The British Association of Sport and Exercise Sciences

Biomechanics Interest Group

29th Easter Meeting

Manchester Metropolitan University

Friday 11th April, 2014
Welcome

We would like to welcome you to the 29th Easter meeting of the British Association of Sport and Exercise Science’s Biomechanics Interest Group (BIG 2014). Following last year’s successful meeting at the University of Wolverhampton, we are delighted to be hosting this year’s event at Manchester Metropolitan University (MMU). It is 21 years since we last hosted the meeting, which at the time was organised by Dr. Neil Fowler, Dr. Stuart Miller and Dr. Carl Payton. The 2014 programme includes 12 oral presentations, 13 poster presentations and a demonstration of active drag measurement. We will also award prizes for 1st, 2nd and 3rd place for both the oral and poster presentations.

The purpose of the BIG meeting is to facilitate the interaction of the sport and exercise biomechanics community and provide an opportunity for biomechanists to present their work in a friendly atmosphere. We were delighted with the interest in this year’s meeting and have 116 registered delegates from across the UK and as far afield as the Czech Republic. We hope that everyone has a stimulating and thought-provoking day and enjoys their trip to Manchester. We have included a list of delegates and their affiliations at the end of this proceedings book.

We would like to acknowledge the internal funding support received from the Institute for Performance Research at MMU Cheshire and also to acknowledge Tracksys (UK suppliers of SIMI Motion) for their sponsorship of the event and Summit Medical and Scientific (UK representatives for AMTI and Myon) for supporting the prize awards. If you are interested in hosting BIG 2015, we would welcome expressions of interest from groups at this year’s meeting.

Thank you very much to those attending the meeting, especially those who are presenting, acting as session chairs, demonstrators or volunteers on the day. On behalf of the biomechanics research group at MMU Cheshire, we wish you all an enjoyable day.

Dr. Conor Osborough
Senior Lecturer

Dr. Adrian Burden
Principal Lecturer

Dr. Islay McEwan
Senior Lecturer

Dr. Sandra Lewis
Research Associate

Dr. Carl Payton
Senior Enterprise Fellow

Professor Neil Fowler
Head of Department

Dr. Keith Winwood
Senior Lecturer
BASES Biomechanics Interest Group Meeting 2014

(Social gathering on 10th April at 7:30pm in the Salutation Pub [12 Higher Chatham St. Manchester, M15 6ED])

Friday 11th April, 2014

All Saints Campus, Manchester (not Crewe)

John Dalton Building (JDT003)

Programme

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<td>9.00 – 9.45 am</td>
<td>Registration and coffee (including poster preparation, uploading of presentations and sign up for swimming demonstration groups)</td>
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<td>9.45 – 10.00 am</td>
<td>Welcome – Professor Neil Fowler, Head of Department of Exercise and Sport Science</td>
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<td>BASES BIG update – Adam Hawkey, BIG Chair</td>
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<td>10.00 – 12.00 pm</td>
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<td>12.00 – 2.00 pm</td>
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<td>Demonstration of active drag measurement in the Manchester Aquatic Centre</td>
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<td>Group 1: 12.15 – 12.55 pm</td>
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<td>Group 2: 1.05 – 1.45 pm</td>
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<td>4.00 – 4.15 pm</td>
<td>Prize giving and handover to host for BIG 2015</td>
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See next page for order of oral presentations
Oral Presentations (morning)
15 minutes with 5 minutes for questions

10.00 – 10.20  Alterations in spatio-temporal gait parameters and musculoskeletal strength after minimalist footwear intervention
Helen Gravestock (University of Worcester)

10.20 – 10.40  Musculoskeletal gearing and the implications for sprinting: lessons learned from the animal kingdom
Penny Hudson (University of Chichester)

10.40 – 11.00  Determinants of countermovement jump performance: a kinetic and kinematic analysis
Stuart McErlain-Naylor (Loughborough University)

11.00 – 11.20  The validity of GPS-integrated accelerometers to measure trunk accelerations during a high intensity turning manoeuvre
Niels Nedergaard (Liverpool John Moores University)

11.20 – 11.40  A sensitivity analysis of gait variables contributing to the movement deviation profile
Malcolm Hawken (Liverpool John Moores University)

11.40 – 12.00  How reliable are knee kinematics and kinetics during side-cutting?
Sean Sankey (University of Bolton; Liverpool John Moores University)

Oral Presentations (afternoon)
15 minutes with 5 minutes for questions

2.00 – 2.20  The effects of soccer match simulation on functional hamstring to quadriceps ratio and peak knee abduction moments in side cutting
Raja Mohammed Firhad Raja Azidin (Liverpool John Moores University)

2.20 – 2.40  How does elbow hyperextension affect ball speed in cricket?
Paul Felton (Loughborough University)

2.40 – 3.00  Biomechtools: interactive flexible learning technologies to enhance students’ understanding of data handling
David Jessop (Southampton Solent University)

3.00 – 3.20  Elastic energy recovery from the Achilles tendon is less efficient with increasing severity of peripheral arterial disease and claudication
S.L. King (Liverpool John Moores University)

3.20 – 3.40  Effect of different ball delivery methods on batsman response in cricket
Chris Peploe (Loughborough University)

3.40 – 4.00  Statistical Parametric Mapping (SPM) for objective, generalizable analysis of multi-muscle EMG time-series
Mark Robinson (Liverpool John Moores University)
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<td>Alexander Dallaway (University of Wolverhampton)</td>
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<td>Roman Farana (University of Ostrava)</td>
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<td>Eunhye (Ravina) Huh (Loughborough University)</td>
<td>BALANCE CONTROL AND RESPONSE TO PERTURBATIONS IN VARIOUS DANCE POSITIONS: A BALANCE STUDY IN DANCE USING A MOVING PLATFORM</td>
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<td>Jaroslav Uchytil (University of Ostrava)</td>
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Travel and Directions

The meeting will take place in central Manchester, on the All Saints Campus in the John Dalton Building (JD003). Directions to the All Saints campus are available on the MMU website: www2.mmu.ac.uk/travel/allsaints/. The following information may also help:

By Rail
Take a train from Piccadilly to Oxford Road station for the All Saints campus. From Victoria station, take the Metrolink tram to St Peter's Square, from which the All Saints campus is a 10-minute walk. Oxford Road station is a 5-minute walk to the All Saints campus.

By Bus
Take the 147 bus from Piccadilly railway station to the stop outside the BBC on Oxford Road. You can also get numerous buses heading towards south Manchester (Bus Number 41, 42, 43, 85, 111, 250, 256), which all stop at the All Saints campus.

By Car
From the M56, south of Manchester, keep in right hand lanes at Junction 3 (signposted City Centre) and continue from the end of the M56 onto A5103 (Princess Parkway), signposted Manchester city centre. Continue ahead until you reach a major roundabout with an overpass and take the third exit, signposted Sheffield A57(M). At next roundabout take the first exit onto Cambridge Street, turn right onto Chester Street and right onto Oxford Road.

From the M60, north and east of Manchester, exit at Junction 22 and turn right at traffic lights onto A62. Continue until the end and turn left onto A665 then, following signs for Universities, turn right. Bear left just before the road rises to become the Mancunian Way and join the dual carriageway, immediately moving into the right hand filter lane to turn right (signposted Manchester Aquatics Centre) onto Grosvenor Street. Follow sign for MMU onto Oxford Road.

From the M602, west of Manchester, proceed to the end of the M602, join the A57(M) (Mancunian Way) and leave by the slip road (signposted Universities) immediately after the MMU buildings visible on both sides of the carriageway. Follow the slip road from the Mancunian Way round to the left and join the dual carriageway (Upper Brook Street). Take the first right into Grosvenor Street, then turn right onto Oxford Road.

GPS
Input the postcode M15 6BH into your satellite navigation system to get to the All Saints campus.
Parking

There are two local car parks within a two-minute walk of the All Saints campus. The first is located on the old BBC site on Oxford Road. Details are available here: www.totalcarparks.co.uk/carparks/manchester/oxford-road. The second is located at the Aquatic Centre. Further details are available here: www.ncp.co.uk/find-a-car-park/car-parks/manchester-aquatic-centre-jv/

When on Campus

The meeting will be held in the John Dalton Building. Oral presentations will take place in JDT003. Buffet lunch, poster presentations and trade exhibitions will take place on the ‘Street’.

The demonstration of active drag measurement will take place in the nearby Manchester Aquatic Centre. There will be guides on hand to lead groups between the John Dalton Building and the Manchester Aquatic Centre.
Oral presentations (in alphabetical order)
A SENSITIVITY ANALYSIS OF GAIT VARIABLES CONTRIBUTING TO THE MOVEMENT DEVIATION PROFILE

Gabor Barton¹, Malcolm Hawken¹, Michael Schwartz²

¹Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK.
²Gillette Children’s Specialty Healthcare, St. Paul, MN, USA.

email: g.j.barton@ljmu.ac.uk ; web: http://www.ljmu.ac.uk/sps/76028.htm

INTRODUCTION
The Movement Deviation Profile (MDP, Barton et al., 2012) is the deviation of a patient’s movement from normality calculated using a self-organising neural network. In its classical use the gait of controls and patients is represented by those nine joint angle waveforms which are most trusted by gait analysts, but the relative importance of the variables is not known. The aim of this study was to perform a sensitivity analysis of the MDP by systematically eliminating the variables and examining the effect on the separation between pathological gait and normality.

METHODS
Pelvic and hip angles in all three planes, knee flexion/extension, ankle plantar/dorsiflexion, and foot progression angles generated using either the Vicon Clinical Manager or Vicon Plug-in-gait model were used from 5352 patients with cerebral palsy and 166 typically developing controls. The neural network was first trained with control data, and then produced the mean deviation from normality (\(\text{MDP}_{\text{mean}}\)) over the gait cycle for each patient. Variables were then eliminated systematically, covering all 511 combinations of the nine variables. For each combination the average of the 5352 \(\text{MDP}_{\text{mean}}\) values was mean-corrected and normalised to the SD of controls (Z-scores) providing a standardised measure of distance between the patient group and controls.

RESULTS
The effects of using seven, eight and all nine variables are presented here, focusing on the three most influential variables. A consistent pattern was found in that elimination of the hip rotation angle increased the separation of patients from controls most, and elimination of the foot progression angle reduced the separation most. When hip rotation was excluded and foot progression angle was included in the seven or eight variables used, the Z-scores were all higher (mean±SD = 3.319±0.077) than the Z-score with all nine variables (3.204). The highest Z-score (3.422) was found when hip rotation and knee flexion/extension were eliminated.

