTU mechanical properties.

CONCLUSION
The results suggest that habitual athletics training may not necessarily lead to discordant muscle and tendon adaptation within healthy young athletes and may help prevent the degeneration of the MTU mechanical properties seen with ageing. However, athletics training appears not to be capable of effectively counteracting the observable discordance within the MTU following AT reconstruction, indicating altered muscle-tendon interaction during functional motor tasks.

REFERENCES
Podium Presentations – Afternoon Session
(Chairs: Dr. Jenny Burbage & Dr. Tim Exell)

15.15  Mohsen Sayyah (Loughborough University)
       Adjustment in the flight phase of 1M springboard forward pike dives

15.30  Rob Leach (Loughborough University)
       Golfers alter their whole-swing biomechanics to achieve successful draw and fade shots with the driver

15.45  Raihana Sharir (Liverpool John Moores University)
       How consistently do prospective ACL risk factors classify individuals in different tasks?

16.00  Dario Cazzola (University of Bath)
       Cervical spine loading in misdirected rugby tackles: An integrated in-vitro and in-silico approach
INTRODUCTION
The variability in the diver’s joint angle changes may be viewed as an unwanted source of error which needs to be minimised to improve accuracy. On the other hand, a diver’s adjustment of body configuration during flight may be a deliberate compensation for variations in takeoff, leading to increased joint angle variability and decreased entry angle variability. Since the time of the flight phase in forward pike dives (Figure 1) is over 1 s, feedback control could be used in flight. However, there is currently no evidence for what kind of control (feedforward or feedback) is used. The purpose of this study is to investigate the extent to which configuration changes during the flight phase control the outcome in 1m springboard forward pike dives.

METHODS
Movement variability of 15 forward pike dives, performed by a male international springboard diver (mass = 69.7 kg, height = 1.79 m), was determined using video analysis (frame rate 250 Hz, exposure time 4 ms, resolution 1280 x 1024 pixels). An 11-segment computer simulation model (Yeadon et al., 1990) was used to perform two analyses to investigate the effect of variability in the initial conditions at takeoff and in the joint angle time histories during flight on entry angle variability. In the first case, the variability in the entry angle arising from the variability of initial conditions was determined. In the second case, the variability in entry angle arising from the joint angle changes during the flight phase was investigated.

RESULTS
The standard deviations of orientation and joint angles at takeoff and entry were small showing that the diver was consistent from trial to trial (Table 1). The hip angle showed large variation in the last half of the flight between 0.6 s and 1.2 s (Figure 2). The peak variation in orientation angle appeared in the middle of the flight phase, at around 0.6 s. This suggests that adjustments are made in flight from dive to dive by changing hip movements.

Table 1: The mean and standard deviation of angles and flight time

<table>
<thead>
<tr>
<th>Variable</th>
<th>Takeoff</th>
<th>Entry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip (º)</td>
<td>163 (2.7)</td>
<td>180 (3.6)</td>
</tr>
<tr>
<td>Knee (º)</td>
<td>177 (1.1)</td>
<td>180 (0.6)</td>
</tr>
<tr>
<td>Arm (º)</td>
<td>179 (4.5)</td>
<td>165 (2.5)</td>
</tr>
<tr>
<td>Orientation (º)</td>
<td>12 (0.9)</td>
<td>165 (1.8)</td>
</tr>
<tr>
<td>Flight time (ms)</td>
<td>1349 (13.5)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Variability of time histories of orientation (black curve) and hip (grey curve) angles of 15 forward pike dives.

The variation in the simulated orientation angle at entry arising from variation in the flight time and angular momentum was 9.4º (case 1) and arising from variation in the joint angle time histories was 8.0º (case 2) (Figure 1). On the other hand, variability in orientation angle at entry in the recorded performances was 1.8º. This indicates that the diver has made adjustments because the recorded variability is much smaller than the average variation obtained from the simulation outcomes.

DISCUSSION
Larger variation in simulation outcome demonstrates that the diver must have used feedback control during the flight phase to compensate for variation arising from takeoff conditions to minimise the entry variability.

CONCLUSION
It is concluded that the diver varied his hip angle to reduce the variability of the entry angle. This demonstrates that variability can have a functional role in human movement. This suggests that it may be beneficial for coaches to be aware of such adjustments.

REFERENCES
Golfers Alter their Whole-Swing Biomechanics to Achieve Successful Draw and Fade Shots with the Driver

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INTRODUCTION
Golf is a hitting sport requiring a range of shot types. Golfers who utilise trajectories, such as draws (right-to-left sidespin) and fades (left-to-right sidespin), have a course management advantage. Although investigated in other sports (Elliott and Marsh, 1989; Sheets et al., 2011) different trajectories have not been the focus in golf biomechanics. The aim of this study was to investigate differences in swing biomechanics between successful draw and fade shots.

METHODS
Seven elite male golfers struck 10 draws, 10 fades and 10 neutral shots using a driver to a target line projected onto a hitting net. A full-body 66 marker-set was tracked using VICON. For each golfer, the five draw and five fade shots with the most pronounced sidespin (based on optical 3D tracking) that were also predicted to land on the fairway (trajectory model) were analysed. Several biomechanical variables relating to address and the whole swing, identified from coaching theory, were calculated using Visual3D.

Address variables between shot types were compared using repeated measures ANOVA. For the whole-swing, principal component (PC) analysis was conducted on the time normalised data for all shot types, giving PCs that explained over 90% of the variance in each variable. PCs were interpreted biomechanically and for each golfer, fade and draw PC scores were expressed relative to their neutral shot score. To compare the change in golfers’ swings between fade and draw shots, the difference between the draw and fade PC scores for all variables were compared using multivariate regression for each golfer pair.

RESULTS
The draw–fade PC score differences for golfers 3, 4, 5 and 7 showed the strongest correlations with each other (Fig. 1).

<table>
<thead>
<tr>
<th>Golfer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>0.43</td>
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<tr>
<td>3</td>
<td>0.37</td>
<td>0.68</td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>0.20</td>
<td>0.19</td>
<td>0.73</td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>0.49</td>
<td>0.54</td>
<td>0.74</td>
<td>0.53</td>
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</tr>
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<td>6</td>
<td>0.24</td>
<td>0.58</td>
<td>0.40</td>
<td>0.10</td>
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</tr>
<tr>
<td>7</td>
<td>0.32</td>
<td>0.57</td>
<td>0.94</td>
<td>0.76</td>
<td>0.74</td>
<td>0.31</td>
</tr>
</tbody>
</table>

At address, golfers aligned pelvis axial rotation and the vector joining foot centres to the right of target for draw and left of target for fade shots. Over the swing there were offsets in pelvis rotation (PC1; Fig. 2), lumbar lateral flexion and pelvis translation along the target line between draws and fades. Magnitude, timing and rate of change differences occurred in pelvis rotation (PC2; Fig. 2), thorax lateral flexion (PC1-3; Fig. 2), pelvis translation and centre of pressure translation.

DISCUSSION
Address position appeared important in setting up biomechanical offsets between fade and draw shots that were subsequently maintained throughout the swing. However, there were also more subtle biomechanical differences during the swing, which may be why many golfers struggle to achieve fade or draw trajectories consistently and successfully. Furthermore, the biomechanical differences during the swing tended to focus on the larger, more proximal segments, i.e. the pelvis, lumbar and thorax.

CONCLUSION
Golfers alter address position and whole-swing biomechanics to successfully achieve driver draw and fade trajectories. The whole swing differences focused on central body segments. These findings have implications for the coaching of specific shot trajectories.

REFERENCES
INTRODUCTION

Many studies often translate biomechanical risk factors to different protocols and populations (Sharir et al., 2016). However, these risk factors have only been found to predict ACL injury when they are calculated within the specific experimental protocol and sample. For screening to effectively separate individuals at risk, risk factors should rank individuals consistently across tasks. These task invariant risk factors would then form an individual’s “ACL movement passport”. This study aims to determine if any previously established prospective ACL risk factors rank individuals consistently across bilateral drop vertical jump (BDVJ), single-leg hop (SLHOP), single-leg drop vertical jump (SLDVJ) and sidestep (SS) tasks.

