

Program & Abstracts

11th Annual Meeting of the Danish Society of Biomechanics

15th November 2019

Editor: Tina Dalager Department of Sports Science and Clinical Biomechanics University of Southern Denmark



Dear colleagues and fellow biomechanists.

The Department of Sports Science and Clinical Biomechanics, University of Southern Denmark is honoured to host the 11th Annual Meeting of the Danish Society of Biomechanics. We are looking forward to an intense day consisting of an interesting Keynote lecture, Invited session, Student Award as well as podium and poster presentations. Also, for the members of the Danish Society of Biomechanics the annual general assembly is held.

The Annual Meeting provides an excellent opportunity for anyone with an interest in biomechanics to exchange and discuss results or ideas with fellow researchers, experts, clinicians, and students.

I also wish to thank our sponsors for their contributions to the Annual Meeting. Please visit their booths during the day.

On behalf of the organizing committee, I wish you a pleasant and interesting day in Odense.

Tina Dalager Alternate of the Danish Society of Biomechanics



KEYNOTE SPEAKER

Dr. Shaoping Bai is an Associate Professor at the department of Materials and Production, Aalborg University (AAU), Denmark. His research interests include assistive robots, parallel manipulators, walking robots, dynamics and design. He is one of the founders of Centre for Robotics Research (CRR), AAU. He was the coordinator of the CRR for the year 2010-2012. Dr. Bai leads several national and international research projects in exoskeletons, including EU AAL project AXO-SUIT and IFD Grand Solutions project EXO-AIDER, among others. Dr. Bai is a recipient of IEEE CIS-RAM 2017



best paper, IFToMM MEDER 2018 best application paper, and WearRAcon Grand Prize of Innovation Challenges 2018. Dr. Bai is an Associate Editor of ASME J. of Mechanisms and Robotics, an Associate Editor of IEEE Robotics and Automation Letters, and a deputy chair of IFToMM Technical Committee of Robotics and Mechatronics.

Abstract for keynote:

Exoskeletons are wearable devices that are designed to help human in various aspects of life. They are increasingly being developed for rehabilitation of stroke and SCI patients, power augmentation of workers and motion assistance of the elderly. The development of exoskeletons is highly relevant to biomechanics principles in exoskeleton design, motion detection and human-robot interaction control.

This talk is focused on human-centered design and development of exoskeletons. The presentation will cover relevant topics including exoskeleton kinematics, dynamics, biomechanics and motion control. An approach of human-exoskeleton biomechanical modelling will be described; novel mechanism design to comply with human anatomy will be discussed with some innovative design achieved. Moreover, a sensing method by means of forcemyography, namely a Force Resistor Sensing (FSR) sensor band, for the control of upper-limb exoskeletons will be introduced. Its working principle, algorithm development, testing and validation will be presented. A few cases of the FRS sensor band as a human-robot interface will also be demonstrated. In this talk, a few ongoing research projects on exoskeletons for applications in motion assistance will be presented too.

VENUE

The 11th Annual Meeting of the Danish Society of Biomechanics is held at:

University of Southern Denmark Campusvej 55, 5230 Odense M

All presentations, and the general assembly will take place in Auditorium O100 Exhibitions, poster presentations, coffee and lunch will take place at Campustorvet right next to the auditorium. Location for the activity of "Refreshments and networking" will be announced at the official closing of the meeting.



If you come by car, use the following address: Fioniavej, 5220 Odense SØ Drive down Fioniavej (From Munkebjergvej) towards parking V1. From the parking lot you walk along the path until you meet stairs. From here you follow the path on the left until you arrive at entrance S32. At this entrance you come to a long hallway, you follow it all the way to O100.

If you come by bus, the bus stops at the purple X. From here, you walk up the stairs and turn right. On your left hand you will have entrance G43. At this entrance, you will have to walk straight ahead for approx. 100 meters, and on your right hand you will meet O100.

PROGRAM OVERVIEW

TIME	CONTENT
09.00-09.30	Registration, coffee/tea and scones
09.30-10.15	Keynote
10.15-11.15	Invited session – topic: 'Human-robot interaction'
11.15-11.30	Break
11.30-12.30	Student presentations
12.30-13.00	General assembly
13.00-13.45	Lunch and networking
13.45-14.45	Podium presentations
14.45-16.00	Poster session
16.00-16.10	Student award
16.10-16.15	Closing
16.15-	Networking

DETAILED PROGRAM

Time	Content		
09.00-09.30	Registration, poster mounting, Coffee/tea and scones		
09.30-10.15	 KEYNOTE LECTURE by Dr. Shaoping Bai, Associate professor Title: <i>Exoskeleton design and human intention detection for motion assistance applications</i> Chair: Ernst Albin Hansen 		
	INVITED SESSION ON HUMAN-ROBOT INTERACTION		
	 Tongue and hybrid human machine interfacing for assistive robots and exoskeletons Lotte N. S. Andreasen Struijk, Aalborg University 		
10.15-11.15	 Project UnOrthoDOKS: towards soft robotic orthoses for personalised osteoarthritis knee support Danish Shaikh, University of Southern Denmark 		
	 Human-machine interfacing to assistive robots Strahinja Dosen, Aalborg University 		
	 RoBody interaction: Integrating embodied social practices in training robots Anders S Sørensen, University of Southern Denmark 		
	Chair: Anders Holsgaard Larsen		
11.15-11.30	Break and exhibition		
	 STUDENT PRESENTATIONS Prediction of post-operative joint instability following total knee arthroplasty D Pedersen, V Vanheule, R Wirix-Speetiens. O Tavlan. H P Delport. L 		
11.30-12.30	 Scheys, M S Andersen The effect of acute body weight support on stride rate, stride length, and speed during preferred walking, preferred running, and during the walk-to-run 		
	transition J Jepsen, D Gregersen, J T Frandsen, R T Jessen, E A Hansen, M Voigt		

	 Predicting throwing speed using accelerometers: First step towards monitoring throwing load in handball S D Skejø, M Møller, J Bencke, H Sørensen Exercise with blood flow restriction reduces time to task failure, induces more pain, but evokes similar changes in activation and oxygenation as free-flow exercise M Kolind, S Gam, J G Phillip, F Pareja-Blanco, Y Gao, H B Olsen, K Søgaard, J L Nielsen Chair: Tina Dalager/Tine Alkjær
12.30-13.00	General assembly of the Danish Society of Biomechanics (For DBS members)
13.00-13.45	Lunch, networking and exhibition
13.45-14.45	 PODIUM PRESENTATIONS Complexity of isometric force production – effect of age P C Raffalt, J M Yentes, S S Geertsen, M E spedden Markerless motion capture can track pre-school children with instrumental variation – but the potential clinical impact is questionable S Harsted, A Holsgaard-Larsen, L Hestbæk, D L Andreasen, H H Lauridsen Assessment of scapular muscles thickness and electromyography in healthy people D Sciacca, A Dýrfjörð, C Couppé, A Cools, T. Alkjær A parametric biomechanical model of running J Rasmussen, M E Lund Chair: Henrik Koblauch
14.45-16.00	 POSTER SESSION Association between handedness and scapular muscle recruitment pattern in healthy individuals A Dýrfjörð, S Magnúsdóttir, E Zwicky, M Henriksen, C Couppé, R Høffner, A Cools, T Alkjær Musculoskeletal pain is common in competitive gaming: A cross-sectional study among 188 Danish recreational E-sport athletes L Lindberg, S B Nielsen, M Damgaard, O R Sloth, C L Strazek

