BASES BIG 2016 Programme

Kindly sponsored by

9:30	**Registration**		James Parsons Lower Lecture Theatre
10:00	**Welcome**		
10:15	**Podium Presentations 1**		
	(Chairs: Prof. Costis Maganaris & Dr. Mark Lake)		
	10:15	Amy Maslivec (Uni. of Cumbria) Differences in head movement between young and older females do not affect whole body movement during gait initiation	
	10:30	Barbara Kalkman (LJMU) The effect of cerebral palsy on Achilles tendon moment arm length	
	10:45	Jim Emery (Sheffield Hallam Uni.) A method for characterising high acceleration movements in small sided football	
	11:00	Eddie Bradley (Uni. of Sunderland) Standardisation and validation of batak reaction walls	
11:15	**Keynote Presentation**		
	(Chair: Prof. Bill Baltzopoulos)		
		Prof. Richard Jones (University of Salford) The use of clinical biomechanics in knee injury and future degenerative disease.	
12:00	**Lunch**	sponsored by Qualisys AB and C-Motion	
12:45	**Poster Presentations**		Biomechanics Labs Tom Reilly Building
1:30	**Coffee Break**	sponsored by Quintic Consultancy Ltd	
			James Parsons Lower Lecture Theatre
2:00	**BASES Supervised Experience, Accreditation, Chartered Scientist Status**		
		Dr Adam Hawkey, Dr Zoe Knowles	James Parsons Lower Lecture Theatre
2:15	**Podium Presentations 2**		
	(Chairs: Prof. Gabor Barton & Dr. Tom O'Brien)		
	2:15	Charlotte Apps (LJMU) Ankle and knee joint stiffness in running; unpredictable and predictable shoe perturbations	
	2:30	Jennifer Hogg (Uni. of North Carolina at Greensboro) The influence of femoral anteversion and hip range of motion on dynamic knee valgus in females during a single-leg forward hop	
	2:45	Mohsen Sayyah (Loughborough Uni.) Factors influencing variation in dive height in 1m springboard diving	
	3:00	Jos Vanrenterghem (KU Leuven) IKD1D: Isokinetic dynamometry analysis for 21st century sport science	
	3:15	Maria Bisele (Nottingham Trent Uni.) Optimisation of an objective predictive machine learning algorithm in human locomotion.	
	3:30	Bodil Oudshoorn (Sheffield Hallam Uni.) Foot velocities causing laceration injuries in rugby union	
3:45	**Student Awards**	sponsored by Human Kinetics	
4:00	**Depart**		

Motion capture

Ideal for improved performance and research.

QUALISYS
Motion Capture Systems

Qualisys is the leading provider of flexible, affordable and mobile solutions for optical motion capture.

We have been supporting the UK biomechanical research community for 20 years with an high end optical motion capture system.

Our Workshop includes presentations of hardware, software and a practical demonstration.

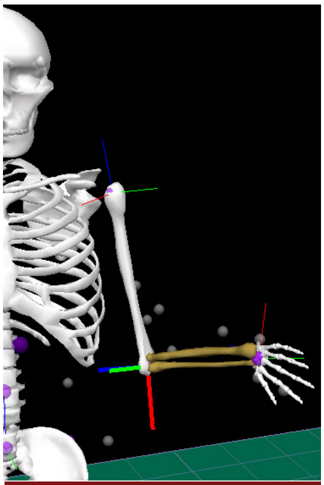
Qualisys

Proud Sponsor of 2016 BASES Biomechanics Interest Group meeting.

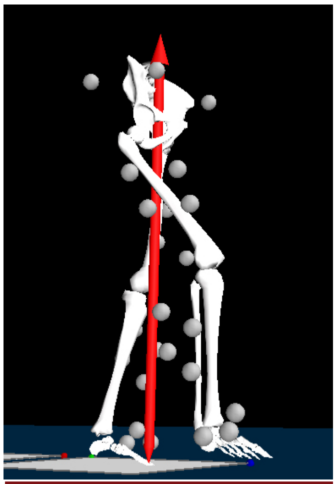
VISIT OUR WORKSHOP AT LJMU
TUESDAY 29 MARCH 12.00-16.30
HOST: DR. MARK ROBINSON

Visual3D™

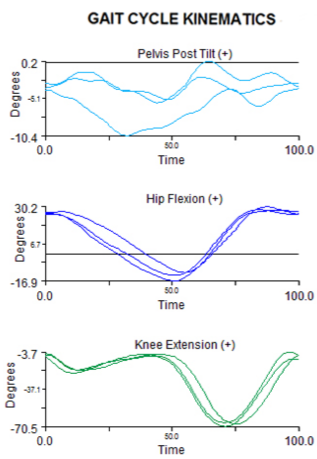
The #1 rated research software package for 3D Motion Capture Analysis and Modeling.



Model Building



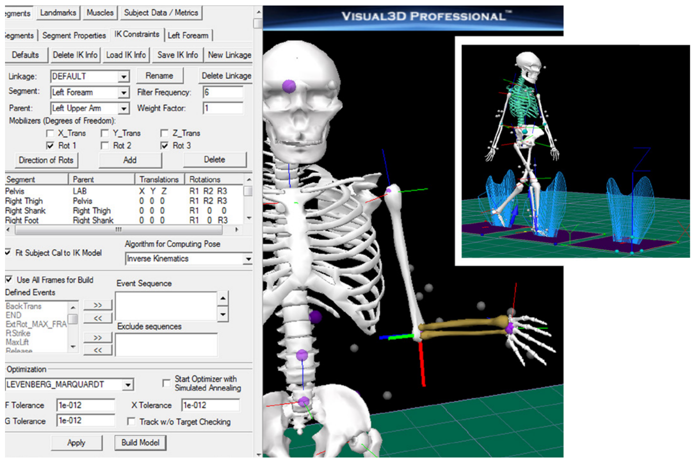
Analysis



Reporting

Visual3D™ Key Features

- Flexible Modeling - Global Optimization, 6 DOF, Conventional Gait, Hybrids, Virtual Markers, and more.
- Kinematics, Inverse Kinematics, Kinetics (Inverse Dynamics)
- Integrate Analog Data: AMTI Stairs, Instrumented Treadmills, Force Plates, EMG, and more.
- Comprehensive Reporting and Graphing
- Export to OpenSim
- Comprehensive Data Management for Complex Analyses
- Real-Time Streaming and Data Capture*
- Keeps a History of all Processing Steps on the Data
- 3D Digitizing Pointer Support
- Functional Joint Center Calculations
- Extensive Pipeline Scripting for Automation



- Real-Time Biofeedback, RT Analysis, RT Pipeline
- Relational Database Support
- Complex Inverse Kinematics
- Induced Acceleration Analysis

Hardware Independent Research Software

Visual3D processes standard c3d files, ASCII, and custom inputs. Analog data (force plates, EMG, EEG, etc) can be integrated and processed with the motion capture data.

*For Real-Time features hardware must support Real-Time data streaming

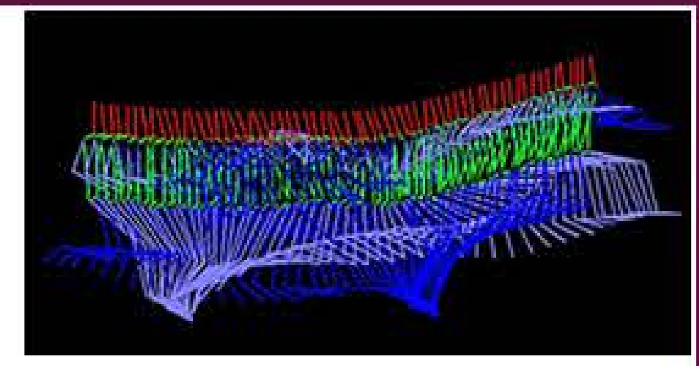
Supported Motion Capture Systems

Qualisys	Phoenix Technologies
Northern Digital	NaturalPoint Optitrack
Codamotion	PhaseSpace
Motion Analysis	Polhemus
Vicon	Xsens

C-Motion
Research Biomechanics
www.c-motion.com | info@c-motion.com

Quintic®
#1 for Sports Analysis

Quintic Biomechanics 2D Analysis Software



"At the University of Chichester we have been users of Quintic Biomechanics for over 12 years. From the inception of this product we have seen excellent developments in both qualitative and quantitative analysis procedures. We use Quintic with all our undergraduate students as we have a site licence for the software. In my mind it is the all-round best value product available for specialist sporting video based motion analysis."

Neal Smith PhD : Field Leader in Biomechanics and Research Methods

Quintic Biomechanics v26 Software Functionality:

- Capture and view up to 6 videos side by side and in synchronisation.
- Manual or automatic tracking of up to 21 points.
- Linear and angular analysis - displacement, velocity and acceleration.
- Multiple trial averaging – average a point/angle for up to 21 trials.
- Synchronise videos with an external *.CSV file (e.g. pressure/force data).
- Centre of mass and intersection models.
- Visual comparison using video blend and overlay.
- Drawing tools and static angle calculations.
- Single photo snapshots and multiple photo sequences.
- Flip, rotate, trim and add logos/watermarking to videos.
- Export analysis – save analysed videos as compressed *.avi files.
- Compatible with the NEW Quintic Automatic Report bolt-on software:
  Human Gait / Cycling / Equine Gait / Golf Putting

Quintic 2D Software Packages:

Packages can be tailored to meet individual requirements: single licences, multiple stand-alone licences and the Quintic Network Licence available. Generous multi-licence discounts provided.

Quintic Network Licence

Quintic Network Licences are very popular with larger clients as they allow for an unlimited number of post processing licences, as well as including 5 stand-alone data capturing licences. Benefits include:

- The software can be accessed from every computer on the Network.
- Reduction in software installation and upgrade time.
- Tailored to be compatible with individual computer networks.
- Automatic enrolment onto the QAMA scheme*.

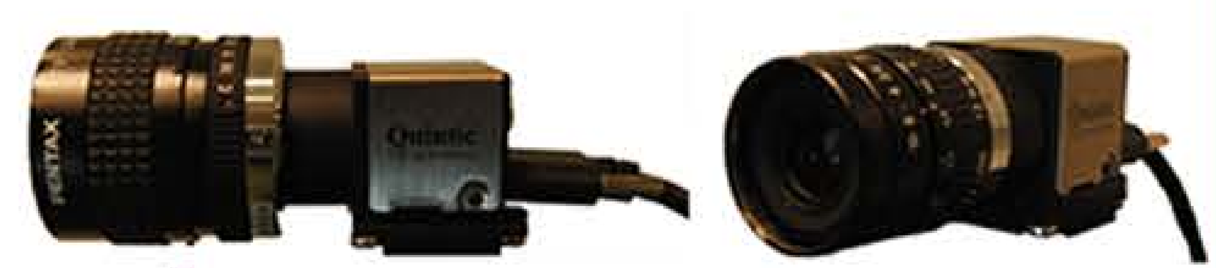
Quintic Annual Maintenance Agreement (QAMA*)

Our popular QAMA's provide the following key benefits:

- Software upgrades included - upgrade upon the release of a new version.
- Initial training session - either on site or at our head office.
- Annual training session - in person (UK) or online.
- Comprehensive support - e-mail, telephone, Skype and PC meeting.
- Ancillary services - licence resets and technical support (e.g. codecs).

Quintic Hardware
New USB3 4MPixel Camera

- Higher specification and greater image resolution, allows the user to capture a larger field of view at the higher frame rates, as well as providing a higher quality and more defined image.
- An impressive frame rate relative to the screen resolution - With image sizes up to 2048 x 2048 at 75 fps, however by changing the area of interest, a recording speed of 500fps can be achieved.
- Greater accuracy tracking makers due to increased pixels
- Powered directly from the laptop - making it portable and ideal for data collection in the field.



Quintic Automatic Reports

" As our software is extensively used in applied settings, where speed and accuracy of analysis and reporting is of a premium, we have developed a range of Quintic Automatic Reports. Our new Quintic Automatic Reports enable the user to analyse a movement and quickly produce a detailed PDF report which quantifies the key variables at the key time events for that specific movement. The Quintic Automatic Reports really are unique in terms of the amount of information they contain and how user friendly they are!"

Dr Paul Hurrion : Managing Director Quintic Consultancy Ltd.

Quintic Automatic Reports:

Additional bolt-on software to the Quintic 2D Biomechanics software for the analysis of:

- Human Gait
- Cycling
- Equine Gait
- Golf Putting

Key Features:

- Automatic calculation of key variables at key time events - no need to spend time determining these parameters!
- Multiple trial analysis - calculate averages and determine variability.
- Provides comprehensive feedback - graphical, numerical and visual.
- Produce detailed and professional PDF reports - including your logo!
- Quick and accurate analysis - essential in an applied setting.

BASES BIG 2016 Programme

30th March 2016

Contents

Podium Presentations 1

(Chairs: Prof. Costis Maganaris & Dr. Mark Lake)

10:15 Amy Maslivec (Uni. of Cumbria)

Differences in head movement between young and older females do not affect whole body movement during gait initiation

10:30 Barbara Kalkman (LJMU)

The effect of cerebral palsy on Achilles tendon moment arm length

10:45 Jim Emery (Sheffield Hallam Uni.)

A method for characterising high acceleration movements in small sided football

11:00 Eddie Bradley (Uni. of Sunderland)

Standardisation and validation of batak reaction walls

DIFFERENCES IN HEAD MOVEMENT BETWEEN YOUNG AND OLDER FEMALES DO NOT AFFECT WHOLE BODY MOVEMENT DURING GAIT INITIATION

Maslivec, A.[1], Laudani, L.[2], Bampouras, TM.[1], Dewhurst, S.[1]
[1] Active Ageign Research Group, University of Cumbria;
[2]: Cardiff Metropolitan University

INTRODUCTION

Older adults are at an increased fall risk during transition tasks such as gait initiation (Melzer, Kurz, Shahar, Levi, & Oddsson, 2007). Differences found in head stability between young and older adults are suggested to threaten balance and thus increase such risk of falls in older adults (Laudani, Casabona, Perciavalle, & Macaluso, 2006). To identify the role of head stability on balance, we examined the effect of upper body segments acceleration and their displacement variability on whole body movement and its variability, an indicator of balance, during gait initiation.

METHODS

Eleven young (23±1 years) and 12 older (75±2 years) females initiated gait at a self-selected, comfortable speed, evaluated using 3D motion analysis. Acceleration root mean square (RMS) values were calculated for the pelvis, trunk and head in the anteroposterior (AP), mediolateral (ML) and vertical (V) direction. Attenuation coefficients of acceleration were calculated for pelvis-head (C_{PH}), pelvis-trunk (C_{PT}) and trunk-head (C_{TH}) in the AP and ML directions. Total linear displacement was measured for centre of mass (COM) in the AP and ML direction. Finally, angular displacement variability of the pelvis, trunk and head, and linear displacement variability of the COM were evaluated by calculation of the average standard deviation (AvgSd). Independent samples t – tests were used to test for differences between young and older for the RMS of acceleration at each upper body segment, attenuation of such acceleration and for the AvgStd of each upper body segment.