METHODS

In a controlled laboratory study, forty-one female athletes regularly participating in dynamic sports (age, 22.2 ± 3.8 years; height, 163.9 ± 7.5 cm; mass, 64.0 ± 10.2 kg) completed five trials of each dynamic task. Each task was performed on dominant legs. Knee biomechanics of the BDVJ, SLHOP, SLDVJ and SS were captured using ten high-speed 3-dimensional motion analysis and two force platforms. Each participant had 44 spherical reflective markers positioned as per the LJMU-model (Vanrenterghem et al., 2010). Knee abduction angle (KAA) and knee flexion angle (KFA) at initial contact, peak knee abduction moment (KAM), peak vertical ground reaction force (VGRF) and knee medial displacement (MD) were extracted then correlated in pairs using a Spearman’s correlation.

RESULTS

Moderate to good correlations were observed for KAA (ρ=0.55–0.85) while other variables had poor to moderate correlations (ρ < 0.34). There were moderate and high correlations between the SLDVJ vs SLHOP across the risk factors (Table 1). Risk factors were noticeably different across tasks especially between a single-leg and bilateral task.

<table>
<thead>
<tr>
<th>Correlation Coefficient</th>
<th>P value</th>
<th>Coefficient</th>
<th>P value</th>
<th>Coefficient</th>
<th>P value</th>
<th>Coefficient</th>
<th>P value</th>
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</thead>
<tbody>
<tr>
<td>BDVJ - Correlation</td>
<td>0.64**</td>
<td>0.67**</td>
<td>0.28</td>
<td>0.26</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SLDVJ</td>
<td>0.00</td>
<td>0.00</td>
<td>0.08</td>
<td>0.11</td>
<td>0.06</td>
<td></td>
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<tr>
<td>BDVJ - Correlation</td>
<td>0.55**</td>
<td>0.63**</td>
<td>0.34*</td>
<td>0.29</td>
<td>0.30</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SLHOP</td>
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<td>0.00</td>
<td>0.03</td>
<td>0.07</td>
<td>0.06</td>
<td></td>
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</tr>
<tr>
<td>BDVJ - Correlation</td>
<td>0.58**</td>
<td>0.39</td>
<td>0.01</td>
<td>0.21</td>
<td>0.10</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>0.00</td>
<td>0.01</td>
<td>0.95</td>
<td>0.19</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SLDVJ - Correlation</td>
<td>0.85**</td>
<td>0.65**</td>
<td>0.68**</td>
<td>0.41**</td>
<td>0.58**</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SLHOP</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.01</td>
<td>0.00</td>
<td></td>
<td></td>
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<tr>
<td>SLDVJ - Correlation</td>
<td>0.72**</td>
<td>0.58**</td>
<td>0.16</td>
<td>0.10</td>
<td>0.02</td>
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<tr>
<td>SS</td>
<td>0.00</td>
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<td>0.54</td>
<td>0.89</td>
<td></td>
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<tr>
<td>SLHOP - Correlation</td>
<td>0.66**</td>
<td>0.48**</td>
<td>0.25</td>
<td>0.25</td>
<td>-0.07</td>
<td></td>
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<tr>
<td>SS</td>
<td>0.00</td>
<td>0.00</td>
<td>0.11</td>
<td>0.12</td>
<td>0.67</td>
<td></td>
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</table>

DISCUSSION

The inconsistency in ranking between tasks suggests individuals’ have different biomechanical strategies for different tasks. Therefore, no generic landing pattern was consistent across the tasks. As KAA had the highest rank correlations, it provides the best information for an ACL movement passport but more exploration is needed regarding the sensitivity of this variable. KAA at initial contact only describes the frontal plane of the knee but not how the posture changes in response to load or after contact. The variability of the data likely influences the ranking of participants as more consistent ranking were seen when the data was widely spread and vice versa. The result also revealed that one variable is unlikely to provide sufficient information to identify high-risk athletes across tasks.

CONCLUSION

KAA provides a moderate to good correlation across tasks, which provides the best information for an individual’s ACL movement passport. Further exploration of other variables may lead to a more consistent classification of at risk behaviours.

REFERENCES

CERVICAL SPINE LOADING IN MISDIRECTED RUGBY TACKLES: AN INTEGRATED IN-VITRO AND IN-SILICO APPROACH

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INTRODUCTION
The mechanisms of cervical spine injury in rugby have been investigated through different methodologies, but none of them alone can fully describe the possible associations between external loads applied to the head and the internal stresses at vertebral level.

We present a combined in-vitro and in-silico approach to simulate a misdirected rugby tackle and to study the influence of head and neck position on the load acting on cervical spine.

METHODS
An anthropometric test device (ATD) (Hybrid III, Humanetics, Germany) was used to replicate the head and neck of the tackling player. The ATD was instrumented with a six-axis upper neck load cell (at C1 joint level) and was attached to a rigid frame to replicate three different neck positions (Figure 1): neutral (0°), head-down (−22°), and head-up (+22°). Simulated tackles were generated using a 40-kg punch bag making contact against the ATD at 2 different speed ranges (low: 2.0-2.5 m/s) and (high: 3.1-3.6 m/s).

Ten repetitions were recorded for each speed condition and ATD orientation, 60 trials in total. Kinematics of the head/neck system was captured through a 16-camera motion capture system (Oqus, Qualisys, Sweden) at 250 Hz, whilst force and torque data were sampled at 500 Hz. Kinematics and external load data were used as input for inverse simulations in OpenSim 3.3. The OpenSim RugbyModel (https://simtk.org/projects/csi_bath) was scaled, and a pipeline including inverse kinematics, inverse dynamics, and joint reaction analysis was run to estimate the joint reaction forces at intervertebral joint level. Mean values of forces and moments were calculated from 10 trials in each condition. ANCOVA (covariate = bag speed) and effect sizes were used to assess the effect of head position on the loads applied to the neck.

RESULTS
ATD measurements showed that low speed tackles generated 37% lower peak impact forces (1.61 ± 0.29 kN) than high-speed tackles (2.61 ± 0.09 kN). Peak flexion/extension external moments measured during high-speed impacts were 54.5 ± 5.7 and 45.3 ± 4.4 Nm respectively for head-down and head-up positions, with values close to the pain thresholds reported in the literature (60 and 45 Nm for flexion and extension) [1]. The compression force was substantially higher in head-down than in neutral (by 13%) and head-up orientations (by 17%). Computer simulations showed that the cervical spine vertebrae underwent high compressive forces at all levels (> 300 N). However, anterior shear forces and flex/extension moments at C2/C3 level reached the maximal absolute values in the head-down condition (Figure 1).

DISCUSSION
The combination of high compressive forces and extension flexion moments at C2/C3 seems coherent with the hypothesis of buckling as the potential injury mechanism during head-first impacts in tackles. High repetitive stresses at this cervical spine level can cause the development of chronic degeneration pathologies as observed in asymptomatic Rugby Union players [2].

CONCLUSION
Our findings support the idea that: 1) an integrated in vivo and in silico analysis of simulated head-first impacts provides insight into how misdirected loads applied to head/neck structures distribute at the level of the individual vertebrae; and, 2) a neutral or head-up position may be preferred in the scenario of unintentional head-first impacts in rugby tackles. The ‘Head-up’ technique aligns with current Rugby Union coaching recommendations.

REFERENCES
List of Poster Presentations

1. Jasper Verhuel (Liverpool John Moores)
   Training load monitoring in football: Can trunk accelerations predict ground reaction forces using a mass-spring-damper model?

2. Olivia Brown (Nottingham Trent University)
   Does the method used to locate force platform centre of pressure affect biomechanical measures obtained during stair walking on an instrumented staircase?