 Possible factors associated with running economy A Nielsen, S E Moise, U G Kersting, M de Zee, C Heyde, R G Larsen
4. Where to apply spinal manipulation – do clinical outcomes differ when targeting spinal stiffness or pain sensitivity? C G Nim, S O'Neil, G N Kawcguk, B Schiøttz-Christensen
 Multi-directional sound wave recordings enhance the identification of sound force relationship during running C I Pirscoveanu, A S Oliveira
6. A novel human motion detection method and its application in hand exoskeleton control M R U Islam, S Bai
7. A thoracolumbar multibody model capable of simulating scoliosis deformities H Shayestehpour, J Rasmussen, C Wong
8. Cadences and direction effect on grinding economy, kinematics and crank effect profiles in Americas cup grinding S Gam, A Boutrup, J Molbech, J Larsen, M de Zee & K Klitgaard
9. Muscle strain and postures during conventional and robotic-assisted laparoscopic surgery: A paired cross-sectional study T Dalager, P T Jensen, J R Eriksen, H L Jakobsen, O Mogensen, K Søgaard
10. A non-invasive assessment of ground reaction forces in the human leg in response to walking, jogging, running and jumping J Pingel, A Harrison
11. Associations between physical activity and sleep among 75+ community- dwelling Danish older adults L-T Tsai, E Boyle, JC Brønd, G Kock, F D'Oriente, A Gigliotti, P Gaserotti
12. Comparing the ViMove system against the Vicon system for neck postures and movements B Hesby, E Boyle, J Hartvigsen, T Skallgaard, G Sjøgaard, P Kjær
13. Task constraints during locomotion affect movement attractor dynamics more than scaling a control parameter P C Raffalt, J Kent, S R Wurdeman, N Stergio

40.00.40.40	Student award decision
10.00-10.10	Chair: Tina Dalager/Tine Alkjær
16.10-16.15	Official closing
16.15-??	Refreshments, snacks and networking

ABSTRACTS IN ALPHABETICAL ORDER

Muscle strain and postures during conventional and robotic-assisted laparoscopic surgery: A paired cross-sectional study

Tina Dalager 1,2, Pernille T Jensen3,4,5, Jens R Eriksen6, Henrik L Jakobsen7, Ole Mogensen4, Karen Søgaard1,8.

Department of Sports Science and Clinical Biomechanics, University of Southern Denmark.
 Centre for Innovative Medical Technology, Odense University Hospital, Denmark.
 Clinical Institute, University of Southern Denmark.
 Department of Gynaecology and Obstetrics, Aarhus University Hospital, Denmark.
 Faculty of Health Institute for Clinical Medicine, Aarhus University, Denmark.
 Department of Surgery, Colorectal Cancer Unit, Zealand University Hospital, Roskilde, Denmark.
 Department of Gastroenterology, Herlev Hospital, Denmark.
 Occupational and Environmental Medicine, Odense University Hospital, Denmark.

INTRODUCTION

Performing surgery is physically demanding. Little is known about the differences in physical workload between conventional laparoscopy (LAP) and robotic-assisted laparoscopic surgery (RALS). In a paired cross-sectional study, we examined and compared muscular workload, work posture, and perceived physical exertion (RPE) among surgeons during the performance of LAP and RALS.

METHODS

Thirteen colorectal surgeons with experience in advanced LAP and RALS performed one of each operation. Bipolar surface electromyography was recorded from forearm, shoulder, and neck muscles, and expressed relative to EMG maximum (%EMGmax). The static, median, and peak level of muscle activity were calculated, and an Exposure Variation Analysis (EVA) was conducted. Postural observations were carried out every ten minutes, and ratings of RPE before and after surgery was recorded.

RESULTS AND DISCUSSION

Performing LAP showed higher static, median, and peak forearm muscle activity compared with performing RALS (figure 1). Left shoulder displayed the highest muscle activity in RALS at peak level (figure 1). The EVA demonstrated long-lasting epochs of low-level intensity muscle activity for LAP in the shoulders, for RALS in the forearms, and for both in the neck. Postural observations disclosed a significantly higher demand for a change in work posture when performing LAP compared with performing RALS. RPE showed no difference between surgical modalities.

CONCLUSIONS

Independent of surgical modality, minimally invasive surgery offers long-term static muscle acitivy, either standing or sitting, which induces a high physical workload for the surgeon. Observation of work postures favored RALS, with recommendations for LAP to change work posture.



Figure 1: The static level (the 10% percentile, i.e., the level exceeded 90% of operation time). The median level (the 50% percentile, i.e., the level exceeded 50% of operation time). The peak level (the 90% percentile, i.e., the level exceeded 10% of operation time). LAP = Conventional laparoscopy. RALS = Robotic-assisted laparoscopic surgery. * Significant difference ($p\leq0.05$). Data are shown as mean with 95% confidence interval.

Association between handedness and scapular muscle recruitment pattern in healthy individuals

¹Arna Dýrfjörð^{*1}, Sigríður Magnúsdóttir^{*1}, Emilie Zwicky^{*1}, Marius Henriksen², Christian Couppé², Rikke Høffner², Ann Cools^{2,3}, Tine Alkjær^{1,2}

¹Department of Biomedical Sciences, University of Copenhagen, ²The Department of Physical and Occupational Therapy, Bispebjerg-Frederiksberg Hospital, Denmark, ³Department of Rehabilitation Sciences and Physiotherapy, Ghent University, Gent, Belgium. *Biomedical engineering student, KU/DTU

INTRODUCTION

Handedness is one of the most studied asymmetries in humans. However, studies on handedness in relation to electromyography (EMG), lack evaluation of larger groups of left- and right-handed participants. Thus, the aim was to investigate if the shoulder muscle activity differs between the dominant and non-dominant side in healthy subjects, including both left- and right-handers. Additionally, the aim was to examine if the degree of handedness was associated with the EMG activity during dynamic exercises. Two hypotheses were formulated and tested: 1) The mean muscle activity is lower for the dominant shoulder compared to the non-dominant during dynamic exercises. 2) There is a relationship between the degree of handedness and the mean muscle activity side differences during dynamic exercises.