REFERENCES

Laudani L, Casabona A, Perciavalle V, Macaluso A. (2006). J Electromyogr Kinesiol, 6, 603–610 http://doi.org/S1050-6411(06)00104-0 [pii]

Melzer I, Kurz I, Shahar D, Levi M, Oddsson L. (2007). Age Ageing, 36, 532–537

RESULTS

No differences in RMS values were found in either the pelvis, trunk, or head in the AP or ML direction between groups. Young were able to attenuate acceleration for AP C_{TH} whilst older could not (10.1±9.48% and -4.6 ±30.14%, [P=0.02], respectively). Young had a larger total AP COM displacement compared to older (408.2±86.7mm and 313.3±33.5mm, [P=0.004]); however, there were no differences in total ML COM displacement. AvgSd of angular displacement of the head was higher in older compared to young in the AP direction (3.7±1.5° and 1.5±0.6° [P=0.004], respectively), however, AvgStd were similar for the pelvis and trunk, and COM between young and older in the AP and ML direction.

DISCUSSION

Despite older demonstrating a dampened ability to attenuate acceleration between the trunk and head, and greater variability in the movement patterns of the head, there was no difference in total ML displacement or variability of COM in the AP and ML direction between age groups. This may be due to the head mass not being sufficiently large enough to alter COM pattern during a dynamic movement or that the variability in head movement itself is aimed to allow achieving this pattern.

CONCLUSION

Differences in head movement between young and older do not affect whole body movement, and therefore does not appear to reduce balance in older adults during gait initiation.

THE EFFECT OF CEREBRAL PALSY ON ACHILLES TENDON MOMENT ARM LENGTH

Barbara M. Kalkman [1], Lynn Bar-On[2], Francesco Cenni[2], Constantinos N. Maganaris[1], Gill Holmes[3], Alfie Bass[3], Gabor J. Barton[1], Kaat Desloovere[2], Thomas D. O'Brien[1].
[1]Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, UK
[2]Department of Rehabilitation Sciences, KU Leuven, Leuven, Belgium
[3]Alder Hey Children's NHS Foundation Trust, Liverpool, UK
email: b.m.kalkman@2014.ljmu.ac.uk

INTRODUCTION

When studying muscle and whole-body function in children with cerebral palsy (CP), knowledge about both internal and external moment arms (MA), defined as the perpendicular distance from the joint centre of rotation to the muscle's line of action and the external force, respectively, is essential since their ratio determines the mechanical advantage of the joint studied (Lee and Piazza, 2009). In children with CP, deformities alter the external moment arm length at the ankle, causing lever arm dysfunction, and disrupting the mechanical advantage (Novacheck and Gage, 2007), which is treated surgically. However, it is currently unknown whether bony deformities affect the Achilles tendon moment arm (MA_{AT}) length in children with CP. Moreover, algorithms to predict the MA_{AT} from anthropometric measurements would be valuable for clinical and modelling application.

METHODS

Nineteen children with CP (age:10.2±3.1 years, 7 with hemiplegia, 12 with diplegia, GMFCS level: I (11) and II (8)) and twenty TD children (age:10.6±3.0 years) participated. MA_{AT} was calculated at 20° plantarflexion, as the derivative of calcaneus displacement with respect to ankle angle, according to the tendon excursion method. Kinematics were measured with a motion analysis system, at 120Hz (Optitrack, USA). Seven anthropometric variables were measured for regression against MA_{AT}.

RESULTS

Normalised MA_{AT} was 10% smaller in children with CP than TD children (p=0.003, 95% CI [0.73, 3.34], figure 1). MA_{AT} could be reliably predicted by all anthropometric measurements with lower leg length (LLL) showing the highest combined R^2 values (table 1).

Table 1: Predictive equations, R^2 and p-value

	Formula	R^2	p-value
CP:	$MA_{AT} = -21.5 + 0.21 * LLL$	0.76	<0.01
TD:	$MA_{AT} = -6.6 + 0.18 * LLL$	0.74	<0.01

DISCUSSION

The smaller MA_{AT} in children with CP, would mean a smaller mechanical advantage at the ankle if it was not for the external MA also being smaller, for example due to equinus.

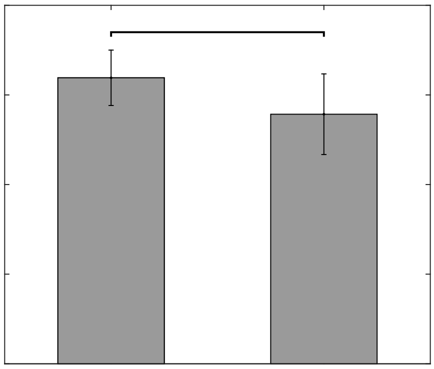


Figure 1: Average Achilles tendon moment arm (MA_{AT}) at 20° plantarflexion normalised to lower leg length (LLL).

Consequently, the combination may mean that mechanical advantage does not become much smaller than typical. Tendon lengthening surgery to correct equinus will lengthen the external MA, with an unintended consequence of reducing the mechanical advantage to values possibly below typical. This effect may contribute to the functional plantar flexor weakness seen after Achilles tendon surgery. The exact role of MA_{AT} length in orthopaedic surgeries correcting lever arm dysfunction needs further investigation.

Also, a smaller MA_{AT} brings about changes in the joint strength profile. A muscle acting over a smaller MA would generate a smaller maximal moment, but can work over a larger range of joint angles, thus, functionally it acts as a muscle with longer fascicles and a smaller physiological cross-sectional area (Lieber and Friden, 2000). The predictive equations provided here, can be used to evaluate MA_{AT} clinically and for calculations in modelling applications.

CONCLUSION

Our findings of a smaller MA_{AT} in children with CP have important implications in clinical decision making since MA_{AT} influences the mechanical advantage about the ankle, which contributes to movement function and is manipulated surgically.

REFERENCES

Lee, SSM., Piazza, SF. (2009). *J Exp Biol.* 212(22), 3700-3707. doi:10.1242/jeb.031096.

Novacheck, TF., Gage, JR. (2007) *Childs Nerv Syst.* 23(9), 1015-1031. doi: 10.1007/s00381-007-0378-6.

Lieber, RL., Friden, J. (2000) *Muscle Nerve.* 23(11), 1647-1666. doi: 10.1002 /1097-4598(200011)23:11<1647::AID-MUS1>3.0.CO;2-M.

A METHOD FOR CHARACTERISING HIGH ACCLERATION MOVEMENTS IN SMALL SIDED FOOTBALL

Jim Emery[1], Heather F. Driscoll[2], Andrew Barnes[3] and David M. James[1]
[1]Center for Sports Engineering Research, Sheffield Hallam University, Sheffield, UK
[2]School of Engineering, Manchester Metropolitan University, Manchester, UK
[3]Academy of Sport and Physical Activity, Sheffield Hallam University, Sheffield, UK
email: j.emery@shu.ac.uk

INTRODUCTION

Traction is defined as 'the propulsive or braking force generated on the sport surface by an athlete or machine to achieve a certain manoeuvre' (Barry & Milburn 2013) and it allows athletes to initiate or change motion. There is a growing body of work investigating the effect of traction on performance using simulated football drills (Luo & Stefanyshyn 2011; Müller et al. 2010).

It is essential that these drills are representative of match play yet there is often little or no empirical justification for their design.

The aim of this research was to provide normative movement profiles to inform the design of footwear test drills. This required the development of a reliable and time effective method for characterizing high acceleration movements in small sided football.

METHODS

Following institutional ethical approval, a recreational under 21s 5-a-side team was observed during eight league matches (age 18±1 year). Matches were captured using two digital video cameras mounted above the goals. Three players wore inertial measurement units located between the shoulder blades.

High acceleration movements were defined as those with horizontal acceleration peaks above the 99.8th percentile of that player's maximum and were identified using a custom Matlab algorithm.

These high acceleration movements were coded by an experienced analyst using a movement classification system adapted from The Bloomfield Movement Classification System (Bloomfield 2004).

Operational definitions were written for 14 primary movements and 22 modifiers in order to characterise on and off the ball movements.

The limits of error for establishing a normative profile were set at 5% of the cumulative mean (Hughes et al. 2004). Inter and intra-observer agreement showed substantial levels of agreement; k = 0.60 and k = 0.64 respectively.

RESULTS

A total of 1824 high acceleration movements were observed in 450 minutes of match play. Overall, the sprint (19%) was the most frequently occurring high acceleration movement, followed by braking (15%), impact (13%), run (12%) and 90 to 180° side cut (8%) (Figure 1).

The movement percentages differed in prevalence and rank order between players. For example; player 1's most prevalent movement is braking (20.3%) followed by sprint (12%), side cut (9.2%) skip (8.9%) and stop (8.9%); whereas player 3's movements were dominated by the sprint (22.7%) followed by run (16.3%), braking (12.7%), side cut (6.4%) and skip (5.9%).

Other movements not shown included; stop, crossover cut, shuffle, turn/twist, fall, jump, land, swerve, crossover cut, and get up.

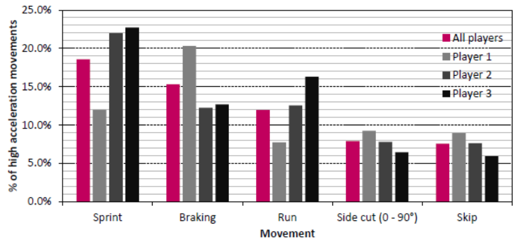


Figure 1. Movement prevalence as a percentage of high acceleration movements.

CONCLUSION

This study presents a new method to characterize the high acceleration movements performed in team sports using a combination of inertial sensors and manual notational analysis. The method has proved reliable, time effective and sensitive enough to observe differences in high acceleration playing style for recreational small sided footballers. This study also presents typical movement profiles for the small sided game. The movement profiles offer researchers and developers the foundations to re-align their current products or practice for this more popular style of recreational football.

REFERENCES

Barry, B. & Milburn, P., (2013). *Footwear Science*, 5(3), 137–145. doi:10.1080/19424280.2013.797030

Bloomfield, J., (2004). *International journal of performance analysis in sport*, 2(1), 20–31.

Hughes, M., Evans, S. & Wells, J., (2004).Abdington: Routeledge, 205 – 226. ISBN: 0203641957

Luo, G. & Stefanyshyn, D., (2011). *Footwear Science,* 3(3), 37–41. doi:10.1080/19424280.2011.639807

Müller, C. et al., (2010). *Sports biomechanics*, 9(3), 193–205. doi:10.1080/14763141.2010.511679

STANDARDISATION AND VALIDATION OF BATAK REACTION WALLS

Edward Bradley[1], Sarah Prudham[1]
[1]Department of Sport and Exercise Sciences, University of Sunderland, Sunderland, UK
email: eddie.bradley@sunderland.ac.uk

INTRODUCTION

Common measures of simple reaction are based around motor responses to the release of an object or a signal, where a single stimulus is presented and the person responds as quickly as possible, with a faster response indicative of better reaction performance (Molnar et al, 2007). Due to the complex motor functions and constantly changing environments observed in sport, functional measures are more appropriate as a representation of reaction performance.

Wall mounted light boards are designed to test and train visuomotor response, coordination, basic cognitive skills, all within a broad visual training setting (Klavora et al, 1995). Due to the interactive design, simple user interface and fun use, Batak walls are used as an interactive test at mass-attendance sporting events and are a popular tool in sports and fitness clubs. However, to the best of our knowledge, the accuracy and robustness of the device is not known. The aim of this study was to assess the procedural issues in using the Batak equipment and to examine the validity and reliability of the equipment as a measure of reaction.

METHODS

16 participants took part in the study. For standardisation each participant completed three trials of the 60 second test on the Batak Pro at six 0.5 m distances in a random order, starting at 0.5 m, to a maximum of 3 m. Participants then performed the 60 second test at 1 m with a rest period of one, two and three minutes between each trial. To assess validity, seven days later the participants returned and performed an online traffic light test and a ruler drop test, followed by 60 second tests on the Batak Pro and Lite walls. Following a further14 days, the participants returned and repeated the Batak Pro and Lite test to assess reliability of the devices. Standardisation was assessed by identifying the average highest score per distance and rest period. Bland & Altman plots were created in Deducer for R and Pearson's Product correlations were calculated to determine the validity of the Batak walls against the classic reaction tests. Intraclass Correlation Co-efficient (ICC) determined the test-retest reliability of the Batak walls.

RESULTS

Highest scores were recorded with the participants at a distance of 1 m and a rest period of 2 minutes. Bland & Atman plots showed no systematic difference in performance on the Batak Pro and Lite against the ruler drop and traffic light tests (Fig 1). While higher scores were recorded on the Batak Lite compared to the Batak Pro, significant strong Pearson's Correlations of between 0.76 (ρ=0.01) and 0.808 (ρ=0.00) found with the two Batak walls at both 0.5 m and 1 m distances. High strength ICC were found between the two Batak walls.

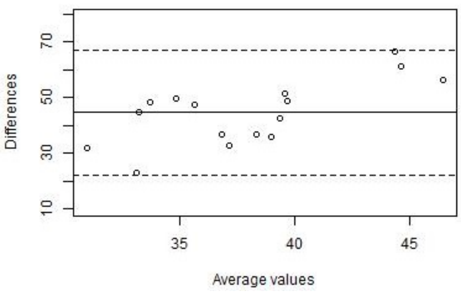


Figure 1: Bland & Altman plot assessment of validity between the Batak Pro and traffic light test.

DISCUSSION

The optimal distance for the user to stand was 1 m. This keeps all of the device buttons in arms-reach and within the full visual scope of the user. The results of our study found excellent levels of validity between the Batak walls and both the traffic light test and the ruler drop test, with both within the 95% limits of agreement of the classic tests. Choice reaction tests, such as the traffic light and ruler drop tests, employed in the current study have classically been used as a measure of reaction (Brown et al, 2012). The Batak wall cannot be viewed as direct variation as it involves greater number of visual processes and motor functions to affect the necessary actions and continuously attempt to strike the light stimuli. As such, using the classic reaction tests as a starting point to determine if performance on the Batak walls is representative of reaction is justified but further work should focus on correlating against other sports specific tests of reaction and agility.

CONCLUSION

Overall, both the Batak Pro and Lite devices were found to be valid and reliable tools for measuring reaction.