DISCUSSION
The low reliability and high error of hip rotation angle (McGinley et al., 2009) possibly due to its dependence on correct thigh wand alignment may explain why leaving this variable out improves the separation of patients from controls. Leaving foot progression angle out moved the patient group closest to normality suggesting that this variable is an important determinant of gait abnormality. Simultaneous elimination of hip rotation and knee flexion/extension resulting in the highest Z-score when compared to keeping all nine variables suggests that in ambulatory patients these two variables are least important when separating patients from controls.

CONCLUSION
A subset of the original nine variables improves separation of patients from controls in the neural network model of the MDP. A similar optimisation of the variables used by other gait indices (Gait Deviation Index [Schwartz and Rozumalski, 2008] and Gait Profile Score [Baker et al., 2009]) might improve their discriminatory power.

REFERENCES
HOW DOES ELBOW HYPEREXTENSION AFFECT BALL SPEED IN CRICKET?
Paul Felton and Mark King
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email: P.J.Felton@lboro.ac.uk ; web: www.lboro.ac.uk

INTRODUCTION
The characteristics of the bowling arm in cricket have been reported to contribute 50% towards ball release speed (Elliott et al., 1986). This study investigates the effect elbow hyperextension has on ball release speed in fast bowling.

METHODS
A two-segment, planar, subject-specific, simulation model of the bowling arm was developed using AUTOLEVTM (Figure 1). The shoulder was driven horizontally using performance data, whilst preventing vertical movement. Ball release occurred once the arm had passed the vertical and the horizontal distance travelled between the predicted landing site and the origin matched the performance data.

Figure 1: The two-segment simulation model of the bowling arm. A torque generator, T_s, opens the shoulder joint angle, a_s, and a torsional spring, T_e, closes the elbow joint.

The torsional spring parameters and constant shoulder torque magnitude were determined by matching three bowling trials, concurrently, using a common set of parameters to minimise a difference score function.

Initially, the amount of ball speed gained by the bowler due to elbow hyperextension was investigated. The simulation model was then optimised to maximise ball speed by allowing the torsional spring coefficients to vary. Subsequently, in order to investigate the effect of different hyperextensions and recoils on ball speed, the torsional spring stiffness was perturbed.

RESULTS
The torsional spring parameters and constant shoulder torque determined by concurrently matching three bowling trials were seen to provide a good overall agreement, with a difference score of 3.8%.

For the elite fast bowler, an increase in ball speed of 4% was found to occur due to elbow hyperextension. Optimisation of the torsional spring parameters found that a 5% increase was possible. Perturbing the torsional spring stiffness uncovered that when peak hyperextension was reached, the ball release speed always increased and that an optimum recoil amount exists (Figure 2).

Figure 2: The gain in ball speed percentage curve as a function of peak elbow hyperextension and recoil percentage

DISCUSSION
A gain in ball speed is a consequence of two mechanisms. Firstly, in order to satisfy the ball release criteria, the shoulder release angle has to increase as elbow hyperextension increases at release. This increases the work done by the shoulder and increases ball speed. Secondly, as the elbow recoils, the angular velocity of the wrist about the elbow acts in the same direction as the shoulder torque, and increases the relative torque of the wrist about the shoulder, resulting in a gain in ball speed. However, as the elbow recoils, the increase in work done by the shoulder due to the first mechanism is reduced. This trade-off between the two mechanisms results in an optimum recoil percentage (Figure 2).

CONCLUSION
Elbow hyperextension causes an increase in ball speed in fast bowling. The increase in ball speed is associated not only with peak elbow hyperextension but also the amount of recoil, with an optimum recoil percentage existing.

REFERENCES
MUSCULOSKELETAL AND SPATIO-TEMPORAL GAIT CHANGES IN WALKING AFTER AN EIGHT WEEKS MINIMALIST FOOTWEAR INTERVENTION

Helen Gravestock, Lisa Griffiths, Mark Corbett, Gavin Thomas, Ross Mizzen and Dan Eastough
Institute of Sport and Exercise Science, University of Worcester, Worcester, UK
email: h.gravestock@worc.ac.uk; web: http://www.worcester.ac.uk/

INTRODUCTION
Manufacturers have now developed minimalist shoes to alleviate the obvious surface hazards that are present while barefoot (Willy & Davies). To date, the minimalist footwear option, that is now readily available, has received limited scientific investigation concerning chronic wear. This intermediate option has inspired many to transition to minimalist footwear or go barefoot through the use of training programs (Warne et al. 2013). Most training interventions regarding the transition to barefoot running commence with walking, yet no scientific rational exists for this decision. Therefore the aim of this study was to compare spatio-temporal walking gait parameters, and peak musculoskeletal torque values of the ankle joint after an 8 week minimalist footwear habituation period.

METHODS
Fourteen healthy male participants were randomly allocated to a control (CG) or intervention group (IG). The IG were provided with a pair of minimalist shoes (2.5 mm sole thickness; Feelmax Osma 2, Feelmax®) to be worn ≥6 hrs a day, 5 days a week over an 8 wk habituation period. Spatio-temporal and lower limb strength data were obtained both before and after the 8 wk period for all participants, in three different footwear conditions, barefoot, minimalist shoe, and traditional shoe. A 16 camera 3D motion capture system (Vicon) was used to collect data, which was subsequently processed and modelled analysed (Workstation, Bodybuilder, Vicon). Peak musculoskeletal torque values of the ankle joint were assessed through isokinetic dynamometry (Humac Norm Isokinetic dynamometer). Five repetitions of bilateral concentric and eccentric strength assessments were made during ankle plantar flexion and ankle dorsiflexion. Paired t-tests were utilised to determine group differences between baseline and post intervention spatio-temporal, and isokinetic force measures. Pearson’s correlation coefficient was used to assess relationships between the spatio-temporal and strength data.

RESULTS
The IG had an increase in stride length (4.2%; p = 0.44), and walking speed (5.2%; p = 0.04) during the barefoot condition. There was a similar increase in barefoot stride length observed in the CG (3.65%; p = 0.11). However, only the IG showed an improvement in eccentric plantar flexion strength of the left limb (18%; p = 0.021). No improvement in lower limb strength was observed in the CG.

DISCUSSION
Participants in the IG walked faster due to an increased stride length, as these spatio-temporal parameters are interrelated. This increase in stride length following the intervention differs to previous reports concerning barefoot gait during running (Kaplan 2014). This may be due to the extended time period the participants habituated to the footwear, or that the footwear worn was considerably more minimal than footwear investigated elsewhere. As significant differences were only observed in the barefoot condition, it can be suggested that the minimalist shoe worn during the 8 week period acted as a suitable transition to barefoot walking. Small improvements in peak torque values suggest that habitual walking in minimalist footwear resulted in increased lower limb strength.

CONCLUSION
To conclude, significant differences in gait parameters were only observed in the barefoot condition. This would suggest the minimalist shoe acted as a suitable training device for those transitioning to barefoot running.

REFERENCES


MUSCULOSKELETAL GEARING AND THE IMPLICATIONS FOR SPRINTING: LESSONS LEARNED FROM THE ANIMAL KINGDOM

Penny E Hudson*, Sandra A Corr** and Alan M Wilson**

*Department of Sport and Exercise Science, University of Chichester, West Sussex, UK
** Royal Veterinary College, University of London, London, UK

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INTRODUCTION

Evolution has created many animal athletes that display exceptional athletic performance from the endurance capabilities of a horse (AE Minetti et al., 1999) to the jumping abilities of a frog (HC Astley et al., 2012). But none is more impressive than the enigmatic cheetah, capable of top speeds almost three times that of Usain Bolt. This study aimed to ascertain how the cheetah’s anatomy is specialised to enable it run at speeds of 29 ms\(^{-1}\) (NCC. Sharp, 1997), and what we can learn from this to influence human sprinter selection and training. To examine this we investigated the limb posture and effective mechanical advantage (EMA = muscle moment arm / GRF moment arm) of the cheetah whilst galloping and compared them to the racing greyhound; an animal of a similar mass yet can only achieve speeds of 19 ms\(^{-1}\).

METHODS

Simultaneous high speed video (4 x AOS Technologies AG; 1000 Hz) and force plate data (8 x Kistler force plates) were collected from two South African Cheetah and six ex-racing greyhounds, running at steady state after a mechanical lure. Joint angles, moments and EMA were digitised and calculated using custom software in Matlab (Mathworks v. 7.5). Parameters were correlated to running speed using LMM’s in MLWin (v. 2.21).

RESULTS

Twenty – two cheetah stances (12 ms\(^{-1}\) ± 2 m/s\(^{-1}\)) and 110 greyhound stances (13.5 m/s\(^{-1}\) ± 1.5 m/s\(^{-1}\)) were analysed. Cheetahs used significantly more flexed limbs during mid-stance (Figure 1), which resulted in the majority of their joints experiencing larger joint moments. This was particularly evident at the ankle of the non-lead hindlimb which experienced a peak joint moment 32 Nm greater than that of the greyhound. The cheetah exhibited a greater mid-stance EMA at the ankle and wrist (P<0.05), however, data were highly variable between trials.

DISCUSSION

Cheetahs were found to use a more crouched posture than the greyhounds at midstance. But how can an animal cope with this? The answer lies in their anatomy. Cheetah’s have exceptionally long muscle moment arms (Hudson et al., 2011), which allow them to retain a greater EMA over the racing greyhound despite experiencing larger joint torques. A more crouched posture has been suggested to enhance stability (Gatsey and Beiwener, 1991) or robustness of gait (Blum et al. 2011). It also has the potential to enhance their capacity to manoeuvre at high speed. All important considerations for our animal athletes, but for a human sprinter a more crouched posture will improve their horizontal EMA enabling them to apply greater horizontal forces, enhancing acceleration (Card et al.). The ability to apply large acceleratory forces may increase the speed at which a power limit to maximum speed is encountered. Therefore the gearing or EMA of a sprinter’s musculoskeletal system, may determine if they will be able to run like a cheetah or just like a greyhound.

CONCLUSION

Animals are increasingly being used as inspiration for robotic design, as species have evolved to specialise in certain locomotor or biomechanical tasks. Here I demonstrate how this can influence athlete selection and the potential for learning from animal biomechanics for inspiration in sport.