METHODS

EMG recordings from four shoulder muscles (upper trapezius, middle trapezius, lower trapezius and serratus anterior) were monitored for dominant, and non-dominant sides in 42 healthy subjects (24 right-handed; 18 left-handed) during 14 shoulder rehabilitation exercises. In addition, two maximum voluntary isometric contractions (MVCs) were recorded. Each exercise was performed in a sequence of 6s with a 3s concentric and a 3s eccentric phase, with a 6s rest between repetitions. Muscle activity was assessed as the mean EMG amplitude over the 5 repetitions normalized to the maximum EMG amplitude obtained during the MVCs (%MVC). All participants filled out the Edinburgh Handedness Questionnaire [1] to determine hand preference during different tasks. From this, the laterality quotient (LQ) was calculated, ranging from -100 to +100, with -100 indicating total left-hand dominance and +100 indicating total right-hand dominance [2]. Statistics were performed using SAS software and repeated-measurement mixed linear model was used for the analysis. The level of significance was set to 5%.

RESULTS AND DISCUSSION

The results showed statistically significant differences in mean muscle activity between the dominant and non-dominant shoulder in 11 out of 56 comparisons in total. Significant differences were detected for three muscles: lower trapezius, middle trapezius, and serratus anterior. The observed differences ranged from -1.9 to 3.6 %MVC, indicating that the muscle activity was not consistently lower in the dominant than in the non-dominant shoulder. Additionally, the overall measured activity was low, generally below 15 %MVC, which was not in agreement with the initial hypothesis. The present results differ from previous studies where lower muscle activity in the dominant shoulder compared to the non-dominant during

dynamic tasks have been reported [3,4]. This discrepancy may be due to the exercises applied in the different studies. The relation between the degree of handedness and side differences in muscle activity was investigated by dividing the cohort into 3 groups, based on their LQ score (Table 1).

 Table 1: Division of subjects into groups based on LQ scores and avg. LQ score for each group.

	L	R	Sum	Average LQ
Left [LQ< -70]	9	-	9	-82.4
Mixed [-69 <lq 69]<="" <="" th=""><th>7</th><th>3</th><th>10</th><th>-4.4</th></lq>	7	3	10	-4.4
Right [LQ > 70]	-	21	21	79.8

Table 2 shows the number of statistically significant differences observed within each of the three groups. For the left-handers, 15 out of 56 comparisons were significantly different: 11 where the right side was higher than left and 4 where left side was higher than right. For the mixed group, 7 side differences were observed. For the right-handers, 8 side differences were observed with equally many significant differences for the dominant arm and non-dominant arm (Table 2).

Table 2: The numbers for which %MVC	of one side was
detected significantly higher than %MVC of	the other side.

Left-h	Left-handed		Mixed		nanded
Right	Left	Right	Left	Right	Left
11	4	2	5	4	4

These results could not confirm our initial hypothesis assuming a relationship between the degree of handedness and muscle activity side differences. We expected that the left- and right-hander groups would show similar and consistent behavior where their non-dominant side would show higher activity than their dominant side. This was not the case.

CONCLUSIONS

Overall, low levels of muscle activity were required to perform the rehabilitation exercises. Moreover, no clear difference in muscle activity between the dominant and non-dominant side during shoulder rehabilitation exercises was detected. Furthermore, no clear relationship between the degree of handedness and mean muscle activity was found.

- 1. Oldfield, R. C. Neuropsychologia 9, 97-113 (Sept. 1970).
- 2. Dragovic, M. Acta Neuropsychiatrica 16, 212–218 (Aug.2004).
- Bagesteiro, L. B. & Sainburg, R. L. Journal of Neurophysiology 88, 2408–2421 (Nov 2002).
- 4. Yoshizaki K. et al. Journal of Shoulder and Elbow Surgery 18, 756-763 (Sept 2009).

MARKERLESS MOTION CAPTURE CAN TRACK PRE-SCHOOL CHILDREN WITH LOW INSTRUMENTAL VARIATION - BUT THE POTENTIAL CLINICAL IMPACT IS QUESTIONABLE

Steen Harsted*1, Anders Holsgaard-Larsen², Lise Hestbæk^{1,3}, Ditte Lundsgaard Andreasen¹, Henrik Hein Lauridsen¹

¹Research Unit for Clinical Biomechanics, Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, 5230 Ordense M. Denmark

Odense M, Denmark ²Orthopaedic Research Unit, Department of Clinical Research, University of Southern Denmark, J. B. Winsløws Vej 19, 5000 Odense C, Denmark ³Nordic Institute of Chiropractic and Clinical Biomechanics, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark *Ph.D. student, corresponding author, email: sharsted@health.sdu.dk

INTRODUCTION

Investigating a potential association between early-in-life motor control and future injury risk likely requires large-scale studies with objective and reliable measures of motor control. Until now, the practical feasibility of obtaining such measures has been low, thereby preventing large-scale studies, but it is now possible to obtain kinematic measures using portable markerless motion capture systems that require little or no participant preparation time [1]. Recently, the validity of one such system measuring pre-school children has shown promising results [2], but the level of instrumental variation requires further scrutiny and the test-retest reliability remains to be estimated.

Hence, the research aim of this study was to estimate and evaluate the instrumental variability and test-retest reliability of objective measures of lower extremity motor control and jump performance, obtained using a novel markerless motion capture system in pre-school children performing standing broad jumps.

METHODS

67 pre-school children performing standing broad jumps were recorded in a test-retest study design using markerless motion capture equipment. 13 variables (10 kinematic, 2 digital scaling estimates of hip-to-hip and hip-to-knee distance and jump length performance) were extracted. Recordings from the first session were processed independently twice and compared to estimate the instrumental variability of the automated post-processing of the markerless motion capture system, while recordings from the first and second test sessions were compared to estimate the test-retest reliability. Statistical tests included 95% limits of agreement (LOA), intraclass correlations of absolute agreement (ICC), and the smallest detectable change.

RESULTS AND DISCUSSION

The 3D scaling estimates, jump length performance, and 6 of the 10 kinematic variables had acceptable instrumental variation (ICC > 0.76, and LOA within prespecified limits). The scaling estimates and jump length performance also showed acceptable test-retest reliability (ICC > 0.79). However, the test-retest reliability of the six kinematic variables with acceptable instrumental variation was found to be moderate or poor (ICC < 0.55). Together these results indicate that pre-school children perform jump-landings with large between-session (biological) variation in their movement patterns.

CONCLUSIONS

Measures of jump-length and selected jump-landing kinematics can be measured in young children with acceptable levels of instrumental variability using 3D markerless motion capture technology.

However, the jump-landing movement patterns found in a representative sample of pre-school children exhibited large intra-individual biological variation. Therefore, any *single* kinematic measure is unlikely to be of high predictive clinical value and may also be challenging to use as reference values for healthy children.

We suggest that future work into the possible relationship between early-in-life motor patterns and future injury risk should explore individuals showing persistent extreme kinematics over *multiple* test-sessions.