REFERENCES

Brown, T. et al. (2012). *Science Activities*, 49, 82-87. doi:10.1080/00368121.2012.671198

Klavora, P. et al. (1995). Cand J Occup Ther, 62, 37-43. doi: 10.1177/000841749506200107

Molnar, FJ. et al. (2007). *Accid Anal Prevt*, 39, 1056-1063. doi: 10.1016/j.aap.2007.02.003

Podium Presentations 2

(Chairs: Prof. Gabor Barton & Dr. Tom O'Brien)

2:15 Charlotte Apps (LJMU)

Ankle and knee joint stiffness in running; unpredictable and predictable shoe perturbations

2:30 Jennifer Hogg (Uni. of North Carolina at Greensboro)

The influence of femoral anteversion and hip range of motion on dynamic knee valgus in females during a single-leg forward hop

2:45 Mohsen Sayyah (Loughborough Uni.)

Factors influencing variation in dive height in 1m springboard diving

3:00 Jos Vanrenterghem (KU Leuven)

IKD1D: Isokinetic dynamometry analysis for 21st century sport science

3:15 Maria Bisele (Nottingham Trent Uni.)

Optimisation of an objective predictive machine learning algorithm in human locomotion.

3:30 Bodil Oudshoorn (Sheffield Hallam Uni.)

Foot velocities causing laceration injuries in rugby union

ANKLE AND KNEE JOINT STIFFNESS IN RUNNING; UNPREDICTABLE AND PREDICTABLE SHOE PERTURBATIONS

Charlotte Apps[1], Thorsten Sterzing[2], Thomas O'Brien[1, 3] and Mark Lake[1]
[1] School of Sports and Exercise Sciences, Liverpool John Moores University, Liverpool, UK
[2] Li Ning Sports Science Research Center, Li Ning (China) Sports Goods Co. Ltd, Beijing, China
[3]School of Sport, Health and Exercise Sciences, Bangor University, Bangor, UK
email: c.l.apps@2013.ljmu.ac.uk

INTRODUCTION

Humans adapt to running over uneven terrain with both predictable and unpredictable perturbations. It has been suggested that lower limb joint stability in to such unstable conditions is achieved by increasing stiffness (Hogan, 1984) but this has not been well documented during running.

The aim of this study was to determine ankle and knee joint stiffness during running in a shoe with unpredictable midsole deformations (UM), a predictable unstable shoe (PS) with a fixed outsole and a control shoe (CS).

METHODS

Eighteen healthy young females ran at 8km/hr (±5%) along a 30m runway in UM, PS and CS. UM was created by attaching three independent highly flexible rubber bags to the shoe upper with small objects moving freely inside the bags (Figure 1, Apps *et al*., 2015). PS was an unstable shoe model (Figure 1; Bubble Gym, Li Ning, China), with a protruding rocker around the midfoot and smaller protrusions in the rearfoot and forefoot regions. The CS midsole was cut and weights were attached to match the width and sole weight of UM.

Figure 1: Shoe with unpredictable midsole deformations (UM) (top) and predictable unstable shoe (PS) (bottom).

Kinetic data from a force plate (1000 Hz, Kistler, Switzerland) and lower limb kinematic data from a 3D motion analysis system (500 Hz, Qualysis, Sweden) were captured. Sagittal-plane ankle and knee stiffness were calculated from the gradient of a least squares linear regression of the joint angle-moment curves. A linear portion for each curve was identified during the loading response: ankle stiffness was calculated during the first 50% of the second rocker period, and knee stiffness from 5% bodyweight until maximum knee flexion. Twenty trials in each condition were averaged and a repeated measures ANOVA determined differences between shoe conditions ($p<.05$).

RESULTS

There was a decrease in ankle stiffness ($p<.001$) and increase in knee stiffness ($p<.003$) observed from CC to PS to UM (Table 1). Linear regressions fit the data very well (Mean r^2 values across conditions varied between .94 and .99).

Table 1: Mean joint stiffness ((Nm/deg/kg (SD)) across participants. R^2 values show linearity.

	Shoe Condition		
	UM	PS	CS
Ankle Stiffness	.076 (.023)	.097 (.024)	.126 (.019)
Knee Stiffness	.102 (.023)	.093 (.014)	.089 (.014)

DISCUSSION

With increasing shoe instability ankle joint stiffness decreased and knee joint stiffness increased. This trend of re-organising stiffness settings in the ankle and in knee has been found during running with a forefoot strike pattern compared to rearfoot strike pattern (Hamill *et al.*, 2014), but until now has not been investigated in response to perturbations.

It is predicted the reduced ankle stiffness in UM is a mechanism to increase stability to the uncertainty; by moving the ground reaction force moment arm closer to the ankle joint centre and preventing excessive motion (Wright *et al*., 2000). In contrast, the reduced ankle stiffness in PS is associated with a reduced plantarflexion moment, as has been found previously in unstable shoes during running (Boyer and Andriacchi, 2009).

CONCLUSION

Ankle and knee joint stiffness change inversely to each other in response to increasing shoe-surface instability during running. Future research should investigate longitudinal training effects of different types of perturbations to joint stiffness.

REFERENCES

Hogan, N. (1984). *Int Elec Eng J*. 29, 681–690. doi.10.1109/tac.1984.1103644

Apps, C et al., (2015). *Footwear Sci,* 7(Supp.1), S109-S110. doi: 10.1080/19424280.2015.1038636

Hamill, J et al., (2014). *Eur J Sport Sci.* 14(2), 130-136. doi: 10.1080/17461391.2012.728249

Boyer, K A., Andriacchi, T P. (2009). *Clin Biomech.* 24, 872–876. doi:10.1016/j.clinbiomech.2009.08.003

Wright, IC., et al (2000). *J Biomech*. 33(5), 513–519. doi:10.1016/S0021-9290(99)00218-3

THE INFLUENCE OF FEMORAL ANTEVERSION AND HIP ROM ON DYNAMIC KNEE VALGUS IN FEMALES DURING A SINGLE-LEG FORWARD HOP

Jennifer Hogg, Randy Schmitz, Sandra Shultz
Department of Kinesiology, University of North Carolina at Greensboro, Greensboro, NC, USA
Email: jahogg2@uncg.edu

INTRODUCTION

Dynamic knee valgus has been associated with anterior cruciate ligament (ACL) injury (Hewett *et al.*, 2005) It represents coupled motion between the hip and knee and is comprised of hip adduction and internal rotation, and knee abduction and external rotation (Ireland, 1999). Factors that contribute to an individual having greater dynamic knee valgus have not been fully unearthed. Therefore, the aim of this study was to quantify the combined impact of femoral anteversion, hip internal rotation ROM (ROM_{IR}), and hip external rotation ROM (ROM_{ER}) on components of dynamic knee valgus during a single-leg forward hop. We hypothesized that participants with greater femoral anteversion and ROM_{IR} and lesser ROM_{ER} would display greater dynamic knee valgus.

METHODS

A cross sectional, single session design was used. Twenty females were recruited who had no history of ligamentous knee injury or lower extremity surgery and injury-free over the previous six months (25.1±4.1yrs, 168.7±8.0cm, 63.8±11.6kg). All measures were obtained with an inclinometer. Participant was prone with knee flexed to 90°. For femoral anteversion, the lower leg was passively internally rotated until the greater trochanter was palpated to be at its most lateral position. For ROM, the lower leg was passively rotated internally and externally until initial sacral movement was palpated by the tester. For all measures, the transverse angle formed by the tibial diaphysis and true vertical at the specified points was recorded. One tester with good to excellent reliability [$ICC_{2,3}$(SEM); .92(1.2°) for femoral anteversion, .97(1.6°) for ROM_{IR}, .85(3.3°) for ROM_{ER}] measured all subjects. 3D motion capture was used to measure hip and knee joint biomechanics during a single-leg forward hop over a barrier onto a forceplate. Barrier height and take-off distance from the force plate were normalized to participant's height (15% and 40%, respectively). Five trials were obtained and variables were averaged across trials. Separate backward-stepwise multiple linear regressions (P out=.20) determined the extent to which femoral anteversion, ROM_{IR}, and ROM_{ER} contributed to hip and knee initial and peak angles, excursions, and internal moments (normalized to Height*Weight) in frontal and transverse planes.

RESULTS

Results are presented in Table 1. Specifically, greater ROM_{IR} predicted higher peak knee abduction moments (R^2=.20, p=.05), while the combination of lesser ROM_{IR} and lesser ROM_{ER} predicted higher peak knee internal rotation moment (R^2=.38, p=.02).

Table 1: Partial correlations between clinical measures and knee biomechanics (FA=Femoral Anteversion; IR=Internal Rotation; ER=External Rotation)

Dependent Variable	Multiple R^2	FA	ROM_{IR}	ROM_{ER}
Initial Hip Rotation Angle	.11	.299	-.054	-.023
Peak Hip IR Angle	.12	.293	-.005	-.013
Peak Hip Rotation Moment	.24	-.287	-.227	-.213
Peak Knee Abduction Moment	.24	.155	-.476	-.179
Initial Knee Rotation Moment	.13	.338	-.096	.079
Peak Knee Rotation Moment	.41	.216	-.542	-.557

DISCUSSION

In support of our hypothesis, greater ROM_{IR} was predictive of higher peak knee abduction moments. Contrary to our hypothesis, greater total ROM (ROM_{IR}+ROM_{ER}) was associated with lower peak knee internal rotation moment. Possibly individuals with less transverse plane hip ROM must compensate by increasing tibial internal rotation. Femoral anteversion exhibits a consistent small effect on hip kinematics.

CONCLUSION

Greater hip ROM_{IR} and ROM_{ER} predict potentially injurious frontal and transverse plane knee moments. Future work should examine the extent to which these structural factors can be counteracted through neuromuscular intervention strategies.

REFERENCES

Hewett, T et al, (2005). *Am J Sports Med*, 33(4), 492-501. doi:10.1177/0363546504269591

Ireland, ML. (1999). *J Athl Train*, 34(2), 150-154. Retrieved February 21, 2015, from http://search.proquest.com/docview/206645539/fulltextPDF?accountid=14604

FACTORS INFLUENCING VARIATION IN DIVE HEIGHT IN 1M SPRINGBOARD DIVING

Mohsen Sayyah, M.R. (Fred) Yeadon, Michael J. Hiley and Mark A. King
School of Sport, Exercise & Health Science, Loughborough University, Loughborough, UK
email: m.sayyah@lboro.ac.uk

INTRODUCTION

Several studies have identified the factors associated with achieving dive height during flight (Harper, 1966; Sanders & Wilson, 1988). However, little is known about the movement variability in different stages of dives, specifically the relationship between touchdown variables and dive height has not been developed. The diver starts the hurdle by jumping from an active leg toward the end of the diving board and there is inevitably an amount of variability in foot placement from trial to trial. It might be expected that there could be an adjustment for the variability of foot placement in the hurdle and that such variability might contribute to the variability in dive height. The aim of this paper was to investigate which factors are responsible for dive height and to what extent the change in touchdown variables can explain the variance in dive height.

METHODS

15 trials of a forward pike dive performed by a male international springboard diver (mass = 69.7 kg, height = 1.79 m) were recorded using a high speed video camera (frame rate 250 Hz, exposure time 4 ms, resolution 1280 x 1024 pixels). Kinematic data were derived from the manually digitised video. The contribution of variables to dive height was investigated by performing stepwise multiple regression analysis using SPSS. A number of regression models were determined to explain the effect of the variables on dive height.

RESULTS

The mean and standard deviations of touchdown and contact phase variables demonstrate that the diver's performances were very consistent (Table 1). There was a relatively large standard deviation in hip angle at touchdown (SD = 5.0º) and less variability in knee angle (SD = 2.7º).

Table 1: The mean and standard deviation of touchdown and contact phase variables

	mean ± SD
CM dive height (m)	1.74 ± .05
Hip extension (º)	66.0 ± 4.7
CM vertical touchdown velocity (m/s)	4.77 ± .07
Hip angle at hurdle touchdown (º)	98.9 ± 5.0
Toe distance from board tip at takeoff (m)	.115 ± 0.060
Knee angle at touchdown (º)	102.3 ± 2.7

Table 2: Stepwise regression for estimating dive height from touchdown and contact variables: models 1 and 2 included only touchdown variables

model	*parameters*	*p*	*Beta* [a]	R^2
1	Vertical velocity	.003	.715	.511*
2	Vertical velocity	.038	.488	.632**
	Initial hip angle	.071	-.415	
3	Hip extension	.000	.875	.765*

a: Standardised coefficient,*(P < 0.05), **(P < 0.1)

The hip extension during board contact from maximum hip flexion to maximum hip extension was the variable most correlated with dive height ($R^2 = 0.765$; Table 2). The Pearson correlation coefficient of the vertical mass centre touchdown velocity with dive height was 0.511 (Table 2).

DISCUSSION

Although it was expected that there might be adjustment for the variability of the foot placement in the hurdle, the standard deviation of the toe distance from the end of the board at board contact (0.060 m) was larger than in the hurdle (0.025 m). The vertical touchdown velocity and hip angle at touchdown together explained 63% of the variation in dive height. It can be hypothesised that the remaining variation comes from body configuration changes during board contact. Although the amount of hip extension explains 77% of the variance in dive height, this factor is highly dependent on the touchdown variables. It is responsible for much of the contact contribution to dive height variability.

CONCLUSION

The amount of energy that the diver has put into the diving board depends on both vertical touchdown velocity and body extension performed during the contact phase. Hip extension during board contact determines the amount of additional energy that the diver put into the board. Greater hip extension increases the dive height. Variation in hip extension primarily accounts for the variation in dive height which is small (< 3%) indicating the consistency of performance of this diver.

REFERENCES

Harper, D. (1966). The physical principles of diving. Athletic Journal, 47, 34, 75-76.

Sanders, R.H. & Wilson, B.D. (1988). Factors contributing to maximum height of dives after takeoff from the 3M springboard. International Journal of Sport Biomechanics, 4, 231-259.

IKD1D: ISOKINETIC DYNAMOMETRY ANALYSIS FOR 21ST CENTURY SPORT SCIENCE

Jos Vanrenterghem[1,2], Ian Poole[1], Raja Mohammed Firhad Raja Azidin[1], Anne Delextrat[3], Vasilios Baltzopoulos[1], Mark A. Robinson[1]
[1]Research Institute of Sport and Exercise Sciences, Liverpool John Moores University, UK
[2]Department of Rehabilitation Sciences, KU Leuven, Belgium
[3]Sport and Health Sciences Department, Oxford Brookes University, UK
email: jos.vanrenterghem@kuleuven.be

INTRODUCTION

Isokinetic dynamometry (IKD) has received a great deal of attention in the context of performance enhancement and (re-)injury prevention (Mendigucha, Alentorn-Geli, & Brughelli, 2011; Tol et al., 2014). IKD data can be a rich data source for sport scientists, but is typically reduced to peak torque values or angles of peak torque. This approach is likely the consequence of a lack of available methods, and this (1) to generate torque-angle profiles, and (2) to analyse the profiles as a single one-dimensional (1D) unit of observation. The aim of the current study was to describe the use of IKD1D (available at http://www.ikd1d.org/), an open-source GUI-based application that is released specifically to make the generation and analysis of torque-angle profiles possible.