3. Gareth Shadwell (University of Central Lancashire)
   Effects of medial and lateral orthoses on Achilles tendon kinetics during running

4. Hannah Wyatt (Cardiff Metropolitan University)
   Growth type influence on injury risk indicators in female gymnasts

5. Rachel Jones (University of Nottingham)
   The effect of Kinesio tape on the latency of the peroneus longus muscle after a sudden ankle inversion perturbation

6. Derryn Jones (Quintic)
   A comparison of amateur rugby union scrummaging in a live scrum and using a scrummaging machine

7. Gaspar Epro (London Southbank University/German Sport University Cologne)
   Achilles tendon is mechanosensitive in old adults: A 1.5-year resistance training intervention

8. Gaspar Epro (London Southbank University/German Sport University Cologne)
   Effect of triceps surae muscle-tendon unit mechanical properties on gait stability and adaptability in older female adults

9. Riyadh Al-Saeed (Loughborough University)
   Hip and knee joint loading during reverse roundhouse (hook) karate kicks performed in training and competition modes

10. Andrew Mitchell (University of Bedfordshire)
    The effect of athletic footwear on muscle reaction time to a simulated lateral ankle sprain mechanism

11. Matthias König (London Southbank University/German Sport University Cologne)
    Age-related differences in drop jump performance are eliminated by matching triceps surae muscle strength and Achilles tendon stiffness

12. Nicholas Thomas (University of Liverpool)
    The biomechanics of walking over complex surfaces: Characteristics of young and old

13. Thijs Ackermans (Liverpool John Moores University)
    Step rise inconsistency may go undetected when ascending stairs: Implications for stair safety

14. Alan Breen (Bournemouth University)
    Intervertebral motion sharing in the lumbar spine and chronic back pain

15. Sara Aspinall (Loughborough University)
    Is the Hudl Ubersense App a suitable replacement instrument for the universal goniometer in measuring knee flexion range of movement?

16. Andy Roberts (Defence Medical Rehabilitation Centre/University of Exeter)
    Plantar pressure in chronic exertional compartment syndrome: A case-control study
TRAINING LOAD MONITORING IN FOOTBALL: CAN TRUNK ACCELERATIONS PREDICT GROUND REACTION FORCES USING A MASS-SPRING-DAMPER MODEL?

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INTRODUCTION

Body-worn sensors measuring GPS and accelerations are frequently used to assess the physiological loading of players (Akenhead et al., 2016). The ability of these sensors to monitor whole-body mechanical stresses such as ground reaction forces (GRF) has been explored less. Recent work has shown that a simple mass-spring-damper model is capable of reproducing GRF curves for constant speed running (Nedergaard, 2017) and a wide variety of football specific tasks (Verheul et al., 2017). This study investigated 1) if this model can use trunk accelerations (TA) alone to predict GRF, 2) the model was able to simulate TA and accurately replicate a given GRF at the same time.

METHODS

A two mass-spring-damper model (Fig. 1) was used to simulate measured TA and predict GRF for 15 team sports athletes who performed football specific running tasks including accelerations, decelerations, and steady running. TA data were collected at 100 Hz using a Catapult GPS unit worn on the upper trunk. Gold standard GRF data were collected at 3000 Hz with a force platform. For each individual step, an optimal combination of eight model parameters was determined to simulate the measured TA and calculate a modelled GRF. The optimal model parameters were selected based on either 1) the lowest value for the mean squared error (MSE) of the model’s upper mass acceleration relative to the measured TA curve, or 2) an equally weighted optimum of the lowest MSE for the upper mass acceleration and modelled GRF relative to the measured TA and GRF profiles respectively.

RESULTS

When using TA as the sole input to the model, MSE for simulated TA signals were low (<0.5 G) for accelerations and moderate (<1 G) for decelerations and steady running, but very high (>5 N/kg) for modelled GRF curves across tasks. Since TA alone did not lead to good GRF estimates, GRF error was included in the error metric which caused MSE for TA and GRF to significantly (p<0.001) increase and decrease respectively. When using both TA and GRF as model input, MSE was moderate to high (0.5-1.5 G) for TA and moderate (<3 N/kg) to very high for GRF across tasks.

Table 1: MSE of simulated TA and modelled GRF curves for different tasks. *Significantly different from when only MSE for TA was considered, p<0.001.

<table>
<thead>
<tr>
<th>Included error metrics</th>
<th>TA</th>
<th>TA and GRF</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSE simulated TA (G)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerations</td>
<td>0.56</td>
<td>0.64*</td>
</tr>
<tr>
<td>Decelerations</td>
<td>0.91</td>
<td>1.22*</td>
</tr>
<tr>
<td>Steady running</td>
<td>0.48</td>
<td>0.82*</td>
</tr>
<tr>
<td>All tasks</td>
<td>0.62</td>
<td>0.90*</td>
</tr>
<tr>
<td>MSE modelled GRF (N/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerations</td>
<td>7.85</td>
<td>2.35*</td>
</tr>
<tr>
<td>Decelerations</td>
<td>13.64</td>
<td>5.22*</td>
</tr>
<tr>
<td>Steady running</td>
<td>8.44</td>
<td>1.94*</td>
</tr>
<tr>
<td>All tasks</td>
<td>9.77</td>
<td>2.95*</td>
</tr>
</tbody>
</table>

DISCUSSION

Although the model could simulate TA well on its own, GRF estimations were poor. Moreover, there were no model parameter combinations that precisely replicated TA and GRF at the same time. Since previous work (Verheul et al., 2017) has shown that the model can reproduce GRF for these tasks, the poor GRF results are likely due to the measured TA not representing the model’s upper mass acceleration that is required to get an accurate estimation of GRF.

CONCLUSION

Since this study shows that a two mass-spring-damper model cannot be used to predict GRF from TA, future studies should focus on other methods to estimate GRF from body-worn sensor data.

REFERENCES

DOES THE METHOD USED TO LOCATE FORCE PLATFORM CENTRE OF PRESSURE AFFECT BIOMECHANICAL MEASURES OBTAINED DURING STAIR WALKING ON AN INSTRUMENTED STAIRCASE?

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INTRODUCTION
Biomechanical analysis of stair climbing using instrumented staircases is relatively commonplace (Andriacchi et al. 2008), although space restrictions often necessitate a portable staircase design. These designs vary in force plate (FP) accommodation, being either solid boxes sitting on top of floor embedded FPs, integrated force transducers within the steps or portable FPs within the staircase structure. In such design, FPs may also be partially obscured by subsequent steps. Therefore, accurate location of FP position and resulting centre of pressure (COP) within the lab coordinate system is important to avoid errors in subsequent analyses. The aim of the current study was to compare two kinematic methods of determining instrumented staircase FP location to a widely accepted location determination method.

METHOD
Initially, spatial location of the force plates was determined using a Cal-Tester instrument (Model MTD-3, Motion-Lab Inc. Germantown, MD) (Holden et al. 2002) with the subsequent FP corner locations generated (x, y, z) being used as a reference. Corner locations were also collected using two alternative kinematic methods, namely Method A (9 mm markers at circles and triangle locations; Figure 1) and Method B (Markers at triangles only opposing corners generated using FP dimensions; Figure 1).

One healthy participant, completed one stair ascent/descent trial at a self-selected speed with markers attached to the lower limbs and torso (Leardini et al. 2007).

RESULTS
The location of the centre of the force plate was more comparable to that generated from the Cal-Tester rod when using Method B than Method A. The root mean square (RMS) difference of COP location over the dynamic trial was larger in Method B for FFP but larger in the Method A for SFP2. Future analysis will determine the effects of different COP location method on estimations of joint kinetic measures such as joint moments and powers.

DISCUSSION
This small difference in RMS, between 0.01 to 1.33, in COP location is in agreement with literature (Croce & Bonato 2007; Whatling et al. 2010) which has found to translate to very small differences in joint kinetics.

CONCLUSION
Identifying FP COP locations in instrumented staircases using the front edge corners and known FP dimensions results in negligible differences in COP location and subsequent joint kinetics. This may be preferable where practically preferable.

REFERENCES

Figure 1: Schematic of the portable staircase.

FFP - Floor Force plate (Model OR6-7-200, AMTI, Advanced Mechanical Technology Inc. USA), SFP1 - Stair Force plate 1 (Model 9286B, Kistler, Winterthur, Switzerland), SFP2 - Stair Force Plate 2 (Model 9260AA3 Kistler, Winterthur, Switzerland).
EFFECTS OF MEDIAL AND LATERAL ORTHOSES ON ACHILLES TENDON KINETICS DURING RUNNING.

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Email: GShadwell3@uclan.ac.uk & JKSinclair@uclan.ac.uk

INTRODUCTION
The Achilles Tendon (AT) is the strongest and thickest tendon in the human body and is subjected to the highest repetitive loads of any tendon within the body (O’Brien., 2005). Achilles tendinopathy represents 9.5% of all cases (Le Bocq et al., 2016). Using appropriate and well-fitting orthoses has been shown to improve walking and running function during activities in daily lives (Le Bocq et al., 2016). The aim of the current investigation was to determine the effects of medial and lateral foot orthoses on AT kinematics.