REFERENCES

1. S.L. Colyer, et al., Sports Med Open 4(1) (2018) 24.

2. S. Harsted, et al., Chiropr Man Therap 27 (2019) 39.

Comparing the ViMove system against the Vicon system for neck postures and movements

Bue Bonderup Hesbyı, Eleanor Boyleı, Jan Hartvigsenı, Tue Skallgaardı, Gisela Sjøgaardı, Per Kjaerı

1: Department of Sports Science and Clinical Biomechanics, University of Southern Denmark.

INTRODUCTION

Measures of neck posture, range of motion, movement speed, and pain are of clinical and research interest when managing people with neck pain. New advances in sensor technology in motion trackers call for innovative use of sensors in the detection of posture and movement impairments. The objective was to assess the reproducibility and agreement between ViMove (sensor device system) and Vicon (infrared camera tracking system) for three neck postures, for movement and speed.

METHODS

Healthy subjects recruited among students at University of Southern Denmark filled in the Tampa Scale for Kinesiophobia (TSK) and numerical pain rating scale questionnaires. An investigator placed the ViMove sensors at the base of the skull and on top of the T3 spinous process. In addition, 12 Vicon reflex markers were placed using a standardized protocol. Subjects were instructed to do: 1) sitting postures in ideal, habitual, and slump positions and 2) movements of head flexion/extension, upper neck flexion, neck lateral flexion and rotation to left and right side. Each movement was repeated five times. The subjects were re-tested using the same procedure one week later.

The data was processed in Matlab $\mbox{\ensuremath{\mathbb{R}}}$ and analysed using Stata 15.1 $\mbox{\ensuremath{\mathbb{R}}}$.

Concordance correlation coefficients (CCC) were calculated between the two test days and between the ViMove and Vicon output.

RESULTS AND DISCUSSION

The 10 subjects had mean neck pain intensity on the day of testing at 0.5/10 and a average TSK score of 39.7/68. The reproducibility for posture measures ranged between CCC -0.26 and 0.56, for range of movement between 0.60 and 0.94, and for movement speed between 0.71 and 0.89. The agreement between ViMove and Vicon for posture and for movement measures ranged between 0.69 and 0.99, and for movement speed, all measures were above 0.92.

CONCLUSIONS

There was low reproducibility for measures of the three neck postures, but higher for the movements. The agreements between the two systems were acceptable and suggests ViMove can be used in clinical practice for assessing range of movement and speed. Further work will determine if the systems can detect differences in the postures and movements of people with and without neck pain.

THE EFFECT OF ACUTE BODY WEIGHT SUPPORT ON STRIDE RATE, STRIDE LENGTH, AND SPEED DURING PREFERRED WALKING, PREFERRED RUNNING, AND DURING THE WALK-TO-RUN TRANSITION J. Jepsen*, D. Gregersen, J.T. Frandsen, R.T. Jessen, E.A. Hansen, M. Voigt

Sport Sciences – Performance and Technology, Department of Health Science and Technology, Aalborg University,

Denmark

*Student

INTRODUCTION

It is a common observation that a walk-to-run transition (WRtransition) during horizontal unconstrained locomotion occurs when the walking speed reaches a certain level. Recent studies have provided evidence for the suggestion that WRtransition reflects that the moving body behaves like a dynamical non-linear complex system [1,2]. In this context, the WR-transition elicited by at speed ramp occurs in a competition between two behavioral attractors represented by the preferred walking and the preferred running stride rate, stride length, and locomotion speed combinations [1,2]. Additionally, the WR-transition stride rate has been shown to occur at the midpoint between the stride rate at preferred walking and the stride-rate at preferred running [1]. This is not the case for the corresponding stride lengths and locomotion speeds. This indicates that the stride rate may follow a specific principle: the attractor principle [2]. It is unknown if the attractor principle is a general feature of the self-organizing behavior of human locomotion during different constraints, or impacts, like e.g. body weight support [3]. The aim was to determine if the attractor principle is valid when human locomotion is affected by body weight support.

METHODS

Three different body weight support conditions were compared in a repeated measures design: 1) BW, 2) -20% BW, and 3) -30 % BW. Eighteen healthy males, all familiar with treadmill locomotion, were recruited. Age (26.9 years (5.4)) (mean (SD)), height (1.80 m (0.08)), body weight (BW) (80.9 kg (11.0)). Two force-sensing resistors (Interlink electronics INC., USA) were used as foot-switches. They were placed in the right shoe, under the insole: 1) under the Metatarso-Phalangeal joints 1-2, and 2) under the Calcaneus. The sensitivities of the footswitches were adjusted for each participant to ensure that all steps were recorded consistently. The participant warmed up for 10 min and got comfortable with the specific body weight support system used in the trials. After a 5-min break, the three loading conditions were completed in randomized order. In each condition: 1) the preferred walking speed (PWS), 2) the preferred running speed (PRS), and 3) the WR-transition elicited during a speed ramp were recorded, also in randomized order, and with 2 min breaks in between. The speed ramp started with a speed of the treadmill belt of 4 km h⁻¹ for 30 s and subsequently the speed was increased by 0.1 km h⁻¹ every 10 s until 9 km h⁻¹. The footswitch signals were sampled at 1 kHz using a custom data acquisition system ('Mr Kick', K. Larsen, Aalborg University). The data were processed in Matlab (Matlab 2015a, Mathworks, Natick MA, USA) and stride-to-stride stride rates, stride lengths, and duty factors were extracted, and the WR-transition speed (WRTS) was determined. Two-Way Repeated Measures ANOVA combined with a Holm-Sidak procedure to correct for multiple pairwise comparisons were used for comparison of the different conditions.

RESULTS

The PWS, PRS, and WRTS did not change significantly between the body weight support conditions. Mean values were: 4.7 (SD 0.5), 8.8 (SD 1.7) and 7.1 (SD 0.6) km h⁻¹. Stride lengths are shown as a function of stride rates in figure 1.



Figure 1. Stride rate – stride length combinations at preferred walking speed (PWS), preferred running speed (PWS), and at the walk-to-run transition speed (WRTS) at three different body weight (BW) support conditions. Stride rates: *-30%BW < -20%BW (p<0.01), **all different (p<0.006). Stride lengths: #BW < -20%BW and -30%BW (p<0.004)

Table 1 presents an analysis of the relation between the WRtransition stride rates and the preferred walking and running stride rates to evaluate the validity of the attractor principle.

Stride rates (St	trides min ⁻¹)					
(N=18)	BW		-20%BW		-30%BW	
	WRTS- PWS	PRS- WRTS	WRTS- PWS	PRS- WRTS	WRTS- PWS	PRS- WRTS
Mean ± SD	10.7±3.8	13.2±4.0	10.4±5.4	10.5±4.4	9.3±3.8	10.2±4.2
%	44.8	55.2	49.8	50.2	47.6	52.3
р	0.1	51	0.9	963	0.5	599
CI of diff	-6.0	to 1.0	-4.4 1	to 4.3	-4.2	to 2.4

Table 1. Comparisons of the stride rate differences between: 1) the walk-to-run transition speed (WRTS) and the preferred walking speed (PWS) and 2) the preferred running speed (PRS) and WRTS at the three different body weight (BW) support conditions.