METHODS

To examine the utility of IKD1D, we used a dataset of concentric knee extension contractions performed by 20 recreational athletes, 10 males and 10 females. Torque-angle profiles were generated based on a hierarchical set of trial selection criteria (Fig. 1, left panel). Suitability of different curve-fitting approaches was then evaluated by artificially inducing a localised reduction in extension torques. We finally compared torque-angle profiles between males and females using the 1D hypothesis testing technique Statistical Parametric Mapping (SPM) in a between-subject comparison using a two-sample t-test.

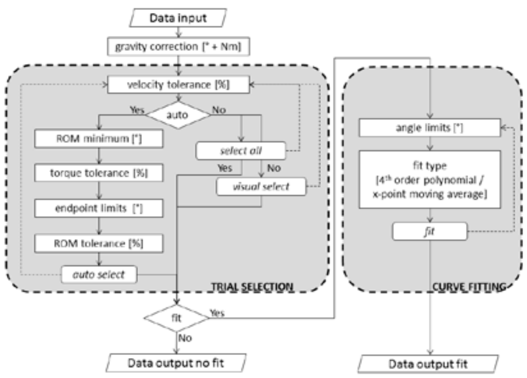


Figure 1: Hierarchical flow chart used in IKD1D for trial selection (left) and curve fitting (right) to produce individually averaged torque-angle profiles.

RESULTS

The introduction of a sharp localised reduction in torque meant that a polynomial fit was unable to represent the data, whilst a mean based on an averaged window closely followed the reduction in torque.

Whereas peak angle torques would have revealed that males were stronger than females (206 ± 40 Nm and 150 ± 27 Nm for males and females, respectively), SPM analysis revealed that this was only the case between 65 and 90 degrees of flexion as can be seen from the joint angles at which the critical threshold was exceeded (Figure 2).

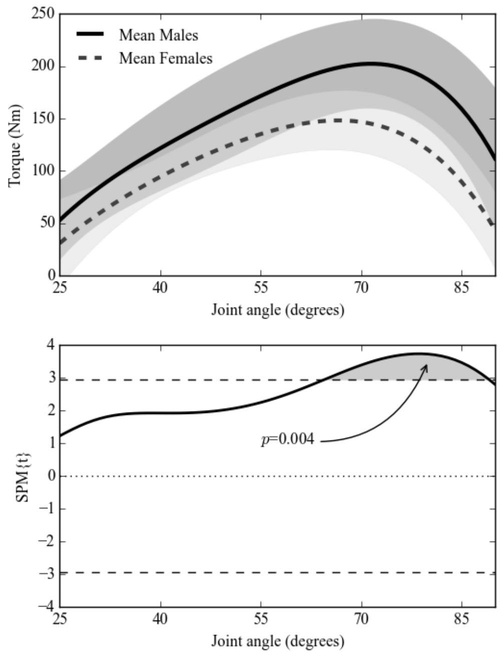


Figure 2: Comparison of torque-angle profiles for males and females, demonstrating a regional difference between groups.

CONCLUSION

With IKD1D we present a user-friendly open source application which allows researchers and practitioners to generate torque-angle profiles in an integrated manner (transparent trial selection and curve fitting procedures), and to test hypotheses that consider the entire torque-angle profile as a one-dimensional observation.

REFERENCE

Mendigucha, J et al (2011) *Br J Sports Med*, 46, 81-85. doi: 10.1136/bjsm.2010.081695

OPTIMISATION OF AN OBJECTIVE PREDICTIVE MACHINE LEARNING ALGORITHM IN HUMAN LOCOMOTION.

Maria Bisele[1], Martin Bencsik[1], Martin G.C. Lewis[1] and Cleveland T. Barnett[1]
[1]School of Science and Technology, Nottingham Trent University, Nottingham, UK
email: maria.bisele2014@my.ntu.ac.uk

INTRODUCTION

Human locomotion, or gait, is often quantified and described using the somewhat subjective analysis of normalised graphical profiles and/or extraction of discrete parameters (Chau 2001). These approaches also neglect temporal information and assume linear relationships exist between variables, whilst certain parameters are not easily identified in pathological gait (Chau 2001). However, multivariate statistical methods such as principle component analysis (PCA) and discriminant function analysis (DFA) have the potential to avoid these data handling issues. Linear PCA is able to reduce and classify data whilst maintaining the variance of the original data (Chau 2001), and DFA reveals the generic discriminating features within a data set (von Tscharner et al. 2013). Together, PCA and DFA provide a simple, robust and objective method for assessing differences between experimental groups. The development of a machine learning algorithm, using PCA and DFA, allows for further discrimination of data sets that have not contributed to the learning process, referred to as the predictive stage (Wu et al, 2007). An optimised machine learning algorithm may improve the objectivity and consistency of gait assessments in both research and clinical settings. Therefore, the aim of the current study was to develop an objective method for data reduction and supervised classification in human locomotion.

METHODS

Twenty participants (14 male and 6 female; age 24±4 years; height 174.5±8.6 cm; mass 72.0±8.5 kg) provided informed consent to participate. Participants were required to run at a self-selected speed both with and without shoes across a 15m runway, contacting a force plate with their right limb. During these trials, 36 reflective markers were attached on the trunk and the lower extremities. Ground reaction force (GRF) data and kinematic data were captured at 1000 Hz and 100 Hz, respectively. Joint angles (°), joint moments (N.m/kg) and joint power (W/kg) for hip, knee and ankle joints and GRF were calculated. Statistical assessment was conducted using PCA and DFA on a training database of unfiltered 30 power spectra of kinetic and kinematic data. The machine learning algorithm was trained using data from a combination of 10 different participants (total 184, 756 combinations).

RESULTS

The machine learning algorithm was able to discriminate with an accuracy of 93.5%. The quality of discrimination is highlighted in Figure 1, which displays minimal overlap between the two clouds of data, with only 6.5% of trials incorrectly discriminated.

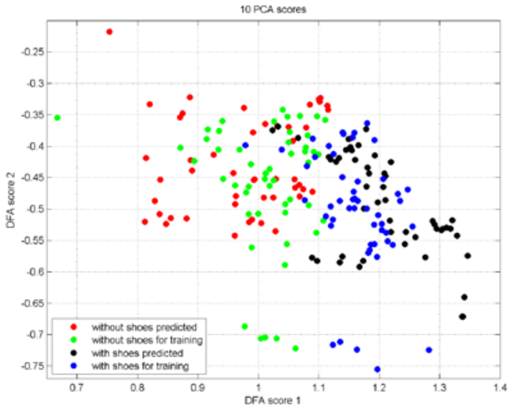


Figure 1: Discrimination of machine learning algorithm of the two experimental conditions (with and without shoes) trials. The red and green dots represent trials without shoes, and black and blue dots represent trials with shoes. The green and blue dots indicate which trials have been used to train the algorithm and the red and black dots indicate the trials used to perform predictions.

DISCUSSION

The optimised algorithm developed using PCA and DFA discriminated with high accuracy. The novelty of this study lies in the fact that the algorithm was validated, all possible permutations to develop it had been explored and the data used to build it were objectively selected. In addition, the algorithm did not require the subjective selection of scalar variables but rather did consider the temporal waveforms of gait as a whole (Wu et al, 2007).

CONCLUSION

A simple machine learning algorithm can be optimised to objectively discriminate large volumes of gait data from temporal waveforms using PCA and DFA.

REFERENCES

Chau T., (2001). *Gait Posture*, 13(1), 49-66. doi:10.1016/S0966-6362(00)00094-1
von Tscharner, (2013). PLoS One. 8(7). doi: 10.1371/journal.pone.0065063.
Wu, J., et al. (2007). *Hum Mov Sci.* 26(3), 393-411. doi:10.1016/j.humov.2007.01.015

FOOT VELOCITIES CAUSING LACERATION INJURIES IN RUGBY UNION

Bodil Oudshoorn[1], Heather Driscoll[2], Marcus Dunn[1] and David James[1]
[1]Centre for Sports Engineering Research, Sheffield Hallam University, Sheffield, UK
[2]Division of Mechanical Engineering, Manchester Metropolitan University, Manchester, UK
email: b.oudshoorn@shu.ac.uk

INTRODUCTION
Laceration injuries in rugby union account for approximately 6% of all injuries sustained during match play. The design of studded footwear has previously been identified as a causal factor in laceration injuries (Hall and Riou, 2004). In order to assess the laceration injury risk of different stud designs, there is a need to develop a testing protocol that is able to replicate the laceration injury event. Stamping during the ruck - a perpendicular movement of the foot impacting a player on the ground - is a common injurious situation. Current stud testing protocols simulate foot impact speeds of 1.0 m/s in the vertical direction (World Rugby, 2015), but no validation is known for this. The aim of this study is to measure the foot velocity during stamping in a ruck, as this velocity should be replicated in testing protocols.

METHODS
In this preliminary analysis, the data of two participants (P1 and P2) was selected from a larger group (N=12). The participants were 24 and 32 years old, 185 cm tall and weighed 76 and 88 kg respectively. Both participants completed five trials in which they set up a one-versus-one ruck and stamp on a dummy person lying on the floor. To standardise the experiment instruction, participants were shown a video explaining the technique of stamping in the ruck. During testing, two high speed cameras sampling at 1000 Hz were aimed at the impacting foot of the participant. Eight shoe markers, four on the stud and four above the studs (Fig. 1) were manually digitised. Custom developed software (Check3D, Sheffield Hallam University) was used to obtain 3D real world coordinates from video footage.

Figure 1: Eight shoe markers were used to obtain foot speed.

The average speed of all markers in the 10 frames prior to first impact of the shoe was used to define impact speed. We calculated the range and mean of observed foot speed and velocity (horizontal and vertical direction) per participant.

RESULTS
During the five trials of P1, pre-impact foot speed ranged from 3.9-6.1 (*mean* 4.7) m/s. P2 had a range of 5.9-7.5 (*mean* 6.8) m/s. An overview of horizontal, vertical and resultant speed can be found in Table 1.

Table 1: Foot speed (mean ± standard deviation) observed during simulated stamping with two participants, P1 and P2

	Resultant speed (m/s)	Horizontal speed (m/s)	Vertical speed (m/s)
P1	4.7 ± 0.8	3.2 ± 1.1	3.3 ± 0.6
P2	6.8 ± 0.6	5.7 ± 0.4	3.7 ± 0.7

DISCUSSION AND CONCLUSION
This preliminary analysis of two participants simulating stamping during the ruck in rugby union suggests that total foot speed is underestimated in current testing protocols. The horizontal foot speed was in one participant greater than the vertical foot speed; the horizontal component should therefore not be neglected in future studies. The presented data here does not investigate potential differences between forefoot and heel markers. Further analysis of another 10 participants will establish a greater confidence in the estimated foot velocity pre-impact. To complete the kinetic and kinematic information needed for the development of a testing protocol for laceration injury risk of stud designs, impact force, peak pressure and stud inclination angle will be extracted from the same trials in the future.

REFERENCES
Dierks, T et al., (2010). *J Biomech*. 43, 2993-2998. doi:10.1016/j.jbiomech.2010.07.001

Hanlon, M., Anderson, R. (2009). *Gait Posture*, 30(4), 523-527. doi:10.1016/j.gaitpost.2009.07.128

Hall, M. J., Riou, P., (2004). *Br J Sports Med*, 38(5), 642. doi: 10.1136/bjsm.2004.012245

World Rugby. *Regulation 12*. Dublin: 2015. http://playerwelfare.worldrugby.org/?documentid=51

Check3D, Sheffield Hallam University. http://www.check3d.co.uk/

Poster Presentations

THE EFFECT OF DISTANCE BETWEEN GIRTH MEASURES IN GEOMETRIC MODELS ON TOTAL THIGH VOLUME ESTIMATION.

Alice M Bullas[1], Ben Heller[1], Simon Choppin[1] and Jon Wheat[1]
[1]Centre for Sports Engineering Research, Sheffield Hallam University, Sheffield, UK
Email: a.bullas@shu.ac.uk

INTRODUCTION

Calculating the kinetics of human movement through inverse dynamics requires the use of body segment inertial parameters (BSIP) estimates. The estimation of BSIPs through direct measurement methods such as water displacement, hydrodensitometry or opto-electronic systems, is frequently costly and unpractical, and regression equation based methods are often unsuitable for atypical population groups. As such, BSIP estimates are predominantly calculated using anthropometric data and geometric models (Rossi et al., 2013). Geometric models divide limbs into multiple segments which are matched to geometric shapes, typically truncated cones or discs. The upper and lower girths of each shape are measured and the volume of each shape is then summed to estimate the total limb volume. However, the distance between girth measures and therefore the number of segments each limb is divided into, is inconsistently reported in the literature. The aim of this study was to explore the effect of the distance between girth measures in geometric models on total thigh volume estimation.

METHODS

As part of a preliminary investigations, a 3D image of one elite female mountain biker's (age 25 years; stature 179 cm; body mass 70.8 kg) left thigh (28.4cm in length) was captured using a high precision surface imaging system (3dMD). The 3D image was manually digitised within KinAnthroScan - custom built software, created using the Microsoft Kinect software development kit (Microsoft Corporation, Redmond, USA). Using KinAnthroScan analysis (based upon Crisco & McGovern, 1998), total thigh volume was estimated. The circumference of the thigh at 2 mm intervals along the long axis of the segment was exported to use within truncated cone and disc based geometric models. The difference between the 3dMD total thigh volume estimation and the geometric models were calculated and analysed.

RESULTS

3dMD total thigh volume was estimated as 5401ml. Both the truncated cone and disc based geometric models mostly underestimated total thigh volume when compared to the 3dMD estimate (Table 1) and demonstrated a significant difference when compared against one another ($p<0.05$).

Table 1: Total thigh volume (TV) estimated by truncated cone and disc based geometric models. Note: Inter-girth distance of 7cm ≈ diving the limb into 4, 9cm ≈ diving the limb into 3, 14cm ≈ diving the limb into 2).