REFERENCES


Card, G., P. G. Weyand, A. A. Biewener and M. Bedford “Changes in muscle mechanical advantage of human runners during sprint acceleration.”


BIOMECHTOOLS: INTERACTIVE FLEXIBLE LEARNING TECHNOLOGIES TO ENHANCE STUDENTS’ UNDERSTANDING OF DATA HANDLING

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INTRODUCTION
It is well established that many HE students lack capability and confidence in their mathematical ability (Mackenzie, 2010), and have difficulty learning and comprehending research methods as a subject (e.g. Edwards & Thatcher, 2004). Sport Science students therefore often have poor comprehension of how best to process data that they have collected. Knowledge of these processes is fundamental for the successful completion of practical investigations including the vast majority of final year research projects.

The aim of this pilot study was to enhance students’ understanding through a purpose built, data processing software with integrated learning modules (BiomechTools). The interactive toolbox guides users through a series of tasks and questions, allowing them to comprehend background theory whilst simultaneously gaining practical experience of data processing techniques and software. Once the user becomes confident in both the procedures and theory, the toolbox may be used solely as data processing software.

METHODS
BiomechTools was evaluated through investigation with 72 undergraduate BSc (Hons) Applied Sport Science and BSc (Hons) Sport Coaching students. An unassessed biomechanics topic was taught using BiomechTools (BIO, N=41) and traditional worksheets/ Microsoft Excel (TRAD, N=22). A control group (ABS, N=9) was made up of students who were absent during teaching. Records were kept of questions and comments made relating to the methods. Students were tested one week later to see what information had been retained. To normalise the results between courses and groups, marks from assessed coursework were subtracted from the test scores. A one way ANOVA with Games-Howell post hoc test was used to assess differences between groups.

RESULTS
There was no significant difference between BIO and TRAD (P= 0.351) but both groups performed significantly better than ABS (P= 0.00, d= 1.237 & 0.00, d= 2.405; Figure 1). TRAD groups failed to finish the work in the allotted time but did score slightly better than BIO who all completed the work in 20-50 mins of the 50 min session. The BIO groups asked fewer questions than TRAD and also commented that they enjoyed this approach.

DISCUSSION
The lack of a significant difference between the teaching methods suggests BiomechTools to be an efficient approach to teaching and learning. As the BIO group completed in a shorter time, this could facilitate further work to deepen understanding. It is also positive that students noted enjoyment of the BiomechTools approach as this may encourage them to be more positive in their attitudes towards data processing.

CONCLUSION
The development of customised toolboxes is considered beneficial however, their use raises interesting questions regarding the development of students’ analytical skills and ability to use established data processing software.

REFERENCES

ELASTIC ENERGY RECOVERY FROM THE ACHILLES TENDON IS LESS EFFICIENT WITH INCREASING SEVERITY OF PERIPHERAL ARTERIAL DISEASE AND CLAUDICATION

S.L. King1,2, N. Vanicek2 T.D. O’Brien1,3
1. Liverpool John Moores University, 2. University of Hull, 3. Bangor University
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INTRODUCTION
Elastic energy can be stored in tendons and recovered during the subsequent muscle contraction to improve the efficiency of movement (Peltonen et al., 2013). Peripheral arterial disease and intermittent claudication (PAD-IC) restrict blood flow to the muscles of the lower limb, reducing the energy available to the working muscles which causes a cramp-like pain during physical activity. Consequently, movement efficiency is paramount to mobility and independence. However, disease and disuse may lead to deterioration in the tendon properties, having further adverse effects on movement efficiency and physical function in this population. In addition, spontaneous tendon rupture has been reported in patients suffering from PAD-IC (Shukla, 2002; Jain & Dawson, 2007). Potentially adverse changes with disease weaken the tendon and, combined with reduced blood flow, may increase the risk of injury. The aim of the study was to investigate the effects of PAD-IC on Achilles tendon properties and hysteresis.

METHODS
23 participants (10 controls, 7 unilateral claudicants and 6 bilateral claudicants) were recruited. Disease severity of the claudicants was assessed using the ankle brachial pressure index (ABPI). Ultrasound imaging was used to quantify Achilles tendon length and cross-sectional area (CSA) at rest. Achilles tendon moment arm length (MA) was quantified according to the tendon travel method using ultrasonography. Participants performed a 5-second isometric plantarflexion ramp to MVC and 5-second relaxation back to rest on an isokinetic dynamometer. We recorded joint moment, antagonist co-activation estimated from EMG, and displacement of the MTJ during loading and unloading using ultrasonography. Tendon force was calculated as (joint moment + antagonist moment) / MA. The tendon force-elongation (F-E) and stress-strain relationships were constructed for loading and unloading. Stiffness and Young’s modulus were calculated as the gradient of the F-E and stress-strain curves during loading, respectively. Hysteresis was calculated as the energy lost between the loading and unloading F-E curves. Pearson’s correlations were used to determine associations between disease severity, determined using ABPI, and tendon properties. Significance was accepted at p<0.05.

RESULTS
Increasing disease severity was associated with decreased tendon length (p=0.010, r=0.624) and increased hysteresis (p=0.016, r=-0.651), with trends towards increased peak tendon strain (p=0.073, r=-0.476) and weak trends towards increased energy stored (p=0.130, r=-0.390). No relationship was found between disease severity and tendon elongation, stiffness, stress, energy recovered or Young’s modulus.

DISCUSSION
More severe PAD-IC led to an increase in tendon hysteresis. Therefore, those with severe forms of disease are less able to recover the elastic energy stored in the tendon and would require greater levels of muscle work and metabolic energy to achieve movement, thereby, reducing movement efficiency. In an ischemic environment where energy is at a premium, this will impact on mobility. Tendons rupture at a given constant strain level, therefore, the reduced tendon length and resulting trends towards increased tendon strain with increasing disease severity may explain previous reports of spontaneous tendon rupture in claudicants. Exercise therapy is a routine treatment for PAD-IC and, resistance training in particular, can improve tendon hysteresis (Reeves et al., 2003), but care must be taken to avoid injury to weakened tendons in those with high disease severity.

CONCLUSION
The reduced peripheral blood flow combined with decreased physical activity levels induced by PAD-IC have deleterious effects on the Achilles tendon, meaning that movement efficiency is reduced and the risk of tendon injury is increased.

REFERENCES
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DETERMINANTS OF COUNTERMOVEMENT JUMP PERFORMANCE: A KINETIC AND KINEMATIC ANALYSIS

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INTRODUCTION
The countermovement jump (CMJ) is a key performance requirement in many sports. Research has shown positive relationships between CMJ height and both kinetic (Sheppard et al., 2008) and kinematic (Moran & Wallace, 2007) measures. Few researchers, however, have investigated both sets of parameters. Therefore, the purpose of the present study is to quantify the relative contributions of kinetic and kinematic parameters in order to identify the most important determinants of CMJ height.

METHODS
Two-dimensional kinematic data (Vicon Motion Analysis System; 480 Hz) and ground reaction forces (AMTI force platform; 960 Hz) were recorded during three CMJs for 18 physically active males of varying jumping experience (21.2 ± 2.2 years, 1.80 ± 0.08 m, 78.1 ± 9.2 kg). Participants also completed a series of Con-Trex dynamometer isometric knee extensions to measure RTD and peak torque (T_{max}). Ten kinetic (body mass normalised) and eight kinematic parameters were determined for the highest jump, describing peak lower-limb joint torques and powers, concentric knee extension rate of torque development (RTD), and CMJ technique. Forwards stepwise linear regressions were used to identify which of the isometric, CMJ kinematic, and CMJ kinetic variables best explained the variation in CMJ height.

RESULTS
The 18 males achieved CMJ heights of 0.38 – 0.73 m (0.55 ± 0.09 m). CMJ peak knee power, take-off shoulder angle, and CMJ peak ankle power explained 74% of this observed variation (adjusted R^2; Figure 1). CMJ kinematic (greater shoulder flexion and ankle plantar-flexion at take-off; 58%) and CMJ kinetic (peak knee power and peak ankle power; or peak knee torque and peak ankle power; 57%) parameters explained a much larger proportion of the CMJ height variation than the isometric parameters (T_{max}; 18%). The correlation between T_{max} and CMJ peak knee power was non-significant (r = 0.267; P = 0.142).

DISCUSSION
Greater joint kinetics inevitably generate greater total body kinetic energy at take-off. The non-significant correlation between T_{max} and CMJ peak knee power suggests maximal strength does not determine the CMJ kinetic variables. Given that T_{max} explained only 18% of the variation and 58% can be explained by kinematics it seems likely that technique determines the extent to which maximal muscle capabilities are utilised during the jump. Greater shoulder flexion indicates greater arm swing, and thus a slowing of hip extension leading to more work done at the hip and shoulder. Both shoulder flexion and ankle plantar-flexion also increase the pre-takeoff displacement.

CONCLUSION
This study revealed the importance of lower-limb joint powers and coachable technique factors including ankle plantar-flexion during propulsion and shoulder flexion during arm swing. Thus both kinetic and kinematic factors are important determinants of CMJ height.

REFERENCES
THE VALIDITY OF GPS-INTEGRATED ACCELEROMETERS TO MEASURE TRUNK ACCELERATIONS DURING A HIGH INTENSITY TURN MANOEUVRE

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INTRODUCTION
Tri-axial accelerometers integrated into miniature GPS units are used in team sports to provide an alternative estimate of external load on players during training and matches. The validity of this acceleration data during running and changes of direction has been explored indirectly using force platform measurements (Wundersitz et al., 2013). The aim of this study was to directly investigate the validity of GPS integrated accelerometers to measure trunk accelerations during a high intensity turning manoeuvre.

METHODS
Ten soccer players (age 21 ± 3 years, height 178 ± 10 cm, weight 73 ± 6 kg) performed six 135 degree ‘V’ cuts at three different approach speeds (50%, 70% and 90% of full effort). Approach speed was measured with timing gates (Brower Timing Systems, Draper, Utah, USA). Trunk accelerations were recorded from a tri-axial accelerometer within a commercial micro sensor unit (SPI Pro, GPSport, Canberra, Australia) at 100Hz and from a reference tri-axial accelerometer (Noraxon, U.S.A Inc., Scottsdale, U.S.A) at 500Hz. Both accelerometers were placed on the posterior side of the upper trunk, between the scapulae, in a small pocket within a vest worn by the participants during the cutting movement. Initial peak resultant trunk accelerations (PAcc) were determined for the last three foot-ground contacts of the ‘V’ cut (Figure 1). A One-Way ANOVA (p < 0.05) test was used to determine the significant difference between approach speeds and Pearson’s correlation coefficients (p < 0.01) were calculated to determine the relationship between the PAcc measured with the two accelerometers.