DISCUSSION

The present results support the suggestion that the human body during locomotion behaves dynamically as a non-linear complex system. Additionally, the results support that the attractor principle most likely is a general principle for human locomotion during varying conditions as long as selforganizing behavior is allowed.

- 1. Hansen et al. Sci Rep, 7:2010, 2017
- 2. Voigt et al. Hum Mov Sci, 67, art. nr. 102509, 2019
- 3. Richter et al. Front Physiol, 8:583, 2017

CADENCES AND DIRECTION EFFECT ON GRINDING ECONOMY, KINEMATICS AND CRANK EFFECT PROFILES IN AMERICAS CUP GRINDING

Søren Gam*, Anders Boutrup, Jakob Molbech, Jesper Larsen, Mark de Zee & Kent Klitgaard*

Department of Health Science and Technology Aalborg University, Fredriks Bajers Vej 7, 9220 Aalborg Øst *Corresponding Author: Søren Gam, E-mail: sorengam1987@gmail.com

INTRODUCTION

In America's Cup sailing the task of grinding is one of the most strenuous and important functions [1,2,3]. An increased focus on safety during the 35th America's Cup (2017) has resulted in suggestions of the use of a hydraulic accumulator, ensuring continuous boat steering ability. Such an initiative may change the metabolic demands from primarily anaerobic- to aerobic conditions and consequently rise importance of factors known to affect aerobic performance, grinding kinematics and crank effect profiles during grinding.

This study aimed to examine how variation in cadences and grinding directions affects grinding economy (VO₂ consumption), kinematics and crank effect profiles during a constant submaximal grinding intensity.

METHODS

Eight elite kayaking athletes (age: 23 ± 3 years, weight: 86 ± 6 kg, height: 1.8 ± 0.05 m) performed four imposed cadences of 60-, 70-, 80-, and 90 RPM in both forward and backward direction at a constant power output at 95% of LTD_{max}.

RESULTS

The grinding kinematics between the subjects were highly individual, express as peak power during the 360° grinding cycle appears at different positions. For peak power, a difference between forward and backwards grinding was observed at the cadence of 60 RPM (161 ± 16 and 181 ± 11 Watt: P=0.02) while no difference was observed in VO₂ (P=0.08)(Figure 1). VO₂ during cadence 60 RPM were lower compared to cadence 90 RPM (3054 ± 271 mL·min⁻¹ and 3313 ± 305 mL·min⁻¹ respectively (P=0.01)).



Figure 1 A and B shows respectively the mean VO2 consumption and peak

power for 60-, 70-, 80- and 90 RPM for both forward and backwards

grinding directions. Cycles and squares represent backward and forward

grinding directions, respectively. *P=0.02; **P=0.01

CONCLUSION: These results confirm that grinding directions and cadence during at constant power output at submaximal intensity influence the grinding economy (VO2) and biomechanical aspect of grinding.

- 1. Bernadi et al., *Journal of Sports Sciences*, **25**:10, 1141-1152, 2007
- 2. Neville et al., Eur J Appl Physiol, 106:149-157, 2009
- Neville et al., Journal of Sports Sciences, 27(9):915-923

Exercise with blood flow restriction reduces time to task failure, induces more pain, but evokes similar changes in activation and oxygenation as free-flow exercise

Mikkel I. Kolindı*, Søren Gamı, Jeppe G Phillipı, Fernande Pareja-Blanco2, Ying Gao3, Henrik B. Olsenı, Karen Søgaardı and Jakob L. Nielsenı

Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark

2Physical Performance & Sports Research Center, Pablo de Olavide University, Seville, Spain

3Faculty of Sport and Health Sciences, University of Jyväskylä, Jyväskylä, Finland.

INTRODUCTION

Blood flow restriction is increasingly being used to increase the effiency af training. The objective of the present study is to examine the acute effect of blood flow restriction (BFR) on muscle activation and oxygenation of the vastus medialis (VM) and vastus lateralis (VL) during a single bout of unilateral knee extension (KE).

METHODS

Seventeen males were enrolled in a within-group randomized cross-over design.

Participants performed unilateral KE at 20% of 1-repetition maximum to task failure, using a BFR or a free flow (FF) exercise protocol in randomized order on two separate days. Changes in oxygenation and neuromuscular activation of VL and VM, were monitored continuously using near-infrared spectroscopy (NIRS) and surface electromyography (sEMG), respectively. Pain measures were collected prior and following set completion. Within- and between-group comparisons were performed at multiple time points of set completion for each muscle.

RESULTS AND DISCUSSION

Subjects performed 43% fewer repetitions during the BFR condition compared to FF (p<0.05). Pain scores were higher during BFR (FF: 4.0 ± 2.0 , BFR: 5.5 ± 2.0 , (p<0.05)). When normalized to time to task failure BFR and FF presented a similar progression in muscle activation and oxygenation.

At task failure there was no difference between BFR and FF in tissue oxygenation but FF for VM resulted in significantly higher degrees of muscle activation compared to BFR (P=0.044), while no differences were observed for VL muscle.

CONCLUSIONS

Our results indicate that low load BFR and FF exercise performed to failure, evoke similar level of increased activation and decreased oxygenation at any given time relative to time to task failure. However, BFR results in more pain, while FF requires a higher volume of contractions to reach the same level of metabolic stress.

Corresponding Author: Mikkel Iwanoff Kolind, Email address: mkolind@health.sdu.dk

- 1. Clark et al., 2009;
- 2. Karabulut et al., 2011;
- 3. Takarada et al., 2002;
- 4. Takarada et al., 2000;
- 5. Yasuda et al., 2010).

Musculoskeletal pain in common in competitive gaming: A cross-sectional study among 188 Danish recreational Esport athletes

Line Lindberg1*, Simon Bay Nielsen1, Mads Damgaard1, Ole Rolskov Sloth1, Christian Lund Straszek1,2,3

1: Department of Physiotherapy at UCN, Aalborg, Denmark. 2: Department of Health Science and Technology at Aalborg University, Denmark 3: Center for General Practice at Aalborg University, Denmark

INTRODUCTION

Competitive Esport is one of the fastest growing sports in the world. Athletes compete online in various games and many hours of practice is needed to participate at a competitive level. Despite the growing popularity little is known regarding musculoskeletal (MSK) pain complaints among these athletes. We aimed to investigate; 1) the prevalence of MSK pain complaints, 2) the association between MSK pain and esports-related training, 3) the association between MSK pain and physical activity levels.

METHODS

Athletes aged 15 to 35 who participated in structured esports through a computer-based game were eligible for inclusion. Participant demographics, hours/week spent on esports, self-report MSK pain sites, pain frequency, sleep, care-seeking behavior and physical activity levels were collected through online-questionnaires.

The primary outcome was any MSK pain in the body during the previous week (yes/no).