METHODS
Twelve male runners (age 26.23 ± 5.76 years, height 1.79 ± 0.11 cm and body mass 73.22 ± 6.87 kg). Commercially available orthotics (Slimflex Simple, High Density, Full Length, Algeos UK). Participants ran at 4.0 m/s (±5%), striking an embedded piezoelectric force platform (Kistler, Kistler Instruments Ltd., Alton, Hampshire). Kinematic data was captured at 250 Hz via an eight camera motion analysis system (Qualisys Medical AB, Goteburg, Sweden). Achilles tendon kinetics were quantified via a bespoke musculoskeletal model allowing max AT load, AT load rate and AT impulse to be extracted for further analysis. Differences in Achilles Tendon Force (ATF) parameters between orthoses were examined using one-way repeated measures ANOVAs.

RESULTS
A main effect (P<0.05, $\eta^2 = 0.33$) was shown for the peak ATF. Post-hoc comparisons showed that peak ATF was significantly lower in the medial orthosis in relation to the lateral and no-orthotic condition. A main effect (P<0.05, $\eta^2 = 0.31$) was observed for ATF load rate. Post-hoc pairwise comparisons showed that ATF load rate was significantly lower in the medial orthosis in relation to the lateral and no-orthotic condition.

DISCUSSION
Medial orthosis produced significantly lower ATF load rate and peak ATF. Findings from this investigation support the propositions of Lorimer., (2014) and Donoghue et al., (2008) who proposed that a high medial foot arch can contribute to the reduction of loads experienced by the AT during running and that orthoses can reduce the symptoms of chronic injuries of the AT as a result of cyclical loading. Excessive loading of the AT is considered to be a key mechanism linked to the aetiology of AT pathologies in runners (Maffulli et al., 1987) as decomposition of the collagen fibres that comprise the structure of the AT exceeds fibre synthesis. Medial orthoses when compared to lateral and no orthoses, reduce the kinetic parameters linked with the aetiology of AT pathologies. It can be speculated that medial orthoses may be able to attenuate the risk of development of AT pathologies in runners, although further prospective work is required to fully establish this.

CONCLUSION
The current study showed firstly that AT kinetics are significantly affected by the orientation of the orthoses used; with lateral orthoses presenting significantly increased max AT load, AT load rate and AT impulse. Indicating that whilst lateral orthoses are important in reducing the forces experienced by the medial aspect of the tibiofemoral joint they may correspondingly increase the risk from Achilles tendinopathies.

REFERENCES

Figure 1: ATF parameters as a function of different orthoses
(Dash = Medial, Black = Lateral & Grey = No Orthoses). orthotic condition.
INTRODUCTION
Gymnastics-based studies have commonly considered the pelvis:shoulder breadth ratio as a measure of growth (e.g. Thomas et al., 2013). The respective growth ratio can occur in two forms, the pelvic breadth can develop at an increased rate to the shoulder breadth (pelvis type) or shoulder growth may occur at an increased rate to pelvic breadth (shoulder type). As a population with high chronic spinal injury susceptibility, growth has been established as a risk factor in female gymnasts (Kerssemakers et al., 2009). The influence of the pelvis:shoulder breadth ratio measure on chronic spinal injury risk is yet to be explored but may be important to consider within musculoskeletal screening protocols. Screening is typically conducted at discrete points in type, however, growth is a dynamic process. Consideration of a discrete measure to characterise growth type may enable indication of longitudinal growth through cross-sectional screening practice. The aim of the study was to appraise the influence of growth type on biomechanical indicators of chronic spinal injury and to examine the use of a discrete measure as indication of growth type.

METHODS
At initial collection, twelve gymnasts (n=12) ranged from 9 to 15 years of age (11.6 ± 2.0 years). Collections for the cohort were repeated at 8.0 ± 1.3 month and 12.0 ± 0.5 month intervals. Due to availability, data were acquired for one gymnast at initial and final collections only. Ethical approval was gained from Cardiff Metropolitan University. An image-based inertia approach enabled calculations of growth (pelvis:shoulder breadth ratio) and body segment inertial parameter measures (BSIP). As biomechanical risk indicators, posture, general stability and lumbo-pelvic stability were determined through the performance of handstands (n=20) using synchronised CODA motion capture and Kistler force plates. Three gymnasts were identified in the shoulder group, whereas in the pelvis group, n=9. A Mann-Whitney U test between groups was undertaken for each handstand measure. A linear regression analysis informed the influence of ten BSIP measures on growth rate.

RESULTS
Longitudinal empirical data (Table 1) revealed the pelvis group gymnasts to have significantly greater posture and lumbo-pelvic stability risk (p<0.05), while shoulder group gymnasts had significantly greater general stability risk in the handstand skill (p<0.05). A linear regression analysis identified torso Iₐ rate of change to have a large, significant effect on rate of growth (r=0.74, p=0.01). Appraisal of discrete torso Iₐ provided indication that the gymnasts in the shoulder group had greater median torso Iₐ than the remainder of the cohort (0.69 kg.m² and 0.27 kg.m², respectively).

Table 1: Descriptive mean (SD) biomechanical data for pelvis and shoulder sub-groups and statistical significance outputs for between sub-groups differences.

<table>
<thead>
<tr>
<th>Posture (º)</th>
<th>Shoulder group</th>
<th>Mean (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>0.7</td>
<td>(4.7)</td>
<td>0.00*</td>
</tr>
<tr>
<td>Pelvis</td>
<td>3.83</td>
<td>(6.14)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General stability</th>
<th>Shoulder group</th>
<th>Mean (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>29.58</td>
<td>(15.87)</td>
<td>0.00*</td>
</tr>
<tr>
<td>Pelvis</td>
<td>21.41</td>
<td>(20.71)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lumbo-pelvic stability</th>
<th>Shoulder group</th>
<th>Mean (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>8.86</td>
<td>(4.64)</td>
<td>0.00*</td>
</tr>
<tr>
<td>Pelvis</td>
<td>13.75</td>
<td>(7.82)</td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION
Continual adjustments to hand balance coping strategies, as a result of the close proximity with the base of support, may provide an explanation for the increased general stability risk in the shoulder group. Greater localised risk (posture and lumbo-pelvic stability) was identified for the gymnasts in the pelvic group, suggesting the fluctuating mechanics to compensate for increased pelvic growth. The respective data is anticipated to enable practitioners to establish biomechanical risk indicators of focus in accordance with the growth type experienced. Evaluation of torso Iₐ at a discrete time point provided preliminary support for the cross-sectional use of the inertial measure to forecast longitudinal growth trends.

CONCLUSION
Consideration of growth type through pelvis:shoulder breadth ratio in longitudinal gymnastics screening programmes and torso Iₐ in cross-sectional screening is advocated.

REFERENCES

THE EFFECT OF KINESIO TAPE ON THE LATENCY OF THE PERONEUS LONGUS MUSCLE AFTER A SUDDEN ANKLE INVERSION PERTURBATION

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INTRODUCTION
Ankle inversion injuries constitute 25% of all injuries to the musculoskeletal system (Van den Bekerom et al., 2013). The literature suggests that dynamic constraints provided by the peroneal muscles are most essential in maintaining joint stability and that failure to adequately activate these muscles can result in injury (Palmieri-Smith et al., 2009). The distinctive elastic properties of Kinesio tape (KT) claim to facilitate muscle activity in the face of tissue deformation, thereby limiting excessive joint movements and preventing injury (Hertel, 2008; Juchler et al., 2014). The breadth of substantiating literature, however, is minimal and research analysing the effect of KT on uninjured ankles has yet to be investigated.

AIM
To investigate the effects of Kinesio tape on the latency of the peroneus longus muscle after a sudden ankle inversion perturbation in healthy participants with uninjured ankles.