Inter-girth distance (cm)	Truncated cone		Disc		Diff' between models (ml)
	TV (ml)	Diff' with 3dMD (ml)	TV (ml)	Diff' with 3dMD (ml)	
1	5390	-11	5298	-104	93
2	5389	-13	5204	-197	184
3	5391	-10	5119	-282	272
4	5363	-38	5028	-373	336
5	5385	-16	4940	-461	445
6	5398	-3	4868	-533	530
7	5388	-13	4755	-647	634
8	5393	-9	4710	-692	683
9	5392	-10	4599	-802	792
10	5366	-35	4501	-900	865
11	5379	22	4475	-926	904
12	5401	-1	4417	-985	984
13	5416	+14	4314	-1087	1101
14	5421	+20	4181	-1220	1240

DISCUSSION & CONCLUSION

The results of this preliminary investigation suggest that disc based geometric models are highly sensitive to changes in the distance between girth measures. They appear to be oversimplified representations of the human body and therefore unsuitable for total thigh volume estimation. Geometric models that use truncated cones appear to be less sensitive to changes in the distance between girth measures and can produce accurate estimates of total thigh volume. Although this study only investigates a single participant, the results demonstrate the significant effect the selection of geometric model and the distance between girth measures can have on thigh volume estimation. It is thereby suggested that biomechanists approach geometric modelling with caution. It is important to note that as recent literature has demonstrated low cost depth camera based surface imaging systems to be capable of accurately estimating total thigh volume (Bullas et al., 2016), such systems could be used as affordable alternatives to geometric models.

REFERENCES

Bullas et al., (2016). *Journal of Sports Science*, (Online). doi:10.1080/02640414.2016.1149604

Crisco, J. J. & McGovern, R. D. (1998). *Journal of Biomechanics*, 31, 97-101. doi: 10.1016/S0021-9290(97)00108-5.

Rossi, M., Lyttle, A., Amar, E. S., Benjanuvatra, N., & Blanksby, B. (2013). *Journal of Sports Science &*

INJURY RISK IN TECHNIQUE SELECTION: INFLUENCE OF HAND POSITION IN THE BACK HANDSPRING.

Sophie Burton[1], Tim Exell[2], Roman Farana[3] and Gareth Irwin[1]

Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK[1]
Department of Sport and Exercise Science, University of Portsmouth, Portsmouth, UK[2]
Department of Human Movement Studies, University of Ostrava, CZ[3]
Email: sburton@cardiffmet.ac.uk

INTRODUCTION

Gymnastics exposes the upper limbs to high loading (Farana *et al*., 2014). The same elements can be executed with various techniques and the coaches' challenge is to select those that reduce injury potential and increase performance. Singh *et al*. (2008) stated that 42% of all gymnastics injuries were located at the upper extremities and the skills most commonly related to these injuries were handsprings. The aim of this study was to investigate the influence of technique (hand position) on the biomechanical injury risk factors at the wrist during the back handspring in female gymnastics.

METHODS

Synchronised 3D kinematic and kinetic data were collected from five injury free gymnasts (mean age 21±2 yrs) using an automated motion capture system (VICON, 250 Hz) and two force plates (Kistler, 1000 Hz). Markers were placed bilaterally on the trunk and upper limbs of the gymnast. Participants performed five trials of back handspring from a hurdle step round off using the "inward", "parallel" and "outward" hand positions. All analyses centred on the support phase of both hands during the back handspring. The Newton-Euler method for inverse dynamics was used to generate 3D wrist joints (Selbie *et al.*, 2014). Kinematic data were filtered using a low-pass Butterworth filter (12 Hz). Vertical and medio-lateral ground reaction force (GRF) data were normalised to body weight (BW) and moment data were normalised to body mass. A one-way ANOVA and LSD post hoc test, examined differences between techniques (P<0.05).

RESULTS AND DISCUSSION

Means and standard deviations for selected external and internal kinetic variables at the wrist for the three hand positions in the back handspring are shown in Table 1. Significantly higher kinetic values were shown at the wrist joint during the outward hand position when compared to the inward and parallel techniques across all analysed variables (Table 1).

Davidson *et al*. (2005) stated that peak force is the most significant feature in determining injury. Significantly higher internal vertical force (3.33±0.82 BW compared to 0.95±0.45 BW and 2.36±0.49 BW) and medio-lateral force (1.74±0.42 BW compared to 0.50±0.12 BW and 0.11±0.05 BW) at the wrist joint were observed in the outward hand position. The current study also displayed significantly higher rotational moments at the wrist when using the outward technique. This increased internal loading combined with increased rotational moment at the wrist indicates that using the outward technique during the back handspring can be potentially harmful to the wrist joint.

Table 1: Summary of kinetic variables for inward, parallel and outward hand positions during the back handspring.
Notes: **^{1}sig. different to inward, ^{2}parallel and ^{3}outward techniques (P<0.05). V = vertical, ML = medio-lateral**

Variable	Anatomical Description		
	Inward	Parallel	Outward
Peak VGRF (BW)	1.37^{3} ±0.28	1.47^{3} ±0.25	$1.66^{1\,2}$ ±0.13
Peak MLGRF (BW)	0.06^{3} ±0.04	0.12 ±0.05	0.17^{1} ±0.05
Internal V force (BW)	$0.95^{2\,3}$ ±0.45	$2.36^{1\,3}$ ±0.49	$3.33^{1\,2}$ ±0.82
Internal ML force (BW)	$0.50^{2\,3}$ ±0.12	$0.11^{1\,3}$ ±0.05	$1.74^{1\,2}$ ±0.42
Internal rotational moment (Nm/kg)	$0.39^{2\,3}$ ±0.13	-0.26^{1} ±0.10	-0.94^{1} ±0.29

CONCLUSION

The outward technique exposed the wrist joint to increased joint kinetics and biophysical loading that may increase injury risk in the back handspring and therefore should be avoided in practice. These implications may offer valuable information for coaches, regarding technique selection and aid clinicians in identifying injury risk.

REFERENCES

Davidson, P.L (2005). *Journal of Applied Biomechanics*, 21 (2),115-128.

Farana, R et al., (2014). *Sports Biomechanics*. 13(2), 123-134. doi:10.1080/14763141.2014.895034

Singh, S et al., (2008). *Pediatrics*, 121(4), 954-960. doi: 10.1177/ 2325967115577596

Selbie, S., Hamill, J. and Kepple, T. (2014). In G. E. Robertson, G. Caldwell, J. Hamill, G. Kamen, and S. Whittlesey (Eds.), Research methods in biomechanics (145–162). Champaign, IL: Human Kinetics.

DETERMINING INITIAL KNEE JOINT LOADING DURING A SINGLE LIMB DROP LANDING: REDUCING SOFT TISSUE ARTEFACT.

Adam Clansey, Josh Isherwood, and Mark J Lake
School of Sport and Exercise Sciences, John Moores University, Liverpool, UK

INTRODUCTION

Ground reaction forces (GRF's) and movement profiles during high tasks such as landing from a jump are used to screen for the risk of joint injury (e.g. knee ligament damage (1)). GRF's are assumed to be reasonably accurate but it is generally accepted that the accelerations obtained from kinematic data are prone to large errors due soft tissue vibrations (2). To reduce the influence of soft tissue errors, it is common practice to use a low cut-off frequency (3), however, this approach is known to typically filter out the higher frequency content associated with initial phase of joint loading (4). The aim of this study was to examine knee joint loading using the traditional approach of a soft tissue-mounted cluster plate and subject specific 3D printed tibial plate. In addition, a global optimisation (inverse kinematics (IK)) modelling approach was also employed to examine its influence on joint moment calculations when constraining the knee to 3DoF.

METHODS

Sixteen young male and female subjects (24.6 ± 2.4 years, 1.76 ± 0.09 m and 68.6 ± 9.5 kg, respectively) performed a series of ten controlled, single leg drop (40 cm) landings. Kinematic and kinetic data were collected simultaneously at 500 Hz and 2000 Hz. In order to mimic data processing approaches in the literature (3) that have used cluster plates (incl IK approach) both GRF and kinematic data were filtered at 15 Hz using a BW dual pass digital filter, while the tibial plate data were all filtered at 35 Hz. Instantaneous rate of moment development (ILR) was determined from the first 50 ms of stance.

RESULTS

ILR was significantly ($p < 0.001$) larger in all moment planes when derived from using the tibial plate as compared to the calf plate and constrained 3 DoF knee IK model (Fig. 1).

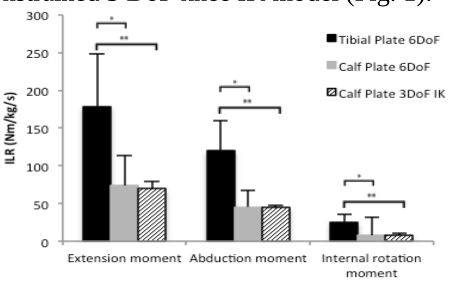


Figure 1: Mean (SD) ILR extension, abduction and internal rotation moments for the three joint modeling conditions.

The internal rotation moment waveform curves (Fig. 2) clearly illustrate a greater rise of the initial peaks obtained by the customised tibial plate. In addition, this faster rise lead to an early temporal shift of the initial peaks of the internal moment curves.

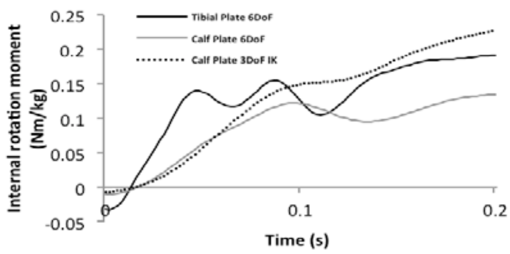


Figure 2: Group mean waveform curves for internal rotation knee joint moment during the first 200ms of landing for the three data collection/analysis approaches.

DISCUSSION

The three modelling approaches and data processing techniques were all geared towards minimising the influence of soft tissue errors (particularly vibration) on the subsequent joint moment calculations. We found that the tibial plate-derived knee joint moments rose earlier, faster and reached a higher peak than the knee joint moments derived using the calf plate data (either 6D.o.F. or 3D.o.F IK data) filtered at a lower cut-off frequency. Constraining the knee joint to move in pure rotation only joint (IK 3D.o.F optimisation approach) produced moment curves in the first 50ms that closely resembled the typical 6D.o.F approach using the calf plate data.

CONCLUSION

Attempting to reduce soft tissue errors through optimisation of knee motion using joint translation constraints did not appear to modify the magnitude and timing of initial knee joint moments during a single leg drop landing. In contrast, the joint moments derived from kinematic data obtained from a customised tibial plate displayed substantially higher initial joint loading. The faster, increased joint loading was thought to be related to real, higher frequency signals being maintained in the dataset rather than them being typically discarded.

REFERENCES

1. Shultz et al., (2012) J.Ath.Training, 47(5) :591-603. 2. Bisseling and Hof (2006) J Biomech.39(13): 2438-44. 3. Kristianslund et al., (2013). Br. J. Sports Medicine. 47(8): 470-473. 4. Boyer et al., (2004) J Biomech. 37(10):1583-1588.

Whole body vibration training's effect on jump performance in male basketball players

Martin Henderson[1] and Adam Hawkey[1, 2]*
[1]Division of Sport and Exercise Science, Abertay University, UK
[2]School of Medicine, University of Dundee, UK.
*Corresponding Author: a.hawkey@abertay.ac.uk @a_hawkey

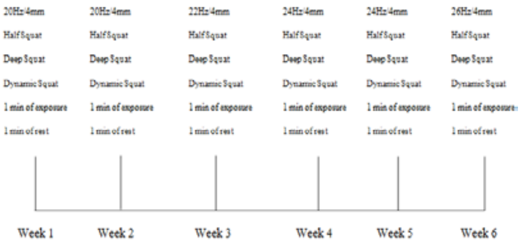
INTRODUCTION

Interest in the use of whole body vibration training (WBVT) as a method for enhancing performance has increased considerably in recent years (Perez-Turpin, et al., 2014). While recent research has reported significant improvements in a range of measures in recreationally active populations (Hawkey *et al*. 2016), there is currently limited data regarding sports performers who regularly incorporate jumping into their training regimes. Studies, which have investigated basketball and volleyball players, have reported contradictory findings, with some demonstrating performance improvements in vertical countermovement jump (VCMJ) with exposure to WBVT (Perez-Turpin, *et al*. 2014), while others report no enhancement with WBVT use (Hawkey et al. 2009). The current study aimed to identify the effects of a relatively short-term (6-week) WBVT program on VCMJ and flexibility performance in male university level basketball players.

METHODS

Following institutional ethics approval, 14 male university basketball players (age mean 21 ± 2years, height mean 187.3cm ± 6.92cm, mass mean 82.42kg ± 12.1kg) performed three VCMJ and sit-and-reach tests prior to, and on completion of, the six-week study. Players were randomly assigned to either a WBVT or control group. WBVT group underwent 6-weeks of WBVT, once- a-week on a side-to-side oscillating vibration platform. Training, in accordance with Hawkey *et al*. (2009), consisted of three different squatting exercises (half, deep and dynamic squat); each exercise performed twice for one-minute followed by one-minute recovery. Training was consistent with the overload principle, increasing from 20 Hz to 26 Hz; amplitude set at 4mm (Figure 1). The control group performed the same exercises, without vibration. Both groups continued with their usual basketball training programmes. In accordance with Hawkey *et al*. (2009), the maximal VCMJs were performed on a Just Jump contact mat (Probiotics Inc.), while flexibility was assessed using a standard sit-and-reach box. Maximal jump heights and flexibility measures in both the WBVT and control groups were analysed using a 2-way ANOVA; with the alpha level set at $P<0.05$.

Figure 1. WBVT programme used in current study



RESULTS AND DISCUSSION

A 2-way ANOVA with repeated measures revealed no significant difference, either by time (P=0.138*)* or group (P=0.838), in the pre- to post- VCMJ performances of the WBVT (49.16 ± 7.94cm to 50.26 ± 7.59cm) and control (46.12 ± 4.85cm to 47.56 ± 3.33cm) groups. The 2-way ANOVA with repeated measures also indicated no significant difference, either by time (P=0.576) or group (P=0.374), in the pre- to post- flexibility measures of the WBVT (16.71 ± 12.64cm to 17.57 ± 11.08cm) and control (17.2 ± 12.1cm to 17 ± 10.86cm) groups. Results of the current study consolidate the results of Hawkey *et al*. (2009a) who reported no improvement in VCMJ following WBVT in national league basketball players; therefore contradicting the findings of Perez-Turpin *et al*. (2014).

CONCLUSION

Current study suggests that a 6-week WBVT programme has no performance improving effect on the VCMJ or flexibility performance of university basketball players. Future research is needed to assess if there is an adaptive threshold for VCMJ performance following exposure to a WBVT programme.

REFERENCES

Hawkey, A. *et al*. (2016). Whole body vibration training and its implications to age-related performance decrements: an exploratory analysis. *Journal of Strength and Conditioning Research*, 30(2): 555-560.

Hawkey, A. *et al*. (2009). Effect of six-week whole body vibration training on vertical jump and flexibility performance in male national league basketball players. *Journal of Sport Sciences,* 27(4): S138-S139.

Perez-Turpin, J.A. *et al*. (2014). Effects of whole body vibration on strength and jumping performance in volleyball and beach volleyball players. *Biology of Sport*, 31(3): 239-254.