RESULTS
Approach speed increased significantly by intensity (50% intensity: 3.9m/s, 70% intensity: 4.4m/s, 90% intensity: 4.9m/s.). High, significant correlations between the two accelerometers were observed, although the SPI Pro accelerometer consistently underestimated the PAcc. This was especially so at the ipsilateral step (IPSI) and PRE step where PAcc was underestimated by 7-12%, over the three intensities (Table 1).

DISCUSSION
The consistent underestimation of high frequency peak trunk accelerations observed in this study could be related to the accelerometer data processing in the SPI Pro unit (e.g., the lower sampling rate (100Hz) compared to the reference accelerometer (500Hz)). A pilot study, down-sampling the reference accelerometer data from a 90% intensity turn of one participant, suggested that increasing the SPI Pro’s sampling rate to 200-250Hz would improve its validity to measure high frequency peak trunk accelerations during turning manoeuvres. As the external load in team sport is typically calculated from the cumulative summation of the resultant trunk accelerations over training, the underestimation error can become quite relevant.

CONCLUSION
Although the GPS-integrated tri-axial accelerometer demonstrated high association with the reference data regardless of turn intensity, it underestimated higher frequency trunk accelerations during rapid turning.

REFERENCES
THE EFFECT OF DIFFERENT BALL DELIVERY METHODS ON BATSMAN RESPONSE IN CRICKET

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2School of Sport, Exercise and Health Sciences, Loughborough University, UK

INTRODUCTION
Skilled cricket batsmen are highly attuned to a number of visual cues, gained from the kinematics of a bowler’s action, that allow them to perceive and act upon information regarding future ball trajectory prior to ball release. This anticipatory skill is seen as essential for batting success. However, many of these cues are not available when facing a bowling machine or Sidearm™ ball thrower, therefore batsmen are believed to utilise different, less useful cues, and as such a different kinematic response is exhibited (Pinder et al., 2011). This research aimed to identify differences in delivery characteristics and the resulting response amongst a group of elite cricket batsmen when facing a bowling machine and Sidearm™ compared to a bowler.

METHODS
Ten elite cricket batsmen from the ECB performance squads each hit repeated front foot drives against the three delivery methods. Twelve bowling machine (BM) trials were delivered in blocked fashion with the subject having prior knowledge of ball bounce location. Ten Sidearm™ (SA) trials were completed in the same manner, followed by a further twenty with randomised bounce length. Finally twenty trials were completed against a bowler (B) again with randomised bounce length. An eighteen camera Vicon Motion Analysis System® (Oxford Metrics, Oxford, UK) and synchronous high-speed video both sampling at 250 Hz were used to capture subject, bat and ball motion. A number of key events were identified, and a range of discrete timing and kinematic variables were extracted from the resulting biomechanical model. Successful trials were then analysed using separate one-way within subjects ANOVA’s and post-hoc pairwise comparisons to assess significant differences between delivery methods.

RESULTS & DISCUSSION
Results showed ball speed and release-to-impact time to be significantly different between delivery methods (Table 1). Although the Sidearm™ was delivered from 2-3m closer to the batsman, as is done in practice, the reaction time available to the batsmen was still significantly longer. The within subjects ANOVA’s also highlighted a number of timing (Table 2) and kinematic (Table 3) differences in response between delivery methods.

<table>
<thead>
<tr>
<th>Mean (BM / SA / B)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball speed (mph)</td>
<td>82.0 / 63.6 / 77.1</td>
</tr>
<tr>
<td>Reaction time (s)</td>
<td>0.497 / 0.600 / 0.536</td>
</tr>
</tbody>
</table>

Table 1: Significant differences in ball speed and release to impact (reaction) time between delivery methods

<table>
<thead>
<tr>
<th>Mean (BM / SA / B)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stride start (s before impact)</td>
<td>0.399 / 0.450 / 0.383</td>
</tr>
<tr>
<td>Stride end (s before impact)</td>
<td>0.065 / 0.090 / 0.070</td>
</tr>
<tr>
<td>Movement initiation (s after release)</td>
<td>0.050 / 0.134 / 0.070</td>
</tr>
</tbody>
</table>

Table 2: Significant differences in batsman response timings and durations between delivery methods

<table>
<thead>
<tr>
<th>Mean (BM / SA / B)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM forward movement (m)</td>
<td>0.276 / 0.317 / 0.220</td>
</tr>
<tr>
<td>Max bat speed (m/s)</td>
<td>18.9 / 20.5 / 20.4</td>
</tr>
</tbody>
</table>

Table 3: Significant differences in kinematic response between delivery methods

These results highlight the fundamentally different technical responses exhibited by batsmen when facing each delivery method, suggesting the use of alternative visual cues in timing and organising movement.

CONCLUSION
A range of significant differences in delivery characteristics and batsman response between each of the ball delivery methods have been identified. These call into question the validity of the Sidearm™ and bowling machine in the way they are commonly used as accurate representations of facing a real life bowler.

REFERENCES
THE EFFECTS OF SOCCER MATCH SIMULATION ON FUNCTIONAL HAMSTRING TO QUADRICEPS RATIO AND PEAK KNEE ABDUCTION MOMENTS IN SIDE CUTTING

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INTRODUCTION
The reduction in functional hamstrings to quadriceps ($H_{ecc}:Q_{con}$) ratio and improper mechanics in side cutting manoeuvres during soccer match fatigue have been shown to be a potential predisposing factor for anterior cruciate ligament (ACL) injury (Delextrat et al., 2011; Sanna et al., 2008). This study aimed to examine the fatiguing effects of a treadmill (TM) versus an overground (OG) soccer match simulation on $H_{ecc}:Q_{con}$ ratio and peak knee abduction moments during side cutting.

METHODS
In a single-group repeated measures design, 15 healthy female participants (age: $24 ± 5$ years; body mass: $62 ± 5$ kg; height, $1.69 ± 0.06$ m) completed 45 min TM and OG soccer match simulations with similar running velocity profiles. Prior to exercise (time 0 min), at half time (time 45 min) and 15 min post exercise (time 60 min) participants performed either five maximal dominant limb isokinetic contractions at $120°·s^{-1}$ for $Q_{con}$ and $H_{ecc}$ or five trials of anticipated $45°$ side cutting manoeuvres. Peak knee abduction moments were calculated using inverse dynamics. Heart rate (HR) and rate of perceived exertion (RPE) were recorded every 5 min throughout the simulation. A two-way ANOVA was used to identify significant differences, with $\alpha=0.05$.

RESULTS
Physiological responses were significantly greater during the OG (HR $164 ± 6$ beats min$^{-1}$; RPE $13 ± 2$) than TM simulation (HR $139 ± 3$ beats min$^{-1}$; RPE $12 ± 1$). A significant time dependent reduction in $H_{ecc}$ at time 45 min (9.3%; $p=0.011$), time 60 min (12%; $p=0.004$) and functional $H_{ecc}:Q_{con}$ ratio at time 45 min (8.5%; $p=0.043$; Figure 1) was observed in the OG simulation only. There were no significant changes in $Q_{con}$ and peak knee abduction moments during both simulations ($p>0.05$).

DISCUSSION
The greater physiological changes imposed in the OG than the TM simulation may be due to high accelerations, decelerations and a broad range of utility movements. The reduction in $H_{ecc}$ peak torques and functional $H_{ecc}:Q_{con}$ ratio may explain the reported increased predisposition to ACL injury during the last 15 min of first halves of match-play (Hawkins et al., 2001).

Figure 1: Functional $H_{ecc}:Q_{con}$ ratio during treadmill and overground simulations. * Indicates a significant difference over time.

Unchanged peak knee abduction moments indicate that these females had an appropriate strategy for performing anticipated side cuts and avoiding excessive knee loading after 45 min of match simulation.

CONCLUSION
The 45 min OG simulation imposed a significantly higher physiological response than TM simulation at the same running velocity profiles. A greater risk of ACL injury in females at the end of the first half are likely due to muscular imbalance rather than an adverse frontal plane knee loading mechanism.

REFERENCES


INTRODUCTION

Multi-muscle EMG time-series are highly correlated and time dependent yet traditional statistical analysis of scalars from an EMG time-series fails to account for such dependencies. Bovi et al. (2011) qualitatively stated that there were “no marked differences” between their Young vs Adult EMG data. By contrasting the outcomes of traditional scalar analysis to SPM vector-field analysis (Pataky et al., 2013), we promote the use of SPM vector-field analysis for the generalised analysis of EMG time-series.

METHODS

We reanalysed the public dataset of Bovi et al. (2011). Gait EMG from 40 healthy subjects, subcategorised into 20 “young” (aged 6–17) and 20 “adult” (aged 22–72), were chosen with specific focus on mean EMG time-series of the Tibialis Anterior, Soleus, Gastrocnemius and Peroneus Longus muscles (Fig. 1a).

Traditional scalar analysis: Maximum scalar values of each EMG time-series at 40% gait cycle were extracted for the Young and Adult groups and statistically compared using a two-sample t-test.

SPM vector-field analysis: We used SPM to statistically examine the whole EMG time-series. Importantly, SPM considers the covariance between the EMG time-series for the calculation of the test statistic - SPM\{T^2\}. SPM\{T^2\} indicates the magnitude of the Young-Adult differences. We next calculated the critical threshold at which only α% (5%) of smooth random curves would be expected to reach. If the SPM\{T^2\} curve exceeded the critical threshold then statistical significance was reached.

RESULTS

Traditional scalar analysis: The null hypothesis was supported as no significant differences (p>0.012) were observed between Young and Adult EMG magnitudes.

SPM vector-field analysis: SPM analysis rejected the null hypothesis based on highly significant differences between the Young and Adult groups (p<0.01) (Fig. 1b). Three supra-threshold clusters at 2-5%, 24-47% and 62-88% gait cycle were identified.

DISCUSSION

The reason for the discrepancy in null hypothesis treatment is due to inter-muscle and time dependence. In the traditional analysis, intra-muscle differences are small with respect to intra-muscle variance, but the inter-muscle (vector) effect is large with respect to inter-muscle covariance. As traditional scalar analysis failed to consider the multi-muscle and time dependence of the EMG time-series this type of analysis is more susceptible to Type II error. SPM vector-field analysis on the other hand accounts for both inter-muscle and time dependence whilst tightly controlling for Type I and Type II error.