METHODS
Ethical approval was granted from the University of Nottingham Medical School Ethics Committee. Prior to testing, all participants were screened against the inclusion and exclusion criteria and provided written informed consent to take part in the study. Eleven subjects participated; five males (age 20.6 ± 1.2yrs; height 179.5 ± 7.4cm; mass 83.5 ± 10.4kg) and six females (age 20. ± 2.3yrs; height 162.8 ± 5.2cm; mass 63.3 ± 7.4kg). Each participant was tested under the KT and control conditions in a randomised order and an average value for peroneus longus latency (PLL) was calculated as a mean of 3 separate 30° inversion perturbations. In accordance with the Clinical Therapeutic Applications of the Kinesio Taping Method, the ‘Y’ technique was used due to its proposed ability to facilitate cutaneous mechanoreceptors (Wallis et al., 2003). Electromyographic (EMG) activity was sampled at 1500 Hz from the peroneus longus (PL) muscle of the tested ankle, with a signal bandwidth of 10-500 Hz. Surface electrodes were used in accordance to the sensor locations recommended for the PL following SENIAM guidelines. A CODA active marker conveying data corresponding to the timing of the perturbation was quantified against EMG recordings to indicate PLL.

RESULTS
Mean values indicated a reduced PLL for participants in the KT condition (0.083s) when compared to the control (0.098s); constituting an overall difference of 0.15s. A Paired Samples T-Test identified a statistically significant difference in these values with p=0.012 in favour of KT.

DISCUSSION
A statistically significant difference between the mean values for PLL suggest that the application of KT reduces PLL. This is in support of research by Ferreira et al. (2011) who similarly found that PLL decreased with the application of KT when compared with elastic adhesive tape or without taping. The results, however, can only be considered relevant statistically and consequently, the role of KT with respect to the prevention of inversion injuries is unsubstantiated.

CONCLUSION
In a population sample with stable, uninjured ankles, PLL was reduced with the application of KT when compared to a control. It is unknown whether this difference would equate to a reduction in ankle inversion injuries and therefore further evidence establishing a clinical relevance for KT would be required to illicit a clinical change.

REFERENCES
A COMPARISON OF AMATEUR RUGBY UNION SCRUMMAGING IN A LIVE SCRUM AND USING A SCRUMMAGING MACHINE

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INTRODUCTION
The scrum was initially designed as a means of restarting play after a stoppage or minor breach of rules. With approximately 25 scrums per game it has become a skill where dominance can result in performance advantages (Quarrie et al., 2013). This requires a large forward force, long associated with a “low body position”; a flat back parallel to the ground and a knee angle of 115-125° (Hislop, 1982). This is supported by Quarrie and Wilson (2000) who suggest a negative correlation between knee angle and forward force production in a parallel stance. This study aims to examine the differences between joint angles of the knee during scrum machine practice and live, modified 5-man scrums.

METHODS
Two props (1 tighthead, 1 loosehead) were analysed during two scrummaging conditions: alone against a scrummaging machine and with a modified pack size of five in a live scrum. Participants competed at an amateur level in RFU Level 7. A high-speed camera (EX-FH100, Casio, Tokyo) was positioned 5m away from the outside leg of the player in the scrum, recording at 120fps. The greater trochanter, femoral condyle and the lateral malleolus were marked with 15 mm flat retro-reflective markers on the outside leg of each player. Players were instructed to perform all pre-scrum processes and assume the pre-engage position. A coach delivered the engagement protocol “CROUCH, BIND, SET”, and gave a separate call to simulate the ball being rolled into the scrum.

Data Processing and Analysis
All recordings were calibrated using a video of a calibration T-frame. Data was analysed using Quintic Biomechanics v29 (Quintic Consultancy Ltd, Sutton Coldfield). Each trial was digitised, using manual and intelligent digitisation. Angular and linear analysis was performed using the Quintic Biomechanics Angular and Linear Analysis tools, with reference to the knee angle.

RESULTS
Greater variation in knee angles are produced in props when scrummaging as part of live 5-man scrums when compared to scrums against a machine (Figure 2).

DISCUSSION
The findings show that despite little difference between the average knee angles during a live scrum and one with a machine, there is greater variation of knee angle during a live scrum. Sayers (2007) suggests a negative training effect from practice using a scrum machine due to differences in lower limb kinematics. The current study supports this, showing increased variation of knee angle during a live scrum.

CONCLUSION
Practicing scrums using a scrummaging machine in amateur rugby union players is not representative of live scrums experienced in-game. Players may benefit more from practice using increased live/modified scrums.

REFERENCES
ACHILLES TENDON IS MECHANOSENSITIVE IN OLD ADULTS: A 1.5 YEAR RESISTANCE TRAINING INTERVENTION

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INTRODUCTION

The aging tendon experiences general degeneration in its structure and function, which is usually described through a diminished ability to adapt to environmental stress as a consequence of deteriorated tissue homeostasis. Tendons of older adults have shown to increase their stiffness after medium-term (12-14 weeks) exercise interventions foremost through an increased Young’s modulus, rather than tendon hypertrophy (Reeves et al., 2003). Nonetheless, there is limited knowledge about the time-adaptive response relationship of tendons experiencing long-term (years) mechanical loading interventions. Therefore, the current study investigated if the older human Achilles tendon (AT) exhibits mechanosensitivity by altering its material and/or morphological properties in response to a long-term mechanical loading exercise intervention.

METHODS

Thirty-four older female adults (age: 65±7 y) voluntarily took part in a medium-term (14 weeks; n=21) strength training intervention using high AT strain cyclic loading (isometric plantarflexion contractions with 90% of MVC for five sets of four repetitions 3 times a week as provided by Arampatzis et al., 2007) or a control group (n=13). A sub-group of the intervention group (n=12) continued the exercise for 1.5 years (long-term intervention). In order to analyse the AT stiffness and Young’s modulus in vivo, ultrasonography and dynamometry were used simultaneously. Tendon cross-sectional area (CSA) was determined along the whole free AT by using custom routines on image sequences obtained through magnetic resonance imaging.

RESULTS

Following 14 weeks of resistance training, the intervention group had a significantly (p<0.05) increased ankle plantarflexor muscle strength (141.5±36.2 vs 116.3±30.8 Nm at baseline), together with a 23% higher AT stiffness (598.2±141.2 Nnm⁻¹ vs 488.4±136.9 Nnm⁻¹ at baseline), 20% greater Young’s modulus (1.63±0.46 GPa vs 1.37±0.39 GPa at baseline) and a homogenous hypertrophy along the entire free AT (approximately 6%). However, despite continuing the strength training intervention for 1.5 years, no further alterations in the muscle strength and tendon properties were found. The control group had no differences neither in muscle or tendon biomechanical properties between measurement time points.

DISCUSSION

The aged AT appears to be able to increase its stiffness in response to medium-term (14 weeks) mechanical loading exercise through changes in both material and morphological properties. Continuing strength training seems rather to maintain, than cause any further adaptive modifications in tendon properties, which indicates that in ageing tendons the time-adaptive response relationship to mechanical loading is non-linear.

CONCLUSION

In conclusion, the current study gives evidence that the human AT preserves its mechanosensitivity in old age and seems to have the capability to increase its stiffness by changing both its material and dimensions and may thereby tolerate higher mechanical loading due to a reduced strain and stress it experiences during tensile loading.

REFERENCES

EFFECT OF TRICEPS SURAE MUSCLE-TENDON UNIT MECHANICAL PROPERTIES ON GAIT STABILITY AND ADAPTABILITY IN OLDER FEMALE ADULTS

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INTRODUCTION
Ageing induces a gradual degradation in the human neuro-motor system resulting in decreased mobility and locomotor performance (Beijersbergen et al., 2013). Moreover, inadequate recovery responses following tripping have been associated with age-related deteriorations in ankle plantar flexion moment output (magnitude and rate) in the push-off phase (Pijnappels et al., 2004). Therefore, the objective of this study was (1) to examine if gait stability and adaptability during perturbed walking is associated with TS muscle strength and Achilles tendon (AT) stiffness in older female adults, and (2) to determine whether elderly with different TS muscle strength capacities show an altered dynamic stability control during perturbed walking, and (3) whether gait plasticity is preserved in old age.

METHODS
Thirty-four older female adults (65±7yrs) experienced unexpected trip perturbations to the swing phase of the right leg while walking on a treadmill (Süptitz et al., 2013). Using a motion capture system (VICON; Oxford, UK) the margin of stability (MoS) and base of support (BoS) were assessed at touchdown (TD) of the perturbed leg and at each following six recovery steps. In order to examine the reactive adaptation potential, the MoS at TD of the perturbed leg was examined in eight unexpected perturbation trials. In an additional session, TS muscle strength and AT stiffness were determined using simultaneous ultrasonography and dynamometry. Pearson correlations were used to inspect the relationship between TS MTU mechanical properties and dynamic stability parameters (both MoS and BoS) of the recovery steps in first perturbation trial. A median split was implemented to classify the subjects into two groups based on their TS muscle strength (strong: n = 16; weak: n = 18).