INFLUENCE OF THE FOOT MODEL ON THE RESULTS OF AN INDUCED ACCELERATION ANALYSIS IN MAXIMAL SPRINTING

Hans von Lieres und Wilkau[1], Gareth Irwin[1], Neil Bezodis[2], Scott Simpson[3] and Ian Bezodis[1]
[1]Cardiff School of Sport. Cardiff Metropolitan University, Cardiff, UK
[2]A-STEM Research Centre, Swansea University, Swansea, UK
[3]Welsh Athletics, Cardiff, UK
email: havonlieres@cardiffmet.ac.uk; web: http://cardiffmet.ac.uk/schoolofsport/

INTRODUCTION

An induced acceleration analysis (IAA) has been used to investigate the contribution of joint moments to the centre of mass (CM) acceleration during various tasks (Hof & Otten, 2005). Previous analyses in sprinting (e.g. Debaere et al., 2015) have not included the MTP joint despite this joint showing large moments in sprint acceleration (Bezodis et al., 2014). The aim of this study was to compare the results of an IAA when using models with a two (2segF; MTP joint included) and one segment foot (1segF; no MTP joint).

METHODS

One sprinter gave written informed consent to participate. GRF (1000 Hz) and 2D video (200 Hz) data were collected from the third step during three maximal 10 m accelerations from blocks. The videos were digitised using an 18 point model. All data were filtered using a 4th order Butterworth filter with a 26 Hz cut-off frequency. Joint moments were calculated using inverse dynamics starting with the distal segment, which was either the foot (MTP to ankle) or forefoot (toe to MTP). An IAA analysis (Hof & Otten, 2005) was performed to identify the joint moment contributions to CM acceleration. The foot-floor contact was treated as a one degree of freedom revolute joint located at the centre of pressure.

RESULTS

Table 1 shows the mean ± SD horizontal (a_y) and vertical (a_z) induced CM acceleration by the MTP and ankle moments using the 2segF and 1segF foot model. With the 2segF model, the MTP contribution to CM acceleration was 30.2 ± 26.2% horizontally and 87.1 ± 18.6 % vertically of the total foot contribution.

Table 1: Mean ± SD induced CM acceleration due to the MTP and ankle moments using a 1segF and 2segF model

	2segF		1segF	
	a_y [m/s^2]	a_z [m/s^2]	a_y [m/s^2]	a_z [m/s^2]
MTP moment	1.95 ± 1.64	13.06 ± 3.48	-	-
Ankle moment	4.57 ± 1.76	1.84 ± 2.72	6.47 ± 0.21	14.80 ± 0.83

DISCUSSION

The inclusion of an MTP joint shifted a substantial portion of the overall contribution to CM acceleration towards the more distally acting MTP joint moment (Table 1). In a simulation study of gait, Chen (2006) reported a similar shift when including a toe joint. These results are perhaps not reflective of the ability of the MTP moment to generate these CM accelerations but rather describe its role in transferring forces to the ground (Chen, 2006).

The larger SDs of the ankle and MTP moment contributions using the 2segF show that factors other than the model also influences the induced accelerations. These could include the magnitude of the joint moments and orientation of the segments, which influence the directions and size of the induced accelerations (Hof & Otten, 2005). These results and those of Chen (2006) suggest that the model used in IAA and the interpretation of the resulting data requires careful consideration. João et al. (2014) showed that by relating data from different contact models, a better understanding of the mechanics of a hopping task was gained. The complexity of the model used should be based on a sound rationale and an understanding of the data (João et al., 2014). Therefore, whilst including an MTP joint appears to warrant consideration, a foot-floor model which limits rotation about the sagittal plane may be of interest as rotation of the forefoot is largely constrained by the floor.

CONCLUSION

The results showed that the inclusion of MTP joint shifts a large portion of the overall contribution to CM acceleration to the MTP joint moment. Including the MTP joint and forefoot segment in the IAA model warrants consideration.

REFERENCES

Bezodis, N. E. et al. (2014). Journal of Sports Sciences, 32(8), 738-746. DOI: 10.1080/02640414.2013.849000

Chen, G. (2006). Gait & Posture, 23(1), 37–44. DOI: 10.1016/S0966-6362(03)00035-3

Debaere, S. et al. (2015). Journal of Sports Sciences, 33(19),2016-2024.DOI: 10.1080/02640414.2015. 1026375

Hof, A. L., & Otten, E. (2005). Gait & Posture, 22(3), 182-188. DOI: 10.1016/j.gaitpost.2004.08.007

João, F. et al. (2014). Human Movement Science 33. 312-20. DOI: 10.1016/j.humov.2013.10.004

INVESTIGATION INTO THE ACUTE: CHRONIC WORKLOAD RATIO AND INJURY OCCURRENCE FOR AN ELITE U21 FOOTBALL PLAYER

Thomas Male[1], Connor Langley[1] and Tina Smith[1]
[1] Institute of Sport, University of Wolverhampton, Walsall, UK
Email: T.Male@wlv.ac.uk

INTRODUCTION

When compared with chronic workloads, high acute physical workloads are associated with an elevated injury risk in elite rugby league players (Hulin et al., 2015). Whether this relationship, between the Acute: Chronic workload (A:C) ratio and injury, also exists in elite young professional footballers is unknown.

Hulin et al. (2015) quantified physical workloads as total distance covered, derived from GPS technology. Given that quantity of accelerations may also be linked to injury prognosis (Nedergaard et al., 2015), applying accelerometry-derived data to the A:C ratio concept may provide additional insight.

The aim of this case study was therefore to assess the relationship between the A:C ratio and injury in one U21 elite professional football player, quantifying workload derived from accelerometer data.

METHODS

Data from an U21 professional English football player was analysed. Cumulative physical workloads for each of the first 29 weeks of the 2015/16 season were calculated.

Workload was represented by 'Dynamic Stress Load' (DSL) (Statsports, 100Hz); an established metric used within elite football, which quantifies accelerations based on magnitude (>2*g*).

A:C ratios were calculated by dividing the present week workload (Acute), by the rolling-average of the present and preceding 3 week's workloads (Chronic). Ratios were classified using z-scores (Hulin et al. 2015).

Injuries sustained, diagnosed by qualified physiotherapists, were subsequently considered in relation to workload ratios.

RESULTS

Of the three recorded injuries, two occurred within 7-14 days of 'spikes' in acute workload, as demonstrated by 'high' (1.91) and 'very high' (3.11) A:C ratios, in Week 21 and Week 27 respectively (Fig. 1).

DISCUSSION

Two of the three recorded injuries occurred 7-14 days following 'spikes' in acute workload. High A:C ratios (>1.9), derived from accelerometry, may therefore increase the risk of subsequent injury in elite young adult football players.

In both instances, in the week following initial 'spikes' A:C ratios remained elevated, potentially influencing the risk of later injury.

The third injury occurred only 6 weeks after the second injury. Accordingly, the A:C ratio concept could be applicable to the 'return to play' process following injury, as suggested by Blanch and Gabbett (2015).

CONCLUSION

This case-study has indicated high A:C ratios, quantified using accelerometer-derived metrics such as DSL, may successfully predict injury occurrence in young adult elite football players. Further analyses are required to derive meaningful conclusions.

REFERENCES

Blanch, P., Gabbett, T.J. (2015). *Br J Sports Med 2015*. 0, 1–5. doi:10.1136/bjsports-2015-095445

Hulin, B.T. *et al.* (2015). *Br J Sports Med 2015*. 0, 1-7. doi:10.1136/bjsports-2015-094817

Nedergaard, N. *et al.* (2015). *The Sport Exercise Scientist, BASES* .45, 26-27. 109481195.

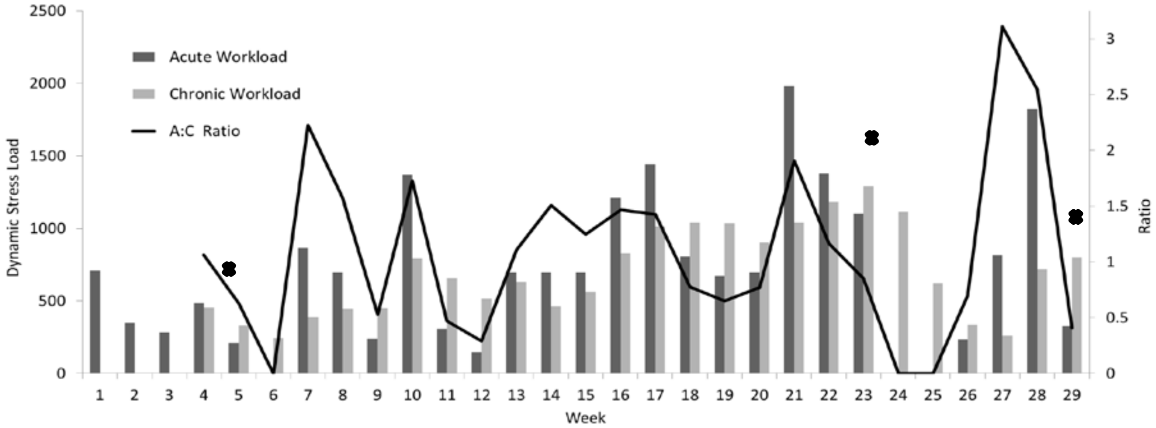


Figure 1: Graphical representation of weekly Acute and Chronic 'Dynamic Stress Load' Workloads, and corresponding A:C ratios. ✖ represent weeks in which an injury was sustained.

EFFECT OF LOAD ON HEXAGONAL BARBELL JUMP SQUAT KINETICS

Shannon Murphy and John J. McMahon
Centre for Health Sciences Research, University of Salford, Salford, UK
email: s.murphy5@edu.salford.ac.uk

INTRODUCTION

Jump squats (JS) performed with no external load have typically been recommended as the ‘optimal’ lower body exercise for producing peak power (PP) output in the elite athlete population (Cormie et al., 2007). More recent research has investigated the use of the hexagonal barbell jump squat (HBJS) for power development and has shown that the load which elicits greatest PP output is higher (20% of one repetition maximum (1-RM) back squat) for this JS variation compared to the traditional (i.e. straight barbell) JS (Swinton et al., 2012). Similarly, Turner et al. (2015) recommended 10-20% 1-RM box squat as the optimal load for PP development during the HBJS. However, both of the aforementioned studies involved elite rugby players, making it difficult to generalise the results to a wider population, and they based their HBJS loading on 1-RM squat scores rather than HB deadlift values which may yield different results. The aim of the present study was, therefore, to examine the effects of 10% of 1-RM HB deadlift increments in load on HBJS kinetics in collegiate athletes.

METHODS

Ten resistance-trained male collegiate athletes (age 23 ± 2.3 years, height 178 ± 4.9 cm, body mass 84 ± 8.3kg, 1-RM HB deadlift 182 ± 32kg) performed two unloaded JS repetitions and two JS repetitions with a HB at loads equal to 10, 20, 30 and 40% of HB deadlift 1-RM on dual AMTI force platforms (type: BP600900-1000) sampling at 1500 Hz. Unfiltered force-time data were subsequently analysed in Microsoft Excel (Microsoft Corp, Redmond, WA, USA). Instantaneous system velocity was determined by dividing vertical force data (minus system weight) by system mass and then integrating the product using the trapezoid rule. Instantaneous power was calculated by multiplying vertical force and velocity data. Concentric peak force (PF) and PP were defined as the maximum vertical force and power values, respectively, attained during the concentric phase of the jumps. RFD was calculated as eccentric PF divided by the time between the onset of the eccentric phase and eccentric PF. Jump height (JH) was determined using the vertical velocity at take-off method. A one-way repeated measures analysis of variance was used to compare kinetics across each load. Statistical analyses were performed using SPSS software (v20; SPSS Inc., Chicago, IL, USA) with the alpha level set at $P = 0.05$.

RESULTS

JH significantly decreased with load, whereas concentric PF significantly increased with load (Table 1). Concentric PP was significantly lower at 0% 1-RM compared to 10%, 20% and 30% 1-RM, but similar to the 40% 1-RM condition, which was also significantly lower than the 10% 1-RM trials (Table 1). RFD was significantly higher at 0% 1-RM compared to 20%, 30% and 40% 1-RM, but similar to the 10% 1-RM values (Table 1). RFD was significantly lower for the 40% 1-RM condition compared to the 10%, 20% and 30% 1-RM trials, with significant differences also noted between the 10% and 30% 1-RM loads.

Table 1: The effect of load on HBJS variables (mean ± SD)

1-RM (%)	JH (m)	PF (N)	PP (W)	RFD ($N \cdot s^{-1}$)
0	$0.30 \pm 0.05^{b,c,d,e}$	$1955 \pm 307^{b,c,d,e}$	$4112 \pm 833^{c,d}$	$5201 \pm 1364^{b,c,d,e}$
10	$0.27 \pm 0.05^{a,c,d,e}$	$2185 \pm 293^{a,c,d,e}$	4506 ± 851^{e}	$4542 \pm 1474^{a,d,e}$
20	$0.22 \pm 0.05^{a,b,d,e}$	$2302 \pm 337^{a,b,d,e}$	4468 ± 860^{a}	$3729 \pm 1395^{a,e}$
30	$0.18 \pm 0.03^{a,b,c,e}$	$2411 \pm 342^{a,b,c,e}$	4379 ± 784^{a}	$3338 \pm 1340^{a,e}$
40	$0.14 \pm 0.03^{a,b,c,d}$	$2560 \pm 403^{a,b,c,d}$	4251 ± 859^{b}	$2775 \pm 1275^{a,d}$

^{a,b,c,d,e} = different ($P < 0.05$) from 0, 10, 20, 30, and 40% 1-RM, respectively.

DISCUSSION

The present study revealed that PP output was optimised at 10% 1-RM HBJS, similar to that of Turner et al. (2015) who reported that optimal PP outputs occurred between 10 and 20% 1-RM box squat loads (no significant differences ($P < 0.05$) between 10 and 20% loads) in the HBJS with elite rugby players. Although comparable to the present study, the method of assessing maximum strength differed to the use of HB deadlift, which is arguably more replicable to the HBJS. Similarly, Swinton et al. (2012) reported that PF significantly increased with HBJS load similar to the present study, although peak RFD was maintained across loads, whereas RFD showed a declining trend within the present study, possibly due to differences in subjects tested or the RFD calculations.

CONCLUSION

The present study revealed that PP is maximised under loaded conditions equal to 10% 1-RM HB deadlift, whereas concentric PF was maximised at 40% 1-RM HB deadlift. JH and RFD were both optimised at body mass only (0% 1-RM).