CONCLUSION

SPM vector-field analysis is highly applicable to EMG data analysis. This is generalizable to linear and non-linear parametric and non-parametric statistical models.

REFERENCES


INTRODUCTION
Anterior Cruciate Ligament (ACL) injury in dynamic sports continues to be prevalent in non-contact lower-limb epidemiology (Hawkins et al., 2001). Side-cutting tasks are commonly used in the dynamic assessment of ACL injury risk, but only limited information is available concerning the reliability of kinematic and kinetic descriptors of side-cutting performance. The aim of this study was to investigate the reliability of side-cutting data, specifically at the knee, with additional focus on modelling approaches and task execution.

METHODS
Eight participants consented to participate in this study (four males, four females; mean age: 25.8 ± 4.4 years; mass: 64.8 ± 7.2 kg; height: 1.7 ± 0.1 m). A repeated-measures design was used. Each subject attended six testing sessions; four on day one and two on day two. Two observers conducted three sessions each; two each on day one, and one each on day two. This allowed each participant to be tested by each observer. After warm-up and familiarisation, 45º side-cuts were performed with a 4-5 m.s⁻¹ controlled approach speed. Direct Kinematic (DK) and Inverse Kinematic (IK) modelling approaches were used. All side-cutting was performed on a force platform sampling at 1500 Hz, kinematic data were synchronously recorded using 10 optoelectronic cameras sampling at 250 Hz.

Inter-trial, inter-session and inter-observer variability were calculated for knee kinematic and kinetic signals across normalised ground contact for DK and IK derived data. Inter-observer/inter-trial ratios were also calculated at each time point to highlight the relative effect of experimental error.

RESULTS
Whilst knee angle variability was low (≤ 5 °) all types of knee moment variability were seemingly high in absolute magnitude, specifically in the early ground contact phase, in all three planes. Knee moment variability was seemingly high in absolute magnitude, peaking at 42.4, 30.6 and 20.4 Nm in the sagittal, frontal and transverse planes, respectively. Trial-to-trial (inter-trial) variability was lowest across all time points for all planes, and inter-observer/inter-trial ratio was consistently ≤ 1.3 for kinetic data.

DISCUSSION
Knee kinematic data displayed low variability across the signal waveform in all planes, which suggests that reliability here is good. Knee kinetic data displayed high absolute variability in all planes, particularly in the ‘weight acceptance’ phase. Thus, interpretation of knee moment data, with the specific aim of predicting injury risk, should be cautiously approached. However, although absolute variability was high, when considered in terms relative to the moment signal, this variability was comparable to that reported recently for drop vertical jumps (Malfait et al., 2014). In addition, low inter-observer/inter-trial ratios were strengths of this study, suggesting that any variability was not due to experimental or methodological errors, but due to the natural variability in the kinetic signals. Modelling type and more stringent experimental control may have a limited impact on reducing this observed knee moment variability.

CONCLUSION
The present study indicates that the investigation of reliability using waveform analyses of side-cutting assessment is valuable for exposing sources of potential variability that were previously unknown.

REFERENCES
Poster presentations (in alphabetical order)
INTRODUCTION
Precision pistol shooting is an event requiring extreme levels of accuracy. To date, most research has compared the performances of different ability shooters and has consistently reported that elite shooters demonstrate significantly lower pistol and centre of pressure movement than lower ability shooters (Mason et al., 1990; Ball et al., 2003). Little research has considered the sources of these movements (Pellegrini & Schena, 2005). Thus, there is limited understanding of the mechanisms behind a successful shooting performance.

Motor control research has demonstrated that not only the degree of movement, but also movement variability, influences the success of a performance. As such there were two aims of the current research (i) to determine the effect of changes in joint angles on pistol movement, and (ii) to identify the extent to which joint angle movement varies between shots.

METHODS
Ten elite pistol shooters (mean age (28.4 ± 10.2 years) completed twenty shots under competition conditions. An opto-electronic shooting system (Nopelt, Finland) was used to record pistol movement. Changes in 18 joint angles were recorded using a VICON MX motion capture system which tracked the movement of 42 reflective markers attached to bony landmarks on the participant. Amount and variability of movement was calculated for 1 s prior to every shot. Cross-correlational analysis compared the patterns of each joint angle with motion of the pistol to identify those most influential to shooting performance.

RESULTS
A common trend for all participants was a high correlation between angles of anterior-posterior body sway and horizontal pistol movement. This was associated with high correlations between anterior-posterior sway and shoulder angle. Vertical pistol movement was less dependent on body sway angle, and more greatly influenced by movement of distal joints in the arm. For some participants changes in wrist angle had the greatest similarity to pistol motion. Others displayed high correlations between elbow and wrist movement, with both influencing vertical movements of the pistol.

DISCUSSION
Cross-correlations and movement variability analysis revealed the different movement strategies that individuals employ when shooting. This supports the need for intra-individual analysis of pistol shooting. Different strategies were used to control horizontal and vertical pistol movements, highlighting the importance of detailed analyses of shooting performance, such as the analysis of the movement of individual body segments.

CONCLUSION
Changes in body sway angle influenced horizontal pistol movement whilst movement of the distal joints was most important to vertical pistol movement. Horizontal pistol movement was most variable whilst greater vertical variability was recorded for the shoulder, elbow and wrist than the pistol.

REFERENCES
ACUTE WHOLE BODY VIBRATION AND TORQUE IN LOWER-LIMB MUSCLES
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INTRODUCTION
Whole body vibration is fast becoming a preferred training modality for recreational and elite athletes (Hawkey, 2012). While acute bouts of whole body vibration (WBV) have shown transient performance improvements in sporting populations, contrary results question its effectiveness as an ergogenic aid (Artero et al., 2007). Therefore, current study examined WBV’s ergogenic effect on concentric torque of quadriceps (Q) and hamstrings (H).

METHODS
Following institutional ethics approval, 11 male recreational team sport players (age: 22.9±3.3yrs, height: 179.3±6.9cm, mass: 82.5±12.6kg) completed three separate weekly WBV sessions on a NEMES Bosco platform. At each session, baseline and post intervention measurements of Q and H concentric torque were taken using a isokinetic dynamometer (KinCom, Chattanooga). Isokinetic knee extension and flexion was performed at 180°s⁻¹ through 90° range of motion. Vibration frequency was set at 0Hz, 30Hz or 50Hz, randomised so participants experienced one frequency per session. Amplitude was fixed at 2mm. Torque data (Nm) and H:Q were analysed using a 3-way and 2-way ANOVA with repeated measures respectively. Three within subjects’ factors were frequency, muscle group and intervention.

RESULTS
Main interaction effect (frequency x muscle group x intervention) was insignificant (F₂,2₀=1.269, p=0.327). ANOVA revealed significant lower order muscle group x frequency interaction (F₂,2₀=5.352, p=0.029) and significant lower order muscle group x intervention interaction (F₁,₁₀=18.902, p=0.001). Intervention, regardless of WBV, significantly increased concentric torque of H (F₁,₁₀=15.022, p=0.003) and significantly reduced concentric torque of Q (F₁,₁₀=6.249, p=0.031). While H:Q x frequency interaction was insignificant (F₂,2₀=1.596, p=0.262) the intervention, significantly improved H:Q (F₁,₁₀=23.285, p=0.001).

DISCUSSION
Results suggest WBV does not affect the concentric torque of the Q and H in recreational team sports athletes. However, the exercises performed elicited significant improvements in the H and caused significant decrements in the Q. The exercises performed likely fatigued the Q as they were required to provide dynamic stability, while the H were marginally stimulated as similar squatting exercises have shown to activate the Q to a much greater degree than the H (Isear et al. 1997). Post-activation potentiation (PAP) of the H may have occurred due to sufficient stimulation without fatigue diminishing the effect; however fatigue in the Q may have diminished the PAP effect. H and Q activity increases with greater knee flexion (Escamilla, 2001); as most of the exercises exhibited large degrees of knee flexion sufficient stimulation induced PAP, while the low demand placed on the H to resist anterior shear forces acting on the proximal tibia during the exercises (Isear et al., 1997) prevented excessive activation of the H attenuating fatigue.

CONCLUSION
While WBV does not appear to affect lower-limb torque, the improvement in H:Q shows potential for the exercise protocol to be used in team sports warm-ups to reduce lower-limb injury risk (Holcomb et al., 2007). Further research should investigate the transient effects of the exercise protocol to ascertain whether impaired Q force output inhibits performance and whether the beneficial effects of improved H:Q are sufficient for an entire match.

REFERENCES
INFLUENCE OF LIMB DOMINANCE ON UNANTICIPATED CUTTING MANOEUVRES

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INTRODUCTION
Side-step cutting manoeuvres are associated with high anterior cruciate ligament (ACL) injury rates due to high peak ground reaction forces (PGRF) and internal tibial rotation at the knee (McClean et al. 2004). However, there is equivocal data regarding whether dominant limbs (DL) or non-dominant limbs (NDL) are at greater risk of injury based on injury incidence information and from ground reaction force data during anticipated cutting manoeuvres (Cowley et al., 2006; Hawkey et al., 2012).

METHODS
Following institutional ethics approval, eight male team sport participants (age: 21±1; height: 178.3±7.3cm; mass: 78.6±7.7kg) performed side-steps at 45° cutting angles off either their DL or NDL, over a force platform (Bertec, USA), past a simulated defensive opponent, at a speed of 4.5ms⁻¹ to 5.5ms⁻¹. The unanticipated stimuli was provided by Smart Speed light gates (Fusion Sport, Australia). Peak mediolateral ground reaction forces (PMGRFs) were recorded, at 1000Hz, for 3 successful trials for both the DL and NDL relating to body weight (BW). PMGRF data was analysed using paired samples t-tests.

RESULTS
Paired samples t-tests revealed significantly greater PMGRF in the DL than the NDL (p=0.020) (Figure 1).