RESULTS
The strong group had about 42% higher voluntary isometric plantarflexion moments and 33% higher AT stiffness than the weak group (138±22Nm vs. 97±10Nm; 588±156Nmm−1 vs. 441±129Nmm−1; p<0.01). The gait perturbation reduced the MoS at TD of the perturbed leg (0.10±0.08cm) compared to baseline unperturbed walking, indicating instability. The strong group needed three recovery steps to return to MoS baseline and the weak group was unable to return to baseline level within the analysed six recovery steps. Significant correlations between both TS muscle strength and AT stiffness, and MoS and BoS at TD of the first recovery step were found (0.41<r<0.68; p<0.05). After eight gait perturbations, both groups were able to adapt their reactive response to the perturbation (increasing MoS at TD), with no between-group differences.

DISCUSSION
The current data suggest that TS muscle strength and AT stiffness partly limit dynamic gait stability control after an unexpected perturbation during walking in older female adults. Recovery stepping behaviour seems to be less effective in weaker older adults, which is explained mainly by the reduced ability to effectively increase the BoS after perturbations. However, independent of TS MTU mechanical properties, older adults seem to be able to improve their reactive response.

CONCLUSION
TS MTU mechanical properties partly limit dynamic stability during perturbed walking in older adults, but they preserve their gait plasticity independent of their TS muscle strength. Thus, in order to reduce falls risk, older adults may benefit from interventions increasing TS muscle strength and tendon stiffness, and by improving reactive recovery responses via repeated gait perturbations.

REFERENCES
HIP AND KNEE JOINT LOADING DURING REVERSE ROUNDHOUSE (HOOK) KARATE KICKS PERFORMED IN TRAINING AND COMPETITION MODES

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INTRODUCTION: Karate is now commonly practiced worldwide but many older western practitioners suffer from chronic joint problems. Most research has looked at acute injuries in karate (Pieter, W., 2005) There are few studies into chronic problems in lower limbs the knees, hips and elbows. The main purpose of this study was to examine hip and knee joint loading during the performance of the common hook kick in training and competition modes.

METHODS
Following ethical approval 28 black belt karate players (20 men and 8 women, mean ± SD: age: 25.6 ± 9 years, height: 1.75 ± 0.2 m, mass: 78 ±12.7 kg and years training: 14 ± 6.2 years) with no injuries to their knees or hips volunteered for this study. They performed the hook kick in two different ways, training and competition modes. They stayed stationary and kicked to the air; they kept their supporting foot on the force plates. Motion and force data were collected with a nine T20 camera VICON motion analysis system (VICON, Oxford Metrics Group, UK) set to 250 Hz and two 0.6x0.4 m Kistler type 9281EA force plates (Kistler Instruments AG, Winterthur, Switzerland) set to 1000 Hz. Twenty-one 14 mm retro reflective markers were put on the players bodies. Data were processed in VICON Nexus and Visual3D (C-motion, Germantown, MD, USA) to calculate 3D joint motion and joint moments about the hip and knee of both the support and kicking legs (moment normalised to body mass). Kicking duration was time normalised to 100% from a common start point and common end point (Actual kicking time was 1-2 second). The X axis is flexion-extension, the Y axis is abduction-adduction and Z axis is internal-external rotation.

RESULTS
The maximum X axis angle of the support leg (left) and the kicking leg (right) hip and knee angles in both modes were generally similar (Table 1). It should be noted that the support leg hip moments in abduction-adduction were higher in training mode than in competition mode but competition mode had higher moments around the X axis.

<table>
<thead>
<tr>
<th>Hip Angle (Degrees)</th>
<th>Knee Angle (Degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Hip</td>
<td>Support Knee</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Max mean</td>
<td>71 ± 1</td>
</tr>
<tr>
<td>Max SD</td>
<td>1.3 ± 2.3</td>
</tr>
</tbody>
</table>

Table 1. Mean and SD of both hips and knee joints for all three axis for both the training and competition moods for hook kick, support leg(left) and kicking leg (right)

DISCUSSION
The maximum joint angles were greater in some cases for the training kick and in others for the competition kick. The maximum moments were more often greater for the competition kick compared to the training kick than vice versa. In part this lack of a clear change across all variables can be down to subtle changes in the way the kick is performed when moving from one to the other with the competition mode usually not just being a faster mode of the training kick. There were high moments around a few joint axes, especially in the hips and the support leg. The support hip had larger normalised abduction-adduction moments than those seen in cutting and turning actions, which are seen as risky and much greater ranges of motion (Kristianslund, E., at al. 2014).

CONCLUSION
Consideration that it is the supporting leg’s knee and hip that may be more at risk from chronic abuse is something that needs bringing to the attention of coaches and athletes, especially at the hip as they tend to focus on the kicking leg.

REFERENCES
THE EFFECT OF ATHLETIC FOOTWEAR ON MUSCLE REACTION TIME TO A SIMULATED LATERAL ANKLE SPRAIN MECHANISM.

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INTRODUCTION
Lateral ankle sprains are the most common injury diagnosed in sport (Roos et al., 2016), accounting for significant time lost from training and competition with 20-40% of patients developing symptoms of chronic lateral instability (Paul et al., 2017). Interventions aimed to improve the response of the ankle to injurious mechanisms have been examined such as braces and taping but little research has looked at the influence of footwear on this dynamic defence mechanism. The purpose of this study was to examine if footwear has an influence on muscle reaction time to a simulated lateral ankle sprain mechanism.

METHODS
Institutional ethics approval was granted and twelve healthy male participants (age 22.6 yrs ± 2.3, height 176.4m ± 6.9, mass 87.6 kg ± 12.0) completed a health screen and provided written consent to take part in the study. Participants had electromyography (EMG) electrodes (Henleys Medical, UK), placed on the Peroneus Longus (PL), Peroneus Brevis (PB), Extensor Digitorum Longus (EDL), Tibialis Anterior (TA), Lateral Gastrocnemius (LG) and Gluteus Medius (GM) of their dominant lower limb following SENIAM recommendations. A PowerLab system (AD Instruments, UK) was used to record the muscle activity. The raw EMG signal was amplified and sampled at 1000Hz. A tilt platform provided a simulated ankle sprain mechanism of 20° plantarflexion and 30° inversion. The participants underwent five tilts per lower limb in a minimalist running shoe (Nike Free-Run), a long-distance shoe (New Balance 1080v6) and a barefoot control condition, in a randomised order. Muscle reaction times were calculated using a computer-based onset detection algorithm (Thain et al., 2015) and confirmed using visual inspection. One-way repeated measures ANOVAs compared the effect of shoe condition on the muscle reaction time for the six muscles analysed.

RESULTS
The alpha level was set at p < 0.05. Fisher’s LSD post-hoc analyses were used to locate where differences existed. The Nike shoe had significantly quicker EDL reaction time compared to the barefoot condition (p = 0.04). In contrast the Nike shoe had significantly slower PB reaction time compared to the barefoot condition (p = 0.014).

CONCLUSION
No significant differences were observed elsewhere. Minimalist shoe structure (Nike) influences the neuromuscular responses of lower limb muscles to a simulated lateral ankle sprain mechanism, compared to a barefoot condition, in healthy males.

REFERENCES
AGE-RELATED DIFFERENCES IN DROP-JUMP PERFORMANCE ARE ELIMINATED BY MATCHING TRICEPS SURAE MUSCLE STRENGTH AND ACHILLES TENDON STIFFNESS

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INTRODUCTION
Reduced leg-extensor muscle strength and tendon stiffness in old age have been associated with changes in locomotor performance and motor task execution strategy (Karamanidis and Arampatzis, 2005; Kulmala et al., 2014). However, if leg-extensor muscle-tendon unit (MTU) mechanical properties are the only primary drivers of these alterations seen with ageing remains unclear. Therefore, we examined if matching triceps surae (TS) muscle strength and Achilles tendon (AT) stiffness eliminates potential age-related differences in drop jump (DJ) performance and motor task execution strategy in younger and middle-aged adults.