RESULTS

A total of 188 athletes replied. 42.6% reported MSK pain during the previous week. The most common sites of pain were the back (31.3%) and the neck and shoulders (11.3%). Athletes with MSK pain during past week participated in significantly less esports related training compared to athletes without MSK pain (P=0.035, mean difference -5.6 hours/week; 95%CI -10.6; -0.7). There was no significant difference in physical activity levels between the two groups (P=0.318, mean difference 1453 Kcal/week; 95%CI: -1760; 3981).

CONCLUSION

One in two Esport athletes experienced back pain. Athletes with MSK pain participated in less training per week compared to those without pain, suggesting a potentially negative effect of pain on Esport participation.

Possible factors associated with running economy

Nielsen, Anders, ^{1*} Emilian Moise, Stefan¹, G. Kersting, Uwe¹, de Zee, Mark¹, Heyde, Christian², and Godsk Larsen, Ryan¹, *Ph.D. student, ¹Sports Sciences, Department of Health Sciences and Technology, Aalborg University, ²Adidas Future

department, Herzogenaurach, Germany

INTRODUCTION

Steady state oxygen uptake (VO₂) at a given velocity reflects the energy demand of running at a constant submaximal speed, which is used to define running economy (RE). Running economy is proposed to be an important determinant of running performance. A number of internal factors have been proposed to influence RE. [1] Studies have found a relationship between the Achilles tendon (AT) characteristics and RE [2]. However, little is known about possible relationships between measures of muscle strength, flexibility, balance, and RE. The purpose of this study was to investigate correlations between measures of lower body strength, flexibility, balance, AT characteristics and RE in recreational runners.

METHODS

Subjects

23 subjects (20 male and 3 female, age: 23 ± 6 years, height: 179 ±8 cm, weight: 75 ±12 kg) were recruited, with the inclusion criteria being over 18 years of age, running at least twice per week, and injury-free during the time of data acquisition. All subjects signed an informed consent.

Equipment

A Vyntus CPX (Vyaire Medical, Illinois, USA) was used to collect breath-by-breath pulmonary gas exchange. Lower body strength was quantified as time in air during a countermovement jump, using a Chronojump platform. Flexibility was assessed using the stand and reach test performed on a 40 cm high platform with feet together and straight legs. The subjects were instructed to reach as far down as possible, while the distance to the floor was measured.

The Y-balance test was performed using a Y-balance equipment. The results were normalized to the leg length (anterior iliac spine to medial malleolus) and averaged in all three directions.

The moment arm of the AT was found using the skin measurement method described by Kongsgaard et al [3]. The AT thickness was measured with an ultrasound scanner (General Electronics, MA, USA) at 2, 4, and 6 cm from the calcaneus bone.

Protocol

The protocol consisted of three visits, where visit 1 included assessment of lower body strength, flexibility, balance, and AT characteristics. In addition, subjects were familiarized to running on the treadmill.

Visit 2 consisted of a 6-minute warmup followed by a 5-minutes break. Afterwards, the subject did two 6-minutes bouts of running with 5-minutes rest in-between. VO2 was averaged over the last two minutes of each bout and running economy was computed as mL O2/kg/km, eliminating the

effect of different speeds [4], and therefore allowing for comparisons across subjects. The pace for these running bouts was self-selected and comfortable. Across subjects, the pace varied from 10.5 km/h to 13.6 km/h.

At visit 3, the protocol from visit 2 was repeated and was conducted at least 48 hours after visit 2, and the final VO2 was averaged over both visit 2 and 3.

Statistics

Pearson correlations, with alpha level of .05, were used to investigate the correlations between measures of lower body strength, flexibility, balance, moment arm and running economy.

RESULTS AND DISCUSSION

There were no significant correlations between measurements of lower body strength, flexibility, balance, AT characteristics and RE (Table 1). In contrast to our results, Scholz et al [2] found a significant correlation between AT moment arm and RE. A possible explanation for this discrepancy between studies could be differences in training status of the subjects used in these studies. The subjects in Scholz et al. [2] were all trained runners with and averaged 10 k time of just above 33 min, while the subjects in the present study were a mixed group of runners (3.4 k running time: between 11-16 min).

CONCLUSIONS

In recreational runners there were no correlations between measurements of balance, AT Thickness, AT characteristics, lower body strength, or flexibility and running economy.

ACKNOWLEDGEMENTS

Thanks to Adidas for funding this project, and to Hugh Robinson and Riccardo Contursi for help in generating data.

REFERENCES

- Barnes, K. & Kilding, A. 2015, "Running economy: measurement, norms, and determining factors", Sports Medicine - Open, vol. 1, no. 1, pp. 1-15.
- Scholz, M.N., Bobbert, M.F., van Soest, A.J., Clark, J.R. & van, H.J. 2008, "Running biomechanics: shorter heels, better economy", Journal of Experimental Biology, vol. 211, no. Pt, pp. 3266-3271.
- Kongsgaard, M., Nielsen, C.H., Hegnsvad, S., Aagaard, P. & Magnusson, S.P. 2011, "Mechanical properties of the human Achilles tendon, in vivo", Clinical Biomechanics, vol. 26, no. 7, pp. 772-777.
- Foster, C. & Lucia, A. 2007, "Running Economy: The Forgotten Factor in Elite Performance", Sports Medicine, vol. 37, no. 4-5, pp. 316-31.

economy was computed as mL O2/kg/km, eliminating the Table 1 shows the coefficients and P values for the Y balance, AT Thickness, AT moment arm, Counter movement jump, and Stand and reach correlated with the running economy.

	Y balance test	AT Thickness	AT moment arm	Counter movement jump	Stand and reach
R coefficient	.280	408	.059	.303	192
P value	.196	.054	.793	.160	.380

WHERE TO APPLY SPINAL MANIPULATION – DO CLINICAL OUTCOMES DIFFER WHEN TARGETING SPINAL STIFFNESS OR PAIN SENSITIVITY?

Casper Glissmann Nim^{1,2,*}, Søren O'Neill^{1,2}, Gregory Neill Kawchuk³ & Berit Schiøttz-Christensen^{1,2}

¹Department of Regional Health Research, University of Southern Denmark, Denmark, ²Spine Centre of Southern Denmark, Hospital Lillebaelt, Denmark, ³Department of Physical Therapy, University of Alberta, Canada, *Ph.D. student (casper.nim@rsyd.dk)

INTRODUCTION

Spinal manipulative therapy (SMT) is known to cause subjective pain relief in some persons with low back pain (LBP) [1]. While the mechanisms underlying SMT-related pain relief are not understood fully, both biomechanical [2] and neurophysiological processes [3] have been proposed. As such, we designed this randomized experimental trial to elucidate the contributions of biomechanical and neurophysiological processes on self-reported reduction of pain following SMT

METHODS

Patients with persistent non-surgical low back pain, who were included from the Spine Center of Southern Denmark, received four sessions of SMT at either the stiffest lumbar segment or the lumbar segment with the lowest pain threshold (measured by mechanical indentation and pressure pain threshold respectively). The primary outcome measure was subjective pain measured with a numerical rating scale (NRS). Secondary outcomes were biomechanical (global stiffness, GS) and neurophysiological (pressure pain threshold, PPT). All outcomes were measured at baseline, post-SMT and at 2-weeks follow-up. Data were analyzed using linear mixed models.