REFERENCES

Cormie et al., (2007). *Med Sci Sports Exerc.* 39(2), 340-349. doi:10.1519/JSC.0b013e31816d5eda
Swinton et al., (2012). *J. Strength Cond. Res*. 26(4), 906-

REGULATION OF GAIT DURING THE POLE VAULT APPROACH PHASE

Laurie Needham[1, 3], Ian Bezodis[1], Tim Exell[2], Scott Simpson[3] & Gareth Irwin[1]
Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK[1]
Department of Sport and Exercise Science, University of Portsmouth, UK[2]
Welsh Athletics, Cardiff, UK[3]
email: Lneedham@cardiffmet.ac.uk

INTRODUCTION

The need for pole vaulters to achieve low end-point variability, i.e. a precise take-off location, is considered to be a key performance factor within pole vault coaching. Movement pattern variability can be considered functional if it allows the performer the flexibility to adapt to changing constraints (Barris et al., 2014). In events such as the pole vault it has been proposed that performers regulate gait through visual control mechanisms (Lee et al., 1982) whereby the athlete uses perceptual reference points close to the target to control locomotion. The aim of this study was to identify visual regulation patterns in pole vaulters of differing skill levels during the approach phase.

METHODS

National (n=5) and international (n=2) level male pole vaulters were recruited (age 21 ±3.7 yrs., mass 76.7 ±12.7 kg, stature 1.85 ±0.07 m) and ranked according to their personal best % of the world record (mean 75% ±8.7%) . Ethical approval was granted. Athletes performed six jumps with the approach run recorded by four HDV cameras. Data were reconstructed using 2D-DLT. Visual regulation was assessed indirectly using standard deviation (SD) of footfall locations during the approach phase. This was defined as the SD of the location of the distal end of the shoe during each ground contact phase across all trials per participant. Means and SDs were calculated.

RESULTS & DISCUSSION

All but one participant presented evidence that gait was being regulated. Three patterns of regulation were identified: An ‘ascending/ descending’ pattern of footfall variability; an ‘ascending’ pattern and a pattern of ‘random fluctuations’ (figure 1). These findings align with those of Hay & Koh (1988). All participants presented ascending/descending patterns, except P4 who presented a purely ascending pattern and P7 who presented random fluctuations. P4 did not demonstrate evidence of visual regulation, but rather a pattern that is representative of unconstrained locomotion. Variability remained low, perhaps due to the reduced number of steps in P4’s approach phase (10 steps compared to 18 steps used by others). P4 may experience difficultly with longer approach runs where greater variability could accumulate.

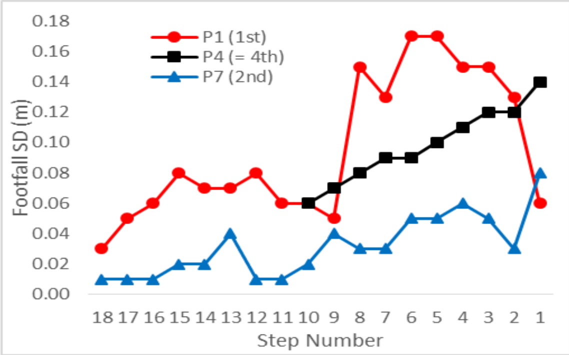


Figure 1: Examples of visual regulation types. Participant no. and rank given in legend. ‘Ascending/descending’ pattern (red). ‘Ascending’ pattern (black). ‘Random fluctuations’ (blue).

Visual regulation patterns do not appear to be associated with skill level here given that P4’s performance level is equal to that of P2 and P5 who did use visual regulation. P7, ranked 2nd, presented low variability (random fluctuations, figure 1) throughout the approach phase (mean ±SD = 0.03 m ±0.02), demonstrating that high performance levels can be achieved using different visual regulation strategies. This strategy may lack robustness as P7 does not show an ability to make functional adjustments during the approach phase.

These findings can provide coaches with meaningful information relating to individual approach phase performance. Practical solutions can be derived from individual’s approach phase data, whereby specific drills that introduce visual regulation (e.g. P4) and / or promote functional variability during the approach (e.g. P7) which may ultimately contribute to an environment in which athletes adapt or develop their gait pattern.

CONCLUSION

Pole vaulters were found to utilise three distinct locomotor control patterns to regulate gait. These were not associated with skill level. The non-stable nature of footfall variability in most athletes enforces the need for degeneracy in approach phase movement patterns. Athletes should be considered on an individual basis in order to effectively, efficiently and safely improve performance.

REFERENCES

Barris et al,. (2014). Research Quarterly for Exercise and Sport, 85(1), 97-106. DOI:10.1080/02701367.2013.872220
Hay & Koh (1988). International journal of sport biomechanics, 4(4).
Lee et al,. (1982). Journal of Experimental Psychology: Human perception and performance, 8(3), 448. DOI: dx.doi.org/10.1037/0096-1523.8.3.448

Comparison of 3rd Generation Artificial Turf and Natural Turf on Internal Knee Moments Whilst Performing Different Football Manoeuvres.

James Osborne[1] and Russ Peters[1]

[1]Physical Education and Sports Studies, Newman University, Bartley Green, UK

email: osbo400@newman.ac.uk

INTRODUCTION

Football is widely played sport across the globe with around 265 million people participating (Cleland, 2015). Football is commonly played on grass, but due to factors such as adverse weather conditions, high maintenance and lack of flexibility (not multi-use), artificial turfs are becoming more common. Ekstrand and Nigg (1989) found that 24% of injuries are caused by unsatisfactory playing surfaces. Within football ankle injuries are most prevalent however knee injuries are often the most serious, which can often be season ending. This leads to the aim of the study which is to compare the internal knee loads between 3rd generation artificial turf and natural grass.

METHODS

Eight Participants were used in this study (height: 1.77 m ± 5.69, weight: 77.84kg ± 19.64). For data collection a 9 camera Qualysis system was used alongside a Kistler force plate which was fitted with either natural or artificial turf. Retro reflective markers were placed on to the appropriate bony landmarks of the lower extremities. The participants were required to wear a standardised lab boot (UMBRO Premio Boot). After a warm up was completed, the participants completed 3 trials of an instep kick, 3 trials of heading a football and landing on the force plate, and 3 180 degree cutbacks. All of the trials were performed on both the artificial grass and the natural grass. Data was analysed using Qualysis Track Manager Software and Visual 3D. IBM SPSS Statistics 22 was then used to create a paired samples t-test to see if there is a significant difference between the 2 football surfaces.

Figure 1.Natural grass and 3rd Generation artificial turf force plate covers

RESULTS

Table 1 shows the results of the study. There is no significant difference between the natural grass and the 3rd generation artificial turf for all conditions.

Table 1. Means (±SD) Internal Knee Moments for the standing kicking leg during instep kick, landing from a header and the 180° cutting maneuver (medial / lateral and anterior / posterior directions)

	Instep Kick (Nm/kg)	Header Landing (Nm/kg)	Cut Medial/ Lateral (Nm/kg)	Cut Anterior /posterior (Nm/kg)
Natural Grass	2.37 ± 0.56	7.34 ± 2.62	0.86 ± 0.14	1.40 ± 0.30
Artificial Grass	2.45 ± 0.54	8.66 ± 3.74	0.87 ± 0.11	1.46 ± 0.34

DISCUSSION

Due to the results of the study and the fact that there was no significant difference between the two playing surfaces it can be said that either surface is a suitable playing surface for football to take place on. A study by Kristensen et al (2013) that compared injury rates between artificial turf and natural grass also found similar results to this study. Overall there were no significant differences between the injury rates between the artificial turf and natural grass which matches the results of this study. However, although no statically significant difference was found, all results were higher in the artificial turf condition compared to the natural turf.

CONCLUSION

To conclude there was no significant difference between the two different playing surfaces, however, it must be noted that participants experience higher knee moments during the artificial turf conditions.

REFERENCES

Cleland, J. (2015). A sociology of football in a global context. 1st edition. Routledge: Cornwall

Ekstrand, J. and Nigg BM. (1989) Surface-related injuries in soccer. *Sports Medicine*, 8(1), pp.56-62.

Ekstrand, J., Hägglund, M. and Fuller, C. (2010). Comparison of injuries sustained on artificial turf and grass by male and female elite football players. *Scandinavian Journal of Medicine & Science in Sports*, 21(6), pp.824-832.

Kristenson, K., Bjørneboe, J., Waldén, M., Andersen, TE., Ekstrand, J., Hägglund, M. (2014). The Nordic Football Injury Audit: Higher Injury Rates for Professional Football Clubs with Third-Generation Artificial Turf at their Home Venue. *British Journal of Sports Medicine*, 48(12), pp.775-781. doi:10.1136/bjsports-2014-093494.166.

A GENDER COMPARISON OF COUNTERMOVEMENT JUMP KINETICS

Sophie J. E. Rej and John J. McMahon
Centre for Health Sciences Research, University of Salford, Salford, United Kingdom
Email: s.j.e.rej@edu.salford.ac.uk

INTRODUCTION

The countermovement jump (CMJ) test is commonly used to distinguish between the neuromuscular characteristics of males and females. The CMJ utilises the stretch-shorten cycle mimicking performance in sports that rely upon sprinting or jumping actions (McLellan et al., 2011). Males typically display higher relative values of force, power and impulse in the CMJ, which are reflected in increased jump heights (JH) (Albian et al., 2008). Most previous studies have explored peak kinetic variables during the concentric phase of the CMJ only, whereas a more comprehensive comparison of the gender differences in the eccentric and concentric phases of athletes' CMJ performances will enable an improved understanding of how male athletes achieve greater JHs than their female counterparts. The aim of this study, therefore, was to explore gender differences in eccentric and concentric kinetic variables attained in the CMJ.

METHODS

Fourteen female regional netballers (age 20 ± 2.3 years, height 168 ± 4.7 cm, body mass 66 ± 7.4 kg) and fourteen male professional academy rugby league players (age 19 ± 1.3 years, height 182 ± 4.3 cm, body mass 88 ± 8.8 kg) performed three CMJs on a Kistler force platform (type: 9286AA) sampling at 1000 Hz. Unfiltered vertical force-time data were analysed retrospectively in Microsoft Excel (Microsoft Corp, Redmond, WA, USA). Impulse was calculated as the area under the net force-time curve (minus body weight) using the trapezoid rule. Centre of mass velocity was determined by dividing vertical force data (minus body weight) by body mass and then integrating the product using the trapezoid rule. Instantaneous power was calculated by multiplying vertical force and velocity data. Concentric and eccentric peak force (P-CON-F/ P-ECC-F) and power (P-CON-P/ P-ECC-P) were defined as the maximum vertical force and power values, respectively, attained during the concentric and eccentric phases of the jump. JH was derived from vertical velocity at take-off.

RESULTS

Males jumped significantly ($p < 0.001$) higher than females (0.32 ± 0.05 m vs. 0.24 ± 0.05 m). As shown in Table 1, P-CON-P, ECC-IMP and CON-IMP attained during the CMJ were also significantly higher for males than females.

Table 1: CMJ kinetic variables for male and female athletes.

Variable	**Mean ± SD**		***p***
	Netball	**Rugby**	
P-ECC-F (N/kg)	22.34 ± 3.57	22.73 ± 2.51	0.738
P-CON-F (N/kg)	23.23 ± 3.54	24.13 ± 2.64	0.613
P-ECC-P (W/kg)	14.5 ± 4.07	16.16 ± 4.01	0.287
P-CON-P (W/kg)	41.81 ± 6.71	50.31 ± 6.56	0.001
ECC-IMP (N/kg.s)	1.04 ± 0.19	1.21 ± 0.21	0.041
CON-IMP (N/kg.s)	2.09 ± 0.21	2.42 ± 0.20	<0.001

P-ECC-F = peak eccentric force; P-CON-F = peak concentric force; P-ECC-P = peak eccentric power; P-CON-P = peak concentric power; ECC-IMP = eccentric impulse; CON-IMP = concentric impulse.

DISCUSSION

This study showed that CMJ height was significantly greater for the male athletes. Unlike in previous research (Laffaye et al., 2014), however, force variables were not found to be significantly different between genders in the present study. Although PFs were not significantly different between groups, PF relates to P-CON-P (West et al., 2011), which was significantly different between males and females in this study. This, alongside ECC-IMP and CON-IMP being significantly greater in males, implies that time-related variables are a contributing factor to the higher JH in males. This is in agreement with Laffaye et al., (2014) in that by minimising key time variables for women through increasing velocity during both the eccentric and concentric phases of the CMJ, the rate of force development will improve alongside greater ground reaction forces allowing for a more explosive vertical jump (Laffaye et al., 2014).

CONCLUSION

In conclusion, males achieve greater JH in CMJ than females due to greater P-CON-P and CON/ECC-IMP. Females should, consequently, train to improve time-related performance variables in the CMJ to lessen the differences seen between genders.

REFERENCES

Albian et al., (2008). *J Strength Cond Res.* 28(4):1096-105.
Cormie et al., (2009). *J Strength Cond Res.* 23(1):177-86. doi: 10.1519/JSC.0b013e3181889324.

A case study of the deceleration during the steps preceding a cutting movement, in relation to the potential of hamstring injuries in soccer.

Ida Bo Steendahl[1], Neal Smith[1], Penny Hudson[1] and Simon Augustus[1]
[1]Department of Sport and Exercise Sciences, University of Chichester, Chichester, UK
email: isteend1@stu.chi..ac.uk

INTRODUCTION

Whole-body decelerations occurs prior to turning movements (Hader, Palazzi & Buchheit, 2015), which have been identified in large numbers during soccer matches (Bloomfield, Polman & O'Donoghue, 2007). Hamstring injuries in soccer account for 12% of all injuries and 57% of all the injuries occurring during soccer (Woods, Hawkins, Maltby, Hulse, Thomas & Hodson, 2004). Since rapid decelerations have been found to cause a significant mechanical stress on the body (Thompson, Nicholas & Williams, 1999), this exploratory case study aims to investigate the decelerating ipsilateral and contralateral steps preceding a cutting movement, to highlight any potential injury risks and additionally explore how field based triaxial accelerometers monitor such decelerations.

METHODS

The participant (male, 3 years experience as semi-professional football player) performed five successful trials consisting of a run up and a 90° cutting movements on his dominant leg, with the ipsilateral and contralateral steps placed on force platforms, while wearing a portable field based triaxial accelerometer (Catapult Minimax, Optimeye S5). Synchronised motion capture was performed at 150Hz via 10 x Vicon T-Series cameras using a University of Chichester lower extremity marker set based on the CAST technique. Due to the nature of the case study, data analysis were comprised of comparisons between the ipsilateral and contralateral steps. Variables of interest included joint angles, moments, power and angular velocities of hip and knees, vertical ground reaction forces and horizontal absorption impulse. Accelerations and Player Load™ for each step and the turning point were extracted from the accelerometer for comparison.