METHODS
Twelve younger (20-30y) and 12 middle-aged (50-65y) adults participated in the study. Ankle plantarflexion moments and AT stiffness of both legs were assessed during isometric voluntary plantarflexion contractions using simultaneous dynamometry and ultrasonography. Tendon elongation during loading was assessed by manually tracking the myotendinous junction of the gastrocnemius medialis muscle and AT stiffness was determined in the linear region of the force-length relationship. The groups showed no significant differences in maximal ankle plantarflexion moment (young: 3.2±0.4Nm/kg; middle-aged: 3.1±0.5Nm/kg) or AT stiffness (580±122 vs. 590±108N/mm). On a separate measurement day, the matched participants performed a series of DJs from different starting heights (13, 23, 33 and 39cm) onto a force plate.

RESULTS
Matched middle-aged and younger adults showed similar DJ heights for all starting heights (from lowest to highest starting height: 19.0±5.0 vs. 18.9±4.5cm; 22.7±4.7 vs. 23.2±4.3cm; 22.7±4.7 vs. 25.5±4.9cm). There were significant age effects (p<.05) on ground contact time, maximal vertical ground reaction force and mechanical power, with higher ground contact times (on average 35-43%) but lower forces (on average 34-44%) and hence lower mechanical power (from lowest to highest starting height: 1498±545 vs. 2496±869W; 2222±320 vs. 3737±894W; 2475±529 vs. 4547±832W; 3034±435 vs. 5210±1050W) for the middle-aged compared to younger adults, independent of starting height. There were significant correlations between DJ performance and TS muscle strength and AT stiffness for all starting heights (.41≤r≤.81; p<.05).

DISCUSSION
Our results illustrate that age-related differences in jumping task performance are eliminated, independent of starting height and hence task demand, when younger and middle-aged adults are matched for TS muscle strength and AT stiffness. However, age-related differences in ground contact times, ground reaction forces and mechanical power were detected for all starting heights, meaning that young and middle-aged adults used different motor task execution strategies. This indicates that while changes in leg-extensor MTU mechanical properties may be the primary drivers of reduced locomotor performance with ageing, they may not be major contributors to motor task execution strategy during jumping.

CONCLUSION
Drop jump performance appears to be unaffected when TS muscle strength and AT stiffness are maintained with age and therefore, countering the degeneration of these properties may help prevent the deterioration of locomotor performance seen with ageing.

REFERENCES
THE BIOMECHANICS OF WALKING OVER COMPLEX SURFACES: CHARACTERISTICS OF YOUNG AND OLD

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INTRODUCTION
The ability to remain active with age is limited in part by mobility deterioration and an increased risk of fall, which if injurious, can affect an individual’s independence. Deterioration of the musculoskeletal system with age causes gait adaptations; stability is known to be impacted whilst walking over irregular surfaces (Marigold & Patla, 2008). Understanding how ageing impacts gait is therefore crucial to appropriate preventative interventions; especially over varied conditions indicative of the mixed environments encountered in everyday life. Therefore, the purpose of this study was to determine the effect of different surface walkway conditions on the movement of young and older (non-elderly) individuals.

METHODS
17 young (8/9 male/female, age 28±6 years, height 1.79±0.11 m, 69±10 kg) and 9 older (5/4 male/female, age 55±5 years, height 1.71±0.07m, 66±10kg) subjects walked at a self-selected speed over two 14.4m walkways; one smooth (SW) and one irregular (IW) surface (Fig. 1). Each condition was completed 5 times, a total of 260 trials. Whole-body kinematics were recorded using a 12-camera motion capture system (Qualisys, Oqus 7). The data was processed using Visual3D 6.0, spatiotemporal measures extracted, Froude numbers calculated, leg length normalised where appropriate and statistics performed using SPSS software (v24; SPSS Inc., Chicago, IL, USA).

RESULTS
Preliminary results indicated there to be a significant interaction between age and surface type when testing for differences in step width \((F(1, 256) = 7.36, \quad p=0.006)\). When walking over irregular surfaces, young subjects showed a significant increase in step width (SW mean = 0.12±0.02m, IW mean =0.13±0.02m) compared to smooth surfaces, whilst old subjects did not (0.12±0.02m, IW mean = 0.12m±0.03m). Furthermore, there was a significant effect of age on normalised speed, older subjects walking significantly slower (mean = 0.23±0.07) than young (mean = 0.24±0.04) regardless of surface type \((F(1, 256) = 291.7, \quad p<0.001)\). Significant differences were found to exist between surface type when accounting for stride length, \(F(1, 256) = 7.40, \quad p=0.007\) (SW mean = 1.68±0.18m, IW mean = 1.64±0.17m) but no significant differences with age and there was no interaction effect.

DISCUSSION
Preliminary results suggest that age affects the way in which individuals traverse different ground surfaces. This is in support of the previous research (Marigold & Patla, 2008). Surface type impacts both the young and older group in relation to stride length, whilst the older group have a reduced gait speed regardless of surface condition. Interestingly, step width is altered by younger individuals who widen their base of support over IW, however the older group fail to adapt their gait similarly, showing no significant increases. The inability to widen gait with age may have possible implications on the stability of gait whilst walking, requiring further data analysis.

CONCLUSION
Results suggest that age does cause significant adaptions to our gait, especially when facing non-smooth surfaces, commonly encountered in and outside of the home.

REFERENCES
STEP RISE INCONSISTENCY MAY GO UNDETECTED WHEN ASCENDING STAIRS: IMPLICATIONS FOR STAIR SAFETY

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INTRODUCTION

Stair use is a daily activity associated with fall risk (Startzell et al., 2000). When compared to falls while level walking, falls on stairs represent a high risk for mortality or for major injury (Startzell et al., 2000; Hemenway et al., 1994). Stair dimensions are often non-uniform within homes and in the community and non-uniformity in step going has been identified as a leading cause of many falls, especially during stair descent (Roys, 2001). However, no studies investigate the impact of a variation in step rise, even though it is likely that the usual movement patterns would be disturbed. In stair ascent an unexpected increased in rise could result in the foot catching the edge of the step, influencing the postural stability and therefore, increasing the risk of a miss step, trip or even fall. Therefore, the aim was to identify the approach strategy of young adults to an unexpected change in rise during stair ascent to help develop guidelines for improving stair safety.

METHODS

Twenty-seven young adults (16 male, 11 female; mean ± SD: age: 24.5 ± 3.3 years; body mass: 70.1 ± 8.4 kg; body height: 173.9 ± 6.4 cm) negotiated an instrumented seven step custom-built staircase (force plates embedded in the first four steps) with step dimensions set to either (1) NORMAL, a uniform staircase (rise 200mm and going 250mm); or (2) RISE, a non-uniform staircase where the 3rd step only was elevated by 10mm. In addition to the recorded movement data, foot clearance of the leading limb and foot contact area were determined. Analysis of movement data focused on the approach of the changed step 3). For statistical analysis the average values out of 5 NORMAL trials were used and compared to the first RISE trial. A paired T-test was executed to identify differences between the two conditions using SPSS (IBM SPSS Statistics for Windows, USA) with the level of significance set at P = 0.05.

RESULTS

Peak joint angles, joint moments, ground reaction forces, CoM accelerations and CoM – CoP distance and angle were not significantly different between conditions in the approach to the elevated step. Foot clearance (Fig. 1.A) and foot contact area (Fig. 1.B) at the elevated step (10mm) were significantly reduced.

DISCUSSION

The results show no significant differences in the approach movement to the elevated step in the RISE condition compared to the NORMAL condition. The lack of any biomechanical adjustments when negotiating the higher rise step suggests that the altered step was not detected. As a consequence, the foot touches down on the elevated step earlier in the unaltered gait cycle, and foot clearance and foot contact area are reduced. This indicates that there may be an increased risk of falling, due to tripping or slipping on the step, respectively.

CONCLUSION

Variability in step rise by 10mm during stair ascent was undetected by young adults resulting in no adjustments in the approach towards an elevated step. The resulting decrease in toe clearance and foot contact area suggest that a variability in step rise increase the risk of tripping / slipping during stair ascent.