RESULTS AND DISCUSSION

132 participants were included and 123 were available for analyses at follow-up. Our results demonstrated that choosing the stiffest or most pain-sensitive segment for SMT application did not influence subjective pain levels differently between groups – NRS did however decrease over time. GS did not change within or between-group at any time point. However, PPT did increase significantly at follow-up within-groups (Figure 1), and a large and significant difference was observed between groups at post-SMT (Table 1).

The minor decrease in NRS questions whether a clinical significant reduction was reached. Possibly, this was due to the complexity of the cohort and the simplistic intervention.

It is questionable whether a mechanical measure of stiffness is important for persistent LBP patients both in terms of underlying SMT effect and overall clinical improvement.

Although, SMT appears to directly impact neurophysiological parameters through a segment-dependant neurological reflective pathway, these effects do not seem to be associated with changes in reported pain levels. This study was limited by the assumption that the applied treatment was sufficient to impact the primary outcome.



Group • Pain.segment • Stiff.segment

Figure 1 Changes in subjective back pain, lumbar stiffness and pressure pain threshold. Mean and standard errors are presented for each time plot.

* = significant between group (time:group) effect. NS = not significant

REFERENCES

1. Rubinstein, et al. BMJ 364, 2019

2. Wong, et al. Spine 40, 2015

3. Millan, et al. Chiropractic & Manual Therapies 20, 2012

 Table 1 Changes in subjective back pain, lumbar stiffness and pressure pain threshold. Between-group adjusted estimates are presented as mean differences at Post-SMT with 95% confidence intervals.

 UPC
 Version 1

NRS = Numerical rating scale, GS = Global stiffness, PPT = Pressure pain threshold

Between-group differences					
Time	ΔEstimate (CI)	Δ P-value	Δ Standard error		
<u>NRS</u> Baseline – Post SMT	0.11 (-0.54;0.75)	0.7	0.28		
GS Baseline – Post SMT (N/MM)	-0.10 (-0.49;0.28)	0.54	0.17		
PPT Baseline – Post SMT (KPa)	-57.58 (-121.37;6.22)	<0.05	27.5		

PREDICTION OF POST-OPERATIVE JOINT INSTABILITY FOLLOWING TOTAL KNEE ARTHROPLASTY

D Pedersen^{1,Ph.D. student}, V Vanheule², R Wirix-Speetjens², O Taylan³, H P Delport³, L Scheys³, M S Andersen¹ ¹Aalborg University, Denmark, ²Materialise N.V., Leuven, Belgium, ³KU Leuven, Belgium

INTRODUCTION

Total Knee Arthroplasty (TKA) is a common surgery for late-stage osteoarthritis. However, complications can lead to implant failure, decreased functionality and/or severe pain. Studies have found that over 20% of patients are dissatisfied with the surgery and 13% need revision. Joint instability is considered the leading cause of early implant failures and accounts for a significant amount of late implant failures primarily due to wear. If we were able to predict post-operative joint instability following TKA by utilizing musculoskeletal (MS) modelling and patient-specific information, we might be able to provide the surgeon with a preoperative planning tool that could help predict the optimal surgical procedure for the individual patient and thereby reduce the patient dissatisfaction and revision rate. However, a model is only as good as its asumptions and we know that the mechanical properties of ligaments and soft tissue around the joint displays high intersubjective variablity, that can have detrimental effect on the predictability of the model. This renders the current MS modelling approach, that assume generic ligament properties from the litterature, inapplicable for preoperative planning where high subject-specificity is present. We propose a novel method combining a non-invasive arthrometer and a MS modelling approach to predict patient-specific post-operative joint instability following TKA.



Fig. 1 - The *in vitro* version (left) of the 3D arthrometer used in the study and the *in vivo* version (right).

METHODS

As a proof-of-concept, a preoperative 3D laxity profile was obtained from a cadaveric specimen using a novel arthrometer presented in [1] (Figure 1). Twelve monoplanar and four multiplanar load cases were applied to the knee in 30 degrees of flexion. The knee pose from each load case were obtained using motion-capture and bone pin markers. Subsequently, a posterior-stabilized TKA was performed on the specimen and a postoperative laxity profile was obtained. A preoperative MS model of the cadaveric knee was constructed in the AnyBody Modelling System (AnyBody Technology, Denmark) displaying subjectspecific bone geometry, cartilage, ligament insertion and origin points gathered from magnetic resonance imaging and

computed tomography scans (Figure 2). Anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), lateral collateral ligament (LCL), medial collateral ligament (MCL), popliteus tendon/popliteofibular ligament complex (PLT), posterior oblique ligament (POL) and anterior lateral ligament (ALL) were modelled as single bundle nonlinear line elements. Force-dependent kinematics [2] was applied to solve the pose of the knee joint during each laxity measurement. A Complex optimisation [3] implemented in MATLAB (MathWorks, USA) was wrapped around the model to optimise ligament slack length to minimize residual error between model and experimental kinematics. For validation, the optimised ligament parameters were applied in a postoperative MS model, where bone and cartilage geometry were replaced with the posterior stabilized TKA implant and both ACL and PCL resected. Model-predicted post-operative laxity was then validated against experimental post-operative laxity measurements.



Fig. 2 – The preoperative MS model used to optimize patient-specific ligament parameters.

RESULTS AND DISCUSSION

The model predictions displayed an average error for the postoperative laxity of 0.76 mm, 3.49 mm, 4.66 mm, 0.19°, 0.48° and 3.58° for proximodistal translation, mediolateral translation, anteroposterior translation, flexion/extension rotation, varus/valgus rotation and internal/external rotation. Compared to an identical MS model using generic ligament properties from the literature, the optimized MS model improved the postoperative predictability by an average of 18 % and 54 % for translations and rotations respectively.

CONCLUSIONS

The proposed method did significantly improve the predictability of post-operative instability following TKA compared to current modelling methods. This approach advances the subject-specificity of MS models, potentially making them applicable in preoperative surgical planning.

ACKNOWLEDGEMENTS

The Danish Council for Independent Research funded this study under the Sapere Aude program. DFF-4184-00018.

- 1. Pedersen, et al. J Biomech, 82:62-69, 2019.
- 2. Andersen, et al. J.Biomech.Eng, 139:091001, 2017.
- 3. Box. The Computer Journal, 8:42-52, 1965.

A non-invasive assessment of ground reaction forces in the human leg in response to walking, jogging, running and jumping.