RESULTS AND DISCUSSION

The ipsilateral step showed despite a shorter stance time, higher vertical GRF and absorption impulses, a 24.16% lower horizontal to vertical absorption impulse ratio indicating a greater amount of braking occurring during the contralateral step. Greater knee angular velocities and peak extension moments were seen during the ipsilateral step, however the hip flexion velocity and moments differed greatly between the two steps (figure 1). Differences were also evident in knee and hip joint power across the steps, with the main energy absorption seen at the knee during the ipsilateral step and at the hip for the contralateral step, which indicated difference in function of the hamstring muscle during the two steps. The accelerometer data showed contradicting data compared to the obtained ground reaction forces, although interestingly the Player Load™ values were lower during the turning step than during any of the two preceding steps.

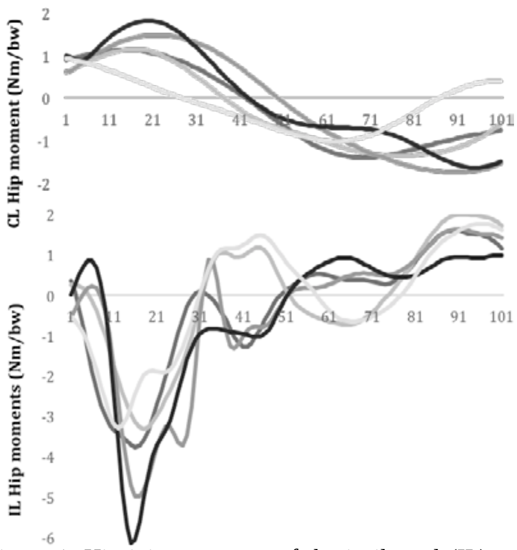


Figure 1. Hip joint moments of the ipsilateral (IL) step (bottom) and the contralateral (CL) step (top) normalised for bodyweight.

CONCLUSION

Data suggested that the hamstring muscles may be under greater demand during the ipsilateral step preceding the 90° cutting movement, and practices involving large numbers of decelerations may predispose hamstring fatigue.

REFERENCES

Hader, K., Palazzi, D. & Buchheit, M. [2015]. *Kinesiology*, 47(1), 67-74),

Bloomfield, J., Polman, R., & O'Donoghue, P. [2007]. *J Sport & Med*, 6, 63-70.

Woods, C., Hawkins, R., D., Maltby, S., Hulse, M., Thomas, A. & Hodson, A. [2004]. *Br J Sports Med*, 38, 36-41. doi:10.1136/bjsm.2002.002352

Thompson, D., Nicholas, C. W., & Williams, C. [1999]. *J Sports Sciences*, 17(5), 387–395. doi: 10.1080/026404199365902

COMPARISON OF LANDING KINEMATICS BETWEEN MALE AND FEMALE ARTISTIC GYMNASTS

Rebecca Straker[1], Timothy Exell[2] and Gareth Irwin[1]
[1]Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK
[2]Department of Sport and Exercise Science, University of Portsmouth, Portsmouth, UK
email: r.straker@cardiffmet.ac.uk

INTRODUCTION

Lower extremity injuries including non-contact anterior cruciate ligament (ACL) injuries during dismounts have been identified as one of the most significant injuries affecting a gymnasts' career. Females have been identified as more vulnerable to lower extremity injuries than males (Kerr et al., 2015). Previous research has investigated dismounts and the potential of injury (McNitt-Gray, 1991) however the landing height and task were not reflective of those performed during gymnastic performances. The aim of the study was to compare the landing kinematics between experienced male and female artistic gymnasts following a back tuck dismount from the high bar.

METHODS

Kinematic data were collected from 4 experienced artistic gymnasts (2 male, 2 female, mean ages 19±0.4 and 21.8±0.3 years respectively) using a 3D CODA motion capture system (200 Hz). Five markers were placed unilaterally on the toe, ankle, knee, hip and shoulder. Participants performed 5 successful back tucked dismounts. Kinematic data were filtered using a modified Butterworth filter (13 Hz). Sagittal plane ankle and frontal plane knee angles were calculated using the CODA software. Coordination between flexion angles of ankle and knee joints was calculated using vector coding.

RESULTS & DISCUSSION

Joint angle results are presented in Table 1 and demonstrate individual landing techniques. No clear trends were apparent for male or female gymnasts.

Table 1: joint kinematics during landing for male and female participants.

	F01	F02	M01	M02
Ankle ROM (°)	29 (±9)	38 (±10)	21 (±11)	39 (±9)
Max Knee Valgus (°)	13 (±4)	15 (±2)	24 (±7)	10 (±5)

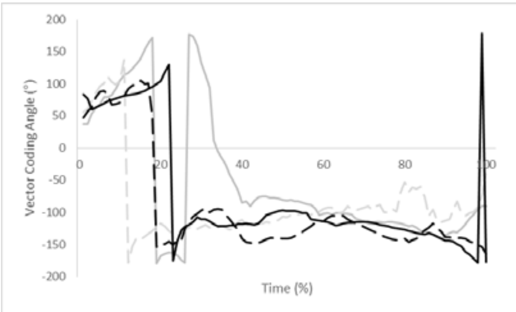


Figure 1: A time series profile of the resulting coupling angles (ankle and knee) for females (grey: bold F1, dashed F2) and males (black: bold M1, dashed M2).

According to Hamill & Knutzen (2009) a knee abduction angle of more than 17° is considered genu valgus. According to this definition only one participant (M1) exhibited this. Decreased ankle ROM may be a potential explanation for this. For the gymnasts included in this study, individual landing mechanics appear to be the primary cause of injury predisposition and not sex. Coordination profiles were gymnast specific with a similar pattern displayed for M1, M2 and F2. F1 showed greater activity at the ankle joint later in the landing phase (30 – 40%).

CONCLUSION

The differences in landing techniques between sexes often reported in the literature were not noted in this study. Findings from this study highlight gymnasts' individual techniques and the importance of assessing gymnasts on an individual basis for technique that may increase injury risk.

REFERENCES

Hamill, J. and Knutzen, K. M. (2009). Philadelphia: Lippincott, Williams and Wilkins.

Hewett, T. E., Myer, G. D., Ford, K. R., Heidt, R. S., Colosimo, A. J., McLean, S. G. et al. (2005). *Am J Sports Med*, 33(4), 492-501.

Kerr, Z. Y., Hayden, R., Barr, M., Klossner, D. A. and Dompier T. P. (2015). *J Athl Train*, 50(8), 870-878.

McNitt-Gray, J. L. (1991). *Int J of Sport Biomech*, **7**, 201-224.

Measuring vertical jump performance: the validity of a portable force platform and contact mat when compared against a laboratory force platform

Jessica Westcough[1] Louise Stewart[1] Rebecca Ross[1] and Adam Hawkey[1, 2]*
[1]Division of Sport and Exercise Science, Abertay University, UK
[2]School of Medicine, University of Dundee, UK.
*Corresponding Author: a.hawkey@abertay.ac.uk @a_hawkey

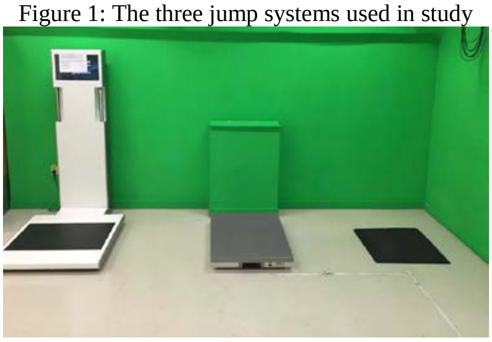
INTRODUCTION

Jump performance has been described as an accurate and reliable method of assessing lower-body muscular power (Markovic and Jaric, 2007). The use of laboratory force platforms is generally regarded as the 'gold standard' for the measurement of vertical countermovement jump (VCMJ) performance. However, cheaper and more portable devices, such as contact mats, are now frequently used. While some research has reported that such contact mats provide a valid alternative to criterion measures (Leard et al. 2007), other research has questioned their validity (Buckthorpe et al. 2012; Hawkey et al. 2016). Therefore, the aim of the current study was to assess the validity of a contact mat system and a portable force platform at measuring VCMJ performance.

METHODS

Following institutional ethics approval 17 healthy university sport students (mean: age = 22.3 ± 2.52 years; height = 1.73 ± 0.08 m; mass = 74.86 ± 12.07 kg) performed three maximal VCMJ on each of a Just Jump™ contact mat, AMTI portable force platform (using Accupower™ software) and a Bertec force platform (incorporated into an MIE FitQuest™ system) in a randomised, counterbalanced order (Figure 1). The average jump heights on each system were analysed using a one-way analysis of variance (ANOVA), with the alpha level set at P<0.05.

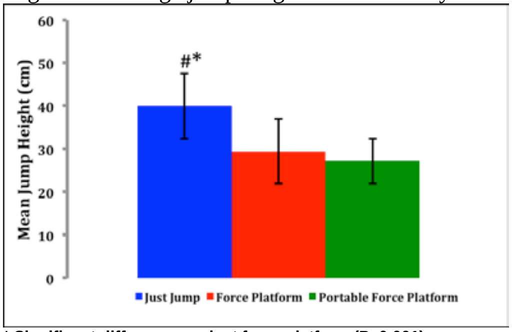
Figure 1: The three jump systems used in study



RESULTS AND DISCUSSION

One-way ANOVA reported a significant difference (P<0.001) in the jump heights recorded by the Just Jump™ contact mat (Mean ± SD = 41.14 ± 7.66 cm) in comparison to both the Bertec laboratory force platform (Mean ± SD = 27.27 ± 5.28 cm) and the AMTI portable force platform (Mean ± SD = 29.32 ± 7.67 cm). No significant difference (P<0.05) was found between the jump heights reported by the Bertec laboratory force platform and the AMTI portable force platform (Figure 2). Results of the current study support previous findings (Buckthorpe et al. 2011; Hawkey et al. 2015) that the Just Jump™ contact mat is not a valid alternative to a laboratory force platform when assessing VCMJ performance.

Figure 2: Average jump height recorded on systems



*** Significant difference against force platform (P<0.001)**
 # Significant difference against portable force platform (P<0.001)

CONCLUSION

Current study suggests that the portable force platform appears to provide a valid alternative to a laboratory force platform in measuring VCMJ performance. The Just Jump™ contact mat, however, cannot be recommended due to the significant variability in comparison to the laboratory force platform's results. Future research should now investigate reliability and validity of a variety of portable jump systems.

REFERENCES

Buckthorpe, M. *et al.* (2012) Validity of vertical jump measurement devices. *Journal of Sports Sciences*. **30**(1): 63-69.

Hawkey, A. et al. (2015). Assessing the validity and reliability of a contact mat and a photoelectric mat against a force platform at measuring countermovement jump performance. Proceedings, BASES 31st Biomechanics Interest Group Meeting.

Leard, J.S., et al. 2007. Validity of Two Alternative Systems for Measuring Vertical Jump Height. *Journal of Strength & Conditioning Research.* 21(4): pp. 1296-1299.

Markovic, G. and Jaric, S. (2007). Is vertical jump height a body size-independent measure of muscle power? *Journal of Sports Sciences*, **25**(12): 1355-1363.

INVESTIGATING THE EFFECTS OF PLYOMETRIC TRAINING ON LEAPING HEIGHT PERFORMACNE IN ELITE RHYTHMIC GYMNASTS

Natalie Williams[1] and Russ Peters[1]
Physical Education and Sports Studies, Newman University, Bartley Green. Birmingham UK
e-mail: will404@newman.ac.uk

INTRODUCTION

Within rhythmic gymnastics, the split leap is commonly used movement, whether to connect two moves together or to move across the floor displaying competence and skill. The actual leaping height as well as the reproducibility of an effective and well-executed leap highly influences scoring at competition level (Hutchinson et al., 2006). Many different approaches have been trialled to improve jump height, such as vibration training (Cardinale & Bosco, 2003) and electro-stimulation training (Malatesta et al, 2003) but researchers have suggested that plyometric training should be the most preferred method to improve vertical jump ability and leg muscle power (Adams et al., 1992). Therefore, the aim of this study was to investigate the effects of a 6 week training intervention of plyometric and squat exercises on vertical jump height of elite rhythmic gymnasts.

METHODS

Ten junior elite female participants (height: 147.75cm ± 6.83, weight: 40.22kg ± 8.49) were used for this study with an average of 8 years' experience within rhythmic gymnastics. Twenty-five retro-reflective markers were attached (Figure 1) and the participants completed 5 trials of drop jumps from a 30cm & 60cm high platform onto a Kistler force platform. They landed and then performed a star jump straight afterwards. Jump height, knee angles at landing and take-off, and ground reaction forces were recorded via a nine camera 3D Qualysis Motion. A six week intervention followed which included squat jumps, box jumps, burpees and box depth jumps with sessions occurring 3 per week. Post-test data was then collected with the same method above.

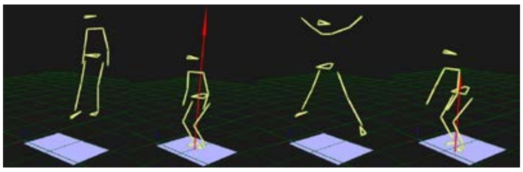


Figure 1: Illustrates the drop jump and split leap performance.

RESULTS & DISCUSSION

Thus far the study has analysed the pre invention data and the post-test data is currently being processed and will be available shortly.

Table 1. Pre-intervention Jump Height Means (±SD)

Jump Height	
30cm (m)	**60cm (m)**
0.41 ± 0.03	0.41 ± 0.03

Table 1 highlights the pre intervention jump heights and table 2 shows the knee angles at impact and take-off from 30cm & 60cm drop heights.

Table 2. Pre-intervention Knee Angle Means (±SD)

30cm Impact (°)	60cm Impact (°)	30cm Take-off(°)	60cm Take-off(°)
103 ± 6.96	88.61 ± 11.8	155.07 ± 6.83	152.78 ± 8.3

A similar study by Hutchinson et al. (1998) carried out a 4-week intervention of intense pool training and Pilates' Method of Body Conditioning in an attempt to improve leaping height in elite rhythmic gymnasts. The study found that all athletes improved their jump height with an average of 16.2%, improved their floor reaction time with an average of 49.8% and also improved their explosive power with an average of 220.4%.

CONCLUSION

Previous studies have suggested that an exercise intervention produces positive results in improving jumping heights. The results of the post-test are in the process of being analysed and will be reported shortly

REFERENCES

Adams et al (1992) The effect of six weeks of squat, plyometrics and squat-plyometric training on power production, *Journal of Applied Sport Science Research*, 6 (1), pp.36-41

Cardinale, M., Bosco, C. (2003) 'The use of vibration as an exercise intervention', *Exercise and Sport Sciences Reviews*, 31 (1), pp.3-7

Hutchinson et al (1998) Improving leaping ability in elite rhythmic gymnasts, *Medicine & Science in Sports and Exercise*, 30 (10), pp.1543-1547

Malatesta et al (2003) Effects of Electromyostimulation Training and Volleyball Practice on Jumping Ability, *Journal of Strength and Conditioning Research*, 17 (3), pp.573-579