DISCUSSION
Results show greater DL than NDL PMGRFs during unanticipated cutting manoeuvres, contrary to findings in anticipated studies (Hawkey et al. 2012). As NDLs have shown significantly shorter peroneus longus (PL) latency response times than DLs (Knight and Weimar, 2011) and as the PL controls ankle eversion, the significantly greater PMGRFs in DL may be due to muscle-strength imbalances and or proprioceptive deficiencies; potentially derived from a greater reliance on the DL for dynamic stability. Ankle eversion causes knee abduction placing the athlete in a dynamic valgus knee position during a cutting manoeuvre. This posture coupled with sufficiently high PGRFs is able to rupture the ACL (McLean et al., 2004). As the DL has a delayed control response of the ankle, athletes performing side-step cutting manoeuvres on their DL are therefore likely to exhibit greater dynamic valgus knee positions compared to the NDL; potentially indicating greater ACL injury risk in the DL than the NDL.

CONCLUSION
Current study highlights potentially higher risk of ACL injury in the DL. Further research should integrate 3D motion analysis and electromyography with GRF data to ascertain whether muscular deficits associated with limb dominance are a risk factor for ACL injury.

REFERENCES
GENDER DIFFERENCES IN LOWER EXTREMITY KINEMATIC AND KINETIC ASYMMETRY DURING DROP LANDINGS FROM TWO HEIGHTS

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INTRODUCTION
Gender differences in Lower limb kinematics have been reported during landing Hughes et al., 2008), quantifying the reports of increased injury rates among females. Symmetry is referred to as a limbs exact replication of the others movement (Exell et al., 2012a). Increased understanding of injury, performance and methods of data collection could be achieved through extensive research into biomechanical asymmetry. The aim of the study was to investigate lower extremity kinematic and kinetic asymmetries from two separate heights, with the purpose of identifying the injury potential associated with high asymmetry.

METHODS
Eight recreational athletes (4 male; 4 female) volunteered to participate in the study. Mean age, mass and stature were 20.5 [±0.7] years, 73.09 [±12.05] kg and 1.77 [±0.75] m, respectively. Each participant completed five drop landings from two heights (0.60 m and 0.90 m). Ground reaction force data were collected through two piezoelectric force plates (Kistler 9287BA), to identify touchdown. Three-dimensional position data were collected through an automated motion analysis system (CODA, Charnwood dynamics, Ltd). Asymmetry was calculated as a percentage using the method of Zifchock et al. (2008). Parametric statistics were used to determine significant asymmetry (p<0.05) between sides (Exell et al., 2012a).

RESULTS & DISCUSSION
Male and female participants demonstrated more asymmetry in the knee angle at touchdown from 0.60 m compared to 0.90 m. Conversely the opposite occurred for the hip angle with a larger number of participants showing significant asymmetry at 0.90 m. For male participants, significant asymmetry was most frequently reported for the ankle joint. For female participants, hip asymmetry was most frequent. The knee joint displayed the least amount of significant asymmetry across all participants. A closer look at joint angle asymmetry shows that (60.71%) of the significant asymmetries show greater flexion on the left hand side.

<table>
<thead>
<tr>
<th>G</th>
<th>P</th>
<th>0.60 m</th>
<th>0.90 m</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>K</td>
<td>H</td>
</tr>
<tr>
<td>1</td>
<td>1.21</td>
<td>-0.34</td>
<td>0.31</td>
</tr>
<tr>
<td>M</td>
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</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>

Positive values = left > right, negative values = right > left, shaded values indicate significant asymmetry

G = gender, P = participant, A = ankle, K = knee, H = hip

The range of asymmetry magnitudes among joint angles at touchdown (0.44 – 2.39%) is similar to values reported in touchdown gymnastic movements (0.87–3.30%; Exell et al., 2012b). Additionally the large number of participants displaying asymmetry at the ankle and hip during touchdown could indicate the amplified prospect of injury in one limb over another.

CONCLUSION
Results show that asymmetry varied among individuals, however both genders exhibited asymmetry in key kinematic variables during landing. Large amounts of asymmetry at the ankle and hip joints during landing may lead to increased injury predisposition.

REFERENCES
INTRODUCTION
When a gymnast performs the same skill a number of times it may be expected that gymnasts are attempting to use the same technique (Hiley et al., 2013). The shape of kinematic/kinetic curves is often a good indicator of how a movement task is accomplished and may help coaches/clinicians in identifying athlete’s/patient’s performance characteristics (Preatoni et al., 2013). In gymnastics the round-off (RO) is a fundamental skill and a key movement in the development of elite female gymnasts (Farana et al., in press). The aim of the present study was to conduct within-gymnast analyses to develop understanding of the continuous measures of variability of elbow joint kinematics and kinetics of expert gymnasts in the execution of the RO with different hand position.

METHODS
Six international level active female gymnasts performed 10 trials each of a RO to a flic-flac with a parallel and T-shaped hand positions. Data for 21 reflective markers attached to the gymnasts’ upper limbs and trunk were captured with an 8-camera Qualisys motion analysis system, sampling at 247 Hz. Simultaneously ground reaction force data were captured using two Kistler force platforms, sampling at 1235 Hz. The data were processed using Visual 3D. Three dimensional elbow angles and internal net elbow moments were determined for the second hand contact. All data sets were interpolated to 101 points using a cubic spline. The kinematic and kinetic continuous data were quantified using coefficient of multiple correlations (CMC) for each gymnast, with values >.70 considered to have acceptable repeatability (Queen et al., 2006).

RESULTS
For the 6 gymnasts and 12 kinematic (Table 1) and kinetic (Table 2) elbow joint variables there were only 4 instances of unacceptable repeatability (i.e. CMC<0.7). These were for different subjects, all for kinematic variables and both hand positions.

DISCUSSION
In our sample of expert gymnasts the higher within-session repeatability of elbow joint kinematics (Table 1) and kinetics (Table 2) were found in the frontal plane for parallel hand position. This may indicate repetitive abduction stress which may lead to overload and biological failure that occurs due to similar motor tasks (Farana et al., in press). Lower within-session repeatability of elbow joint kinematics found in the transverse plane for both hand positions (Table 1) suggests that different motor strategies can be used to achieve the same motor task (Preatoni et al., 2013).

CONCLUSION
Expert gymnasts show the lowest repeatability for rotation angles in the transverse plane during a fundamental RO skill. Analysis of repeatability may have important implications for performance and injury.

REFERENCES

Table 1: Within-gymnast CMC for elbow joint angles

<table>
<thead>
<tr>
<th>Gym</th>
<th>Parallel</th>
<th>T-shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abd.</td>
<td>Flex.</td>
</tr>
<tr>
<td>P1</td>
<td>.92 (.02)</td>
<td>.90 (.05)</td>
</tr>
<tr>
<td>P2</td>
<td>.85 (.07)</td>
<td>.90 (.02)</td>
</tr>
<tr>
<td>P3</td>
<td>.90 (.05)</td>
<td>.66 (.11)</td>
</tr>
<tr>
<td>T1</td>
<td>.83 (.07)</td>
<td>.71 (.05)</td>
</tr>
<tr>
<td>T2</td>
<td>.93 (.05)</td>
<td>.86 (.02)</td>
</tr>
<tr>
<td>T3</td>
<td>.94 (.05)</td>
<td>.93 (.02)</td>
</tr>
<tr>
<td>Group M</td>
<td>.90 (.05)</td>
<td>.83 (.05)</td>
</tr>
</tbody>
</table>

(50) (11) (12) (05) (11) (11)

Table 2: Within-gymnast CMC for elbow joint moments

<table>
<thead>
<tr>
<th>Gym</th>
<th>Parallel</th>
<th>T-shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>.97 (.05)</td>
<td>.94 (.02)</td>
</tr>
<tr>
<td>P2</td>
<td>.95 (.05)</td>
<td>.94 (.02)</td>
</tr>
<tr>
<td>P3</td>
<td>.94 (.05)</td>
<td>.81 (.02)</td>
</tr>
<tr>
<td>T1</td>
<td>.95 (.05)</td>
<td>.88 (.02)</td>
</tr>
<tr>
<td>T2</td>
<td>.98 (.05)</td>
<td>.89 (.02)</td>
</tr>
<tr>
<td>T3</td>
<td>.98 (.05)</td>
<td>.95 (.02)</td>
</tr>
<tr>
<td>Group M</td>
<td>.96 (.05)</td>
<td>.90 (.02)</td>
</tr>
</tbody>
</table>

(02) (05) (02) (07) (02) (05)

Notes: Gym P1, P2, P3 prefers parallel position; Gym T1, T2, T3 prefers T-shape position; Abd, Abduction; Flex, Flexion; Int. r., Internal rotation; Add, Abduction; Ext, Extension; Ext. r., External rotation M, mean; SD, standard deviation.
REFERENCE MEASUREMENTS OF ELITE JUDOKAS’ BODY COMPOSITION: UTILISATION OF A DUAL-ENERGY X-RAY ABSORPTIOMETRY METHOD

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2British Judo Centre of Excellence, University of Wolverhampton, UK
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INTRODUCTION
Regulations of the International Judo Federation (IJF) and International Olympic Committee (IOC) require athletes to compete in set weight categories. As a result, judokas demonstrate relatively low levels of body fat with high strength to mass ratios (Ali et al., 2010). However, previous studies, which have reported lower levels of body fat in Olympic competitors compared to other level performers, have analysed body composition utilising methods such as skinfold thickness and bioelectrical impedance. These methods are less accurate than “gold standard” analysis techniques such as dual-energy x-ray absorptiometry (DXA) (Hawkey, 2012). With judokas often having to reduce their weight significantly prior to competition (Artioli et al., 2010), potentially reducing performance and causing health risks, it is crucial to monitor judokas effectively. Therefore, the purpose of the current study was to assess the body composition of elite judokas using DXA.

METHODS
After institutional approval and consent, 12 elite judokas’ (mean: age = 19 ± 1.5 yrs.; height = 1.7 ± 0.1 m; mass = 71.5 ± 16.4 kg) body composition was analysed as part of their regular health and performance monitoring. Composition, including total bone mineral content (BMC), total bone mineral density (BMD) and corresponding Z-Score, total lean + BMC, % body fat, and visceral adipose tissue (VAT), was analysed using a Hologic Discovery W machine, with National Health and Nutrition Examination Survey (NHANES) reference data (Figure 1 & Table 1).

RESULTS
Table 1. Body composition data from DXA scans

DISCUSSION
As this is the first time body composition data on judokas has been reported using DXA, it is proposed that the data set act as a reference point for future investigations in this area. Judokas regularly reduce weight pre-competition to obtain a competitive advantage over lighter opponents. Crucially, this is often achieved using a number of aggressive nutritional strategies, which place the judoka at a high risk of injury and/or health complications, and can also limit performance. With regular monitoring of judokas’ body composition, essentially extending what has been introduced in this reference data set, it may be possible to identify those suitable for ‘making weight’ in certain categories and for better assessment of training protocols.