REFERENCES


A

B

Figure 1: Mean vertical foot clearance of the leading limb for all steps (A) and contact area at touch down (B) for all instrumented steps for condition NORMAL and RISE.
* Statistically significant differences between the NORMAL and RISE condition (P < 0.05).
INTERVERTEBRAL MOTION SHARING IN THE LUMBAR SPINE AND CHRONIC BACK PAIN

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INTRODUCTION
Evidence of intervertebral mechanical markers in chronic, non-specific low back pain (CNSLBP) is lacking (Deyo, Dworkin et al. 2014). This research used dynamic fluoroscopic studies to compare intervertebral angular motion sharing inequality and variability (MSI and MSV) during continuous lumbar motion in CNSLBP patients and controls. Passive recumbent and active standing protocols were used and the relationships of these variables to age and disc degeneration were assessed.

METHODS
Twenty patients with CNSLBP and 20 matched controls received quantitative fluoroscopic lumbar spine examinations using a standardised protocol for data collection and image analysis (Breen, Teyhen et al. 2012). Composite disc degeneration (CDD) scores comprising the sum of Kellgren and Lawrence grades from L2-S1 were obtained (Kellgren and Lawrence 1958). Indices of intervertebral motion sharing inequality (MSI) and variability (MSV) were derived and expressed in units of proportion of lumbar range of motion from outward and return motion sequences during lying (passive) and standing (active) lumbar bending and compared between patients and controls. Relationships between MSI, MSV, age and CDD were assessed by linear correlation.

RESULTS
MSI was significantly greater in the patients during recumbent flexion (0.29 vs 0.22, p=0.02) and combined flexion, extension, left and right motion (1.40 vs 0.92, p=0.04). MSV tended to be higher for combined recumbent directions (0.19 vs 0.15, p=0.25), but not for standing flexion. There were substantial correlations between age (R=0.85, p=0.004), CDD (R=0.70, p=0.03) and MSI in lying passive investigations in patients only and substantial correlations between age (R=0.77, p=0.01), CDD (R=0.85, p=0.004) and MSV in standing flexion in patients only.

DISCUSSION
Greater inequality and variability of motion sharing was found in patients with CNSLBP than in controls, confirming previous studies and suggesting a biomechanical marker for the disorder at intervertebral level. The relationship between disc degeneration and MSI was augmented in patients, but not in controls during passive motion and similarly for MSV during active motion, suggesting links between in vivo disc mechanics and pain generation.

CONCLUSION
This study supports previous research that reported a biomechanical marker for chronic back pain based on intervertebral motion (Mellor F.E., Thomas et al. 2014). Future work could now investigate the role of these markers as moderators or mediators of clinical outcome.

REFERENCES


IS THE HUDL UBERSENSE APP A SUITABLE REPLACEMENT INSTRUMENT FOR THE UNIVERSAL GONIOMETER IN MEASURING KNEE FLEXION RANGE OF MOVEMENT?

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INTRODUCTION
The universal goniometer (UG) is commonly used to measure knee range of movement (KROM) in clinical practice. However, research has demonstrated that the UG lacks reliability failing to meet the standard of clinically acceptable error (5°) (Hellebrandt et al 1949, Trappler et al. 2009, Lenssen et al. 2007).

Objective: This study tested the concurrent validity and intra-rater reliability of a photographic based ‘app’ developed for feedback in sport, the Hudl Ubersense App (HUA), as an alternative instrument for measuring KROM.

METHODS
Measurements of KROM were made concurrently with the electrogoniometer (EG) and HUA, across a pre-determined randomised set of 20 functional knee angles between 35° and 130°. This was then repeated. The pre-agreed standard of concurrent validity was that 95% of HUA measurements would be within 5° of the EG and differences were displayed in Bland-Altman plots.

RESULTS
39 (97%) of the 40 HUA readings differed from the corresponding EG readings by less than 5°. The mean differences between the EG and HUA measurements over each trial were 1.75° (Fig 1) and 0.80° (Fig 2) respectively, indicating a high level of concurrent validity. There was less than 1.0° mean difference between the first and second set of results indicating a high level of intra-rater reliability.

DISCUSSION
The HUA has demonstrated a high level of agreement and a small degree of bias between angles of knee flexion from 35°-135° compared to the EG. The results confirm far superior concurrent validity of the HUA compared to the UG where research has found 22% of the UG measurements differ by 5° or greater (Edwards et al 2004). This has significant implications for clinical practice as the HUA is simple to use, cheap and accessible, advantages shared with the UG meaning that it could potentially replace the UG in the clinical setting.

CONCLUSION
The results suggest that the HUA has high levels of concurrent validity (using the EG as the gold standard) and intra-rater reliability, scoring better than previous research on the current clinical measuring device, the UG. The HUA has clinical advantages over the EG, so further research is recommended to determine its inter-rater reliability, acceptability, and appropriate clinical practice procedures.

REFERENCES
PLANTAR PRESSURE IN CHRONIC EXERTIONAL COMPARTMENT SYNDROME: A CASE-CONTROL STUDY

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INTRODUCTION
Chronic exertional compartment syndrome (CECS) of the anterior compartment has been suggested to develop due to excessive muscle activity and foot pronation. Plantar pressure has previously been demonstrated to be related to both lower limb muscle activity (Morga et al., 1999) and foot type (Cavanagh et al., 1987). Several plantar pressure parameters have also been identified as being predictive of the development of exercise-related lower leg pain (Willems et al., 2006). Plantar pressure may therefore provide insight into this condition. The aim of this study was to compare the plantar pressure in cases with CECS and asymptomatic controls.

METHODS
70 male cases with CECS of the anterior compartment of the leg and 70 asymptomatic controls were recruited. A clinical diagnosis of CECS was established from typical symptoms, with clinical examination excluding other pathologies. Plantar pressure variables during walking, hypothesised to be related to anterior compartment muscle activity or had previously predicted general exercise-related lower leg pain, were extracted. Measurements of height, body mass and ankle dorsiflexion range of motion were also completed. Bootstrapped t-tests were carried out on all variables using the bias-corrected and accelerated method (Efron, 1987). Significant variables were then entered into a forward stepwise binary logistic regression model.

RESULTS
Cases had greater body mass (mean difference 4.4kg), were shorter in height (mean difference 2.4cm), and had reduced ankle dorsiflexion range of motion than controls (mean difference 1.5cm). There was no difference between groups in foot type and toe extensor - related plantar pressure variables (p>0.05). Logistic regression demonstrated that mass; height and forefoot loading were the best predictors of group membership. The magnitude of load under the medial forefoot was the strongest plantar pressure predictor of the presence of CECS (Table 1). Cases also demonstrated greater loading under the lateral heel at 5% of stance time.

<table>
<thead>
<tr>
<th>Predictor</th>
<th>β</th>
<th>Wald</th>
<th>OR</th>
<th>p-values</th>
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<tr>
<td>Height</td>
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<td>1.2</td>
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</tr>
<tr>
<td>Mass</td>
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<td>18.3</td>
<td>0.9</td>
<td>&lt;0.001</td>
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<td>0.9</td>
<td>0.005</td>
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<tr>
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<td>&lt;0.001</td>
<td>0.002</td>
</tr>
</tbody>
</table>

DISCUSSION
The identification of small stature as a risk factor for the development of CECS in the military supports earlier reports (Roscoe et al., 2016) strengthening the evidence for this measure. The greater body mass observed in cases in this study concurs with two further military studies (Birtles et al., 2006; Roberts et al., 2016). It is not possible from this study to determine whether this is a result of deconditioning following the development of CECS or a risk factor for the condition itself.

The lack of association with toe extensor activity and foot type - related plantar pressure variables suggest that these are not risk factors for the development of CECS, contrary to earlier hypotheses. The greater lateral to medial loading could theoretically represent increased muscle activity of Tibialis anterior at heel strike but a subsequent loss of control as the ankle is lowered. For example, a simulation study suggested that a medial shift in heel loading at initial contact occurs when the force output of Tibialis anterior is reduced (Gefen et al., 2001). Future studies directly investigating muscle activity and function are now required.

CONCLUSION
Anthropometrical differences, in particular small stature, may play a key role in the development of CECS. The plantar pressure differences suggest that Tibialis anterior muscle function may be altered in CECS; although additional measures of foot type or anterior compartment activity did not vary between groups.

REFERENCES
Willems et al, Gait Posture, 23(1):91-8, 2006

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