CONCLUSION
This is an important data set that can be used as a reference point for future longitudinal invention studies on judokas to ensure effective and accurate monitoring of body composition.

REFERENCES


Figure 1. Image (left) showing bone (blue), muscle (red/pink), and fat (yellow) and (right) segmental x-ray.
OLDER FEMALES EXHIBIT GREATER PERFORMANCE IMPROVEMENTS FOLLOWING VIBRATION TRAINING THAN YOUNGER FEMALES

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INTRODUCTION
Muscle performance decreases with age (Doherty, 2003). Evidence suggests that whole body vibration (WBV) improves jump performance and range of motion (ROM) in younger cohorts (Delecluse et al., 2003; Hawkey, 2012). Research investigating interactions between WBV and age is limited. Present study determined the effects of WBV training on performance outcomes in older and younger recreationally active females.

METHODS
Following institutional ethical approval, 25 recreationally active females (Young: 20–30 yrs) (mean: age = 23 ± 4 yrs.; height = 1.64 ± 0.08 m; mass = 59 ± 9 kg) and Older 45–55 yrs. (mean: age = 51 ± 4 yrs.; height = 1.63 ± 0.08 m; mass = 68 ± 17 kg) were randomly assigned (within each age group) to WBV or control groups. The WBV group trained on a Power Plate pro5 platform (Figures. 1-3), in accordance with the overload training principal (Figure. 4). Control group performed identical exercises, with sham vibration. Prior to, and after, 5-week study vertical jump (Just Jump), and ROM (sit-and-reach) were measured.

RESULTS
There was a significant effect (P < 0.001) from pre- to post- values for jump performance and a significant interaction (P < 0.001) between intervention vs. control group and pre- to post-intervention for jump performance. There was also a significant 3-way interaction effect (P = 0.020) for group-by-pre-post-by-age, with the older group improving at a greater rate than their younger counterparts. There was a significant effect (P = 0.003) and a significant interaction between intervention vs. control group for ROM: Fig 5.

DISCUSSION
The present study contributes novel data demonstrating that WBV is a time-efficient exercise paradigm for enhancing jump performance and ROM in an older population; confirming data from younger cohorts (Hawkey, 2012). The greater improvements in older females compared to their younger counterparts has important health implications, given the age-related reduction in muscle performance (Doherty, 2003).

CONCLUSION
Short-term WBV training improves jump performance to a greater extent in older compared to younger females. It is, therefore, recommended that WBV training be undertaken to minimise age-related performance deterioration. Future studies are encouraged to address this possibility.

REFERENCES
INTRODUCTION
The velocity, amplitude, and direction of perturbations are identified by the sensory system and useful neurological information can be found by studying the influence of sensory inputs via EMG signals (Diener et al., 1988). Balance and recovering from perturbed balance is a key fundamental skill in dance. Currently there is no research which investigates balance control in dancers when responding to well defined perturbations from platform translations. The aim of this study was to investigate whether EMG latencies are altered depending on different postures commonly utilised in dance.

METHODS
Eight female dancers performed 64 perturbed stance trials in anterior and posterior directions for four dance positions (ballet 2nd position flat feet, ballet 2nd position demi-pointe, contemporary position feet flat and contemporary position demi-pointe) on two Bertec force plates embedded in a CAREN virtual reality environment (Picture 1).

There were four slow (10 cm at 10 cm.s⁻¹ for flat feet positions, 5 cm at 5 cm.s⁻¹ for demi-pointe positions) and four fast platform transitions (10 cm at 20 cm.s⁻¹ for flat feet position, 10 cm at 10 cm.s⁻¹ for demi pointe positions) in each direction. Six Trigno EMG sensors (2000Hz sample rate) were attached bilaterally to: Tibialis-Anterior (TA), Peroneus-Longus (PL) and Gastrocnemius (G). EMG delays were calculated from the stimuli (platform movement based on horizontal force) to the first burst of any muscle by visual inspection. One-way ANOVA was used to test for significant differences (p<.05).

RESULT AND DISCUSSION
Group mean EMG latencies were: 89±21 ms ballet flat; 138±20 ms ballet demi-pointe; 102±15 ms contemporary flat; 145±22 ms contemporary demi-pointe (Table 1). Calculated EMG latencies show demi-pointe positions have longer delays than flat positions and there were significant differences between flat and demi positions. This result seems to occur because muscles were already activated and there was limited ankle movement available to deal with balance recovery in demi pointe. For most of the dance positions, G or PL were active first for backward perturbations and TA or PL were activated first in forward platform perturbations. Interestingly, in contemporary flat position, PL was not activated as fast as in other conditions during forward direction perturbations.

CONCLUSION
Neurological delays may be controlled differently by CNS depending on dance positions and the effect at other muscles and joints is also under investigation.

REFERENCE
INTRODUCTION

Segmental kinematics are frequently investigated within golf. However, the number of trials analysed varies widely between studies and there is no consensus on how many are required to ensure a stable mean. Other areas have developed data analysis techniques to determine the number of trials required, e.g. walking (Hamill & McNiven 1990) & jumping (Racic et al. 2009). This study aimed to use similar techniques to investigate how many driver swing trials are necessary to ensure stable mean values for pelvis and thorax kinematics.

METHODS

Four low handicap (0-2) golfers attended the lab on two consecutive days. On both days procedure and tester were the same. A 12 camera VICON system (250Hz) collected kinematic data from 15 reference driver trials. Axial rotation and velocity for pelvis (PR, PV) and thorax (TR, TV) along with X-factor (X) and X-factor velocity (XV) were calculated and low-pass filtered (15Hz) using Visual 3D.

Data was analysed in MATLAB. Cumulative means were generated in trial order, for each variable, at top of the backswing (TB), ball contact (BC) and for maximum X-factor during the downswing (X_{MAX}). An arbitrary limit of ± 0.25 × SD of the overall mean was set as the criterion. The point at which the cumulative mean, and all subsequent means, fell within these limits was identified (Fig. 1).

RESULTS

Table 1 shows the number of trials to achieve stability for each golfer, session and variable. Mean number of trials to achieve stability are shown across golfer and variable. The mean number of trials to reach stability when averaged across all golfers and variables is 10.

DISCUSSION

Previous studies have recommended the overall mean (rounded up) across all subjects and variables (e.g. Racic et al. 2009). In this study, a minimum of 10 trials would be required. Although, notably this fails to ensure stability of any variable mean across all golfers. The maximum values for all variables range from 11 to 15. If these maximum values are considered it would suggest that in order to achieve comprehensive stable pelvis and thorax kinematic means 16+ trials would be required; the maximum of 15 was reached for PR and TR. Achieving stability only with the inclusion of all reference trials may indicate more are needed. Regardless, data from table 1 suggest the amount of trials should be at least 10 and possibly even greater than 15.

CONCLUSION

The overall mean across golfers and variables suggests a value of 10 trials are required when investigating pelvis and thorax kinematics in golf driving; however caution is urged due to inconsistency across golfers. To account for all variables across all golfers the maximum values indicate 16 or more trials would be required.

REFERENCES

INTRODUCTION
Within the literature, two methods are presented as the criterion method for measuring mean power output during the push-off phase of the loaded countermovement jump (CMJ): the force platform (FP) method (Hori et al., 2007) and the combined method (Cormie et al., 2007). When compared to the FP method, the combined method produces significantly greater values (Cormie et al., 2007; Hori et al., 2007). However, testing for significant differences tells us little about agreement. Assessing agreement may help elucidate meaningful differences between the two methods, as well as aid the comparison and generalizability of the results of previous studies. Therefore, the aim of the present study was to assess agreement between the FP method and the combined method measurements of mean power output during the loaded CMJ.

METHODS
Forty resistance trained athletes (age 22.5 ± 2.8 years, height 1.81 ± 0.05 m, mass 89.1 ± 12.4 kg) performed two single maximal effort CMJ with additional external loads of 0, 25, 50, 75 and 100% of body mass (BM).

Data were collected using two force platforms (1000 Hz, Kistler Instruments Ltd., Hook, UK) synchronised with a 10-camera optoelectronic motion capture system (250 Hz, Vicon Motion Systems Ltd., Oxford, UK). Retro-reflective markers were placed on the end points of the external load.

**FP method:** Instantaneous power was calculated as the product of the vertical ground reaction force (VGRF) and the vertical velocity of the system (body + external load) centre of mass (CM).

**Combined method:** Instantaneous power was calculated as the product of the VGRF and the vertical velocity of the external load.

For both methods, power was averaged over the push-off phase, which was calculated according to Hori et al. (2007).

The mean of the differences, the standard deviation (SD) of the differences and the 95% Limits of Agreement (LOA: mean of the differences ± 1.96 SD) were calculated on base 10 logarithmically transformed data. Practically unacceptable LOA were determined a priori as greater than ± 5%.

RESULTS AND DISCUSSION

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0%</td>
<td>1.44</td>
<td>0.06</td>
<td>1.28</td>
<td>1.63</td>
</tr>
<tr>
<td>+25%</td>
<td>1.30</td>
<td>0.04</td>
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<td>1.41</td>
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<tr>
<td>+50%</td>
<td>1.22</td>
<td>0.05</td>
<td>1.11</td>
<td>1.34</td>
</tr>
<tr>
<td>+75%</td>
<td>1.16</td>
<td>0.06</td>
<td>1.03</td>
<td>1.32</td>
</tr>
<tr>
<td>+100%</td>
<td>1.14</td>
<td>0.10</td>
<td>0.95</td>
<td>1.38</td>
</tr>
</tbody>
</table>

Note: a ratio of greater than 1.00 indicates that the combined method gave a higher estimate than the FP method.

When the two methods were compared, fixed bias and practically unacceptable LOA were observed at all external loads (Table 1). From a theoretical perspective, the FP method is derived from Newton’s 2nd Law. Conversely, the combined method is underpinned by the assumption that the velocity of the external load is equivalent to the velocity of the system CM (Cormie et al., 2007). Therefore, the observed differences may be explained by violations of this assumption (Hori et al., 2007). However, agreement appeared to improve as load increased, suggesting that this assumption depends on the magnitude of the external load. As such, the results of previous studies using the combined method should be interpreted with caution, particularly when comparisons are made between external loads. Further, as agreement was influenced by the magnitude of external load, comparisons between the results of previous studies using the FP method and the combined method should also be made with caution.

CONCLUSION
The FP method and the combined method should not be used interchangeably for measuring mean power output during the push off phase of the loaded CMJ between external loads of 0 and 100% of BM.

REFERENCES

THE EFFECT OF THE IMPACT POINT ON GOLF BALL ROLL KINEMATICS

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INTRODUCTION
Little research has investigated the effect of the impact point on the golf ball and on ball roll kinematics (velocity, side spin, initial ball roll [IBR], forward roll [FR], vertical launch angle [HLA], horizontal launch angle [HLA] and whether the ball was pushed or pulled [ended left or right of the target]. Pelz (2000) identified that dimple patterns affect the direction variability (HLA and whether the ball was pushed or pulled) during the putt (dimple error). Richardson and Hughes (2014), using a putting robot, identified that the variability of the impact point on a golf ball had significant associations with the HLA and whether the ball was pushed or pulled. Whereby, when the edge of a dimple was struck, the resultant putt travelled with direction error away from the intended target line. Both putter face angle and putter path have been demonstrated to cause putting direction variability (Karlsen et al., 2008; Pelz, 2000). However, neither author considered the influence of the impact point on the golf ball. Therefore, the aim of this study was to investigate the effects of impact point on golf ball roll kinematics, with human participants.

METHODS
A total of 22 right handed golfers participated (age 42 ± 12.4; handicap 13.6 ± 7.4 (range 0 – 28); height 1.76 ± 0.21 m; mass 88.6 ± 23.8 kg). Participants completed six successful 3.2 m trials with two different putters with a layer of pigmented emollient (PE) on the face (one groove faced, one non-grooved). Post trial a picture was taken showing the PE imprint on the golf ball. The impact point was determined by identifying the centroid location (centre of dimple pattern). From which, the following impact variables (IV) were measured: distance (mm) and angle (°) from the centroid location and surface area of the impact zone (mm²). Multiple regression analysis was used to identify if any significant associations existed between the IV and kinematic ball roll variables measured using Quintic Ball Roll software v2.4.

RESULTS
Multiple regression analysis identified a significant association between the IV and ball velocity for both the grooved and non-grooved putters. A significant association was identified between the impact variables and the ball velocity. No other significant associations were observed for both putters for any of the other variables. (Figure 1).

DISCUSSION
All kinematic ball roll variables were subject to variability from trial to trial. However, with the exception of velocity, none of this variation can be accounted to the impact point on the golf ball. The variability of velocity caused by the impact variables was minimal (Grooved = 0.02 m s⁻¹, Non-grooved = 0.01 m s⁻¹) and will have little bearing on the success rate of a putt. With a putting robot, significant associations were identified for HLA and whether the ball was pushed or pulled (Richardson & Hughes, 2014). This was not observed within the current study, possibly because of the variation of the putter face angle and putter path. These might have negated the effect of dimple error, or the differences by which energy was imparted to the ball. This demonstrates that Karlsen et al. (2008) and Pelz (2000) did not need to consider the impact point on the golf ball when assessing putting direction variability.

CONCLUSION
No significant associations were identified between the IV and horizontal launch angle and whether the ball was pushed or pulled, this may have been due to the variance of putter face angle and putter path, rendering the effects of dimple error negligible.

REFERENCES
MUSCLE ACTIVATION DURING THE FRONT AND BACK SQUAT: A PILOT STUDY

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INTRODUCTION
Traditionally the back squat has been used to strengthen the lower limb and back muscles required for many sporting activity (Clark et al. 2012). However, there are increased concerns regarding injury risks during the back squat, particularly in the lower back and knee regions (Gullett et al. 2008). The front squat has been recommended as a safer alternative and has been suggested to provide similar training adaptations to the back squat as a result of similar muscle activity produced (Gullett et al. 2008). Additionally, previous reports identified differences in activation during the concentric and eccentric phases of the squats (Gullett et al. 2008). However, it is unclear whether the muscle activations during these phases are influenced by squat variation. Therefore this pilot study aims to the examine muscle activation during the two squat variations and their contribution during ascent and descent phases of both squats.

METHODS
Three Royal Marines (age 29 ± 1.5 y, 92.6 ± 14.4 kg, 188 ± 7 cm), who were experienced at performing both squats volunteered for the pilot study. Following a warm up, participants were asked to perform three repetitions at 70% of their 1 repetition maximum for the front and back squats.

Muscle activity was collected using surface electromyography (EMG, Biometrics Ltd, UK) for the Rectus Femoris (RF), Vastus Medialis (VM), Vastus Lateralis (VL), Bicep Femoris (BF), Semitendinosus (ST), Erector Spinae (ES) and Gluteus Maximus (GM). A goniometer was placed on the Femur and Tibia to identify the eccentric and concentric phases of the squats. Data was then processed using a custom written Matlab code (Matlab, 2012b), which included full-wave rectification, a band pass (15-500 Hz) Butterworth filter and RMS with a 20 ms window. Data was normalised to the average of the three repetitions maximum for the front and back squats.

RESULTS
Figure 1 highlights no significant differences in muscle activity between the front and back squats. However, during the eccentric phase significantly greater peak RF was reported during the back squat compared to the front squat. Greater peak VM occurred in back squat compared to the front squat during the concentric phase. The back squat took significantly longer time to complete compared to the front squat which had greater peak knee flexion.

DISCUSSION
The present pilot study is in agreement with previous reports, where little differences in muscle activation, occurred between the front and back squat (Gullett et al. 2008). This data suggests that the front squat may produce similar adaptations to the back squat with reduced risk of injury through lower knee moments and less trunk inclination during the front squat (Gullett et al. 2008). Greater adaptations have been reported during eccentric training compared to concentric training (Roig et al. 2009). The higher RF activations during the eccentric phase of the back squat may suggest greater adaptations in the RF compared to the front squats.

CONCLUSION
The data collected in this pilot study and previous literature suggests that the front squat may produce similar muscle activations to the back squat without the implications the back squat has on injury risks. Further investigation of the ankle and hip joint may further explain possible differences between the squats.

REFERENCES
COMPARISON OF TEMPORAL-SPATIAL PARAMETERS OF GAIT IN TRANSFEMORAL AMPUTEE WITH BIONIC AND MECHANICALLY PASSIVE KNEE – CASE STUDY

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INTRODUCTION

Transfemoral amputees must overcome the loss of two major joints and the less or partial loss of many of the lower limbs muscle groups. New knee prosthetic designs are supposed to provide amputees with greater comfort and achieve symmetry between the affected and nonaffected limb. Gait asymmetry quantification in amputees in relation to nonamputees represents the first step trying to define the intensity of asymmetry which would be acceptable for prosthesis gait during rehabilitation (Dingwell et al., 1996). The aim of study was to compare kinematic parameters and symmetry of gait in amputees using the bionic knee joint with those in patients wearing the mechanically passive knee joint in relation to nonpathological gait.

METHODS

One female (age – 26, height – 1.64 m and weight – 50 kg) with transfemoral amputation participated in the study. The amputation was on the right side. The participant visited the laboratory on two occasions (first with mechanically passive knee joint and second with bionic knee joint). The participant performed 15 trials of gait. For kinematic analysis we applied a set of seven infrared cameras (Qualisys, Oqus 100, Sweden). The recording frequency of the cameras was 247 Hz. For inematic data measurement and processing, we used Visual3D v4 software (C-motion, Germantown, MD, USA) was used for model creation and data processing. The symmetry index (SI) was used to assess gait symmetry:

\[ SI = \frac{1}{2}(X_{\text{nonaffected}} - X_{\text{affected}}) \times 100\% \]

where SI = 0 represents absolute symmetry. The effect size (ES) was used to assess practical significance. The ES values were: 0 – 0.2, insignificant effect; 0.2 – 0.6, low effect; 0.6 – 1.2, mean effect; 1.2 – 2.0, high effect; 2.0 – 4.0, very high effect; ≥ 4.0, excellent effect.

RESULTS

Step time and step length of the affected limb in patients with a passive knee joints is longer than that in the control group and bionic group.

Symmetry index shows that gait with bionic knee is more symmetric than with passive.

Table 1: Comparison of the temporal-spatial parameters of gait in bionic (Rheo) and mechanically passive (Pasiv) patients with control group. (Un – unaffected limb, Af – affected limb)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Limb</th>
<th>Rheo</th>
<th>Pasiv</th>
<th>Kontrol</th>
<th>ES R</th>
<th>ES P</th>
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</thead>
<tbody>
<tr>
<td>Step t. (s)</td>
<td>Un</td>
<td>0.52±0.01</td>
<td>0.53±0.02</td>
<td>0.58±0.03</td>
<td>2.80</td>
<td>1.95</td>
</tr>
<tr>
<td></td>
<td>Af</td>
<td>0.58±0.01</td>
<td>0.64±0.02</td>
<td>0.66±0.03</td>
<td>6.16</td>
<td>4.42</td>
</tr>
<tr>
<td>Stance t. (s)</td>
<td>Un</td>
<td>0.68±0.02</td>
<td>0.71±0.02</td>
<td>0.72±0.04</td>
<td>1.11</td>
<td>0.57</td>
</tr>
<tr>
<td></td>
<td>Af</td>
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<td>0.63±0.03</td>
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Table 2: Symmetry index (SI) between unaffected and affected limb. (Rheo – group with bionic knee joint. Pasiv – group with passive knee joint)

<table>
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<tr>
<th>Variable</th>
<th>SI(%) Rheo</th>
<th>SI(%) Pasiv</th>
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<tr>
<td>Step time (s)</td>
<td>10.49</td>
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<td>Stance time (s)</td>
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<td>Swing time (s)</td>
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<td>Cycle time (s)</td>
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<tr>
<td>Step length (m)</td>
<td>10.7</td>
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DISCUSSION

Gait asymmetry is considered to indicate pathology (Sadeghi et al., 2000). For unilateral amputees, a symmetrical gait is important to prevent excessive loading of the intact leg (Nolan et al., 2003). Our results suggest that the gait symmetry is better when used bionic knee, this may indicate the greater stability of bionic knee joints.

CONCLUSION

Compared with a mechanically passive knee joint, a bionic knee joint evinced gait symmetry. Gait with bionic knee were similar to those non amputees.

REFERENCES

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