Jessica Pingel1*, and Adrian Harrison2

Department of Neuroscience, Motor Control Research Group, University of Copenhagen, Denmark 2PAS, Physiology, Faculty of Health & Medical Sciences, University of Copenhagen, Denmark

INTRODUCTION

Running is one of the most popular way to exercise. Even though regular exercise is beneficial to human health, running is also often associated with an increased injury risk. Lack of shock absorption in running shoes has often been stated as one of the main reasons for running related injuries this increased. The aim of the present study was to assess to degree to which GRF can be dissipated in the human leg without shoes in connection with diverse physical activities.

METHODS

Acoustic myography (AMG) is a biomechanical method measuring generated pressure waves from a contracting muscle (1-2). AMG recordings were carried out with a CURO unit and CURO sensors (CURO-Diagnostics ApS, Denmark; formerly MyoDynamik ApS) and followed in real time on an iPADAir (Apple Inc, Cupertino, CA, USA) via the App "CURO Clinic" and a specialized data recording system. This allowed us to see the actual wave recordings and the ESTi score while recording. The ESTi-score with its three components: 1) efficiency (E-score) 2) temporal fibre recruitment (T-score) and 3) spatial fibre recruitment (S-score), was calculated using the company software (4,5).

One healthy and trained subject participated in this study, with the following details: gender: female, age: 39 years, weight: 60 kg, BMI: 22.3.

The subject was measured whilst physically active and engaged in a number of diverse gaits without shoes: walking, jogging, running and a big jump on the spot. These diverse gaits were measured for both a hard and smooth concrete floor, as well as for a soft grass lawn, with an irregular surface. Measurement sites: 1st metatarsal, the ankle (medial malleolus; 2), the lower leg (tibial tuberosity; 3) and the hip (iliac crest; 4) = site 1,2,3 & 4 respectively.



Fig. 1 An overview of the combined ESTiTM-score for the AMG signals at sites 1, 2, 3 and 4, for A: Walking, B: Jogging, C: Running and D: Big jump, for a subject on a hard and a soft surface.

RESULTS AND DISCUSSION

Walking The data for the hard surface show much lower E, S and T parameters than those for the soft surface, and these lower values are observed mainly for sites 1 (toes) and 2 (ankle). Jogging AMG parameters for this gait reveal very low E, S and T scores for site 1 and site 2. Big jump Data reveal that on a hard surface, the lowest E, S and T scores were for site 2, and that on a soft surface the values at site 2 were greatly improved and similar to those for site 1.



Fig. 2 A plot of the conduction velocities for the AMG signals between sites 1 and 2 for different gaits on both a hard and a soft surface.

CONCLUSIONS

The present study reveals that the ankle joint is exposed to the greatest forces during jumping and running. In addition the present data prove that exercising on a hard surface does increase the stress on the toes and ankles. Furthermore the toes and the ankle are absorbing most forces during running while the knee and ankle joint remains undisturbed by the present activities.

REFERENCES

1.Harrison AP. P Clinical Physiology and Functional Imaging 2018

2. Claudel C.G. et al. Physiological Reports, 2018, 6(1): e13580, doi.org/10.14814/phy2.13580. Reddy BD. *ISB*

MULTI-DIRECTIONAL SOUND WAVE RECORDINGS ENHANCE THE IDENTIFICATION OF SOUND FORCE RELATIONSHIP DURING RUNNING

Cristina-Ioana Pirscoveanu^{1,*} and Anderson Souza Oliveira¹

¹Aalborg University

* Research Assistant

INTRODUCTION

Sound-based movement analysis is a low-cost alternative, recently used to investigate running mechanics [1]. The sounds produced between the foot and surface, during footfall impact, contain features relevant for gait analysis [2]. The investigation of running footstep sounds can be an alternative procedure for the assessment, analysis and modification of running mechanics [1,3]. Assessing running performance through multiple sound recordings accounts for any foot contact variability by capturing footfall sound propagation from all directions [4]. Therefore, the aim of this study is to investigate the effect of running with a decreased impact sound on running footfalls from multiple sound and force perspectives.

METHODS

Thirty-four recreational runners (26.85 ± 3.79 years, 77.26 ± 12.01 kg, 177.42 ± 9.38 cm) were asked to run overground at their self-selected speed, normally and silently by voluntarily reducing footfall impact sound. Sound waves from four microphones, kinematics and ground reaction forces were recorded from 30 running steps for each participant. Peak vertical (PVF) and propulsion forces (PPF), loading rate (LR), foot strike pattern and contact angle as well as frontal (anterior and posterior) and sagittal (medial and lateral) sound parameters were collected and normalized to body weight, respectively sound calibrated to dB. One-way Anova, chi-square and multiple regression (r^2) analysis between sound and force parameters were performed.

RESULTS AND DISCUSSION

When instructed to run silently, runners significantly altered their foot strike pattern from rearfoot to midfoot (Pearson chi-square = 17.86, p = 0.00) and managed to reduce by 78% their foot contact angle (normal: 1830 \oplus 2014) (11) 3300 \oplus 2014) (p = 0.00). Running silently significantly reduced by 54% the loading rate (normal: 58.67 ± 16.16 N/BW/s; silent: 26.98 ± 6.69 N/BW/s). The peak sound



Fig. 1 Peak sound amplitude (dB) from anterior (Pk_ant), posterior (Pk_pos), lateral (Pk_lat) and medial (Pk_med) microphones; *** denotes p = 0.000; ** denotes p = 0.01.

amplitude (Figure 1) was reduced by 31% in the posterior microphones and 49% in anterior microphones, whereas the peak medial sound showed the highest values and the peak lateral sound recorded the lowest running sounds. Therefore, the magnitude of peak sound amplitude depends on the recording direction. PVF, PPF and running speed showed significant correlation during normal running with peak sound amplitude from the anterior microphones, this relationship was transferred to the posterior microphones during silent running (Table 1). This transfer can be explained by changes in foot strike pattern, as it induced different air propagation properties, capturable from opposite directions. Therefore, the use of multi-microphone data acquisition can detect changes in foot strike pattern. Moreover, the significant relationship between forces and sounds highlight the distinct information that may be extracted depending on the microphone location and foot strike pattern.

Table 1 Coefficient of determination (r^2) for peak anterior (Pk_ant) and posterior (Pk_pos) sound amplitude, p < 0.05

Parameter	Pk_ant	Pk_pos
	(normal running)	(silent running)
PVF	0.12	0.15
PPF	0.24	0.25
SPEED	0.38	0.50

CONCLUSIONS

Our results show that running with a reduced impact sound can substantially reduce vertical loading rate and modify the foot strike pattern. Furthermore, the expected reduction in peak sound amplitude was dependent on the recorded sound direction. Moreover, the use of a multi-directional sound recording setup allows the capture of any foot strike pattern modifications, as the change from rearfoot to midfoot induced the force-sound relationships to convert from anterior to posterior microphones. Therefore, reducing running impact sounds is a simple and efficient method of achieving immediate loading rate reduction and altering running strike patterns. This method can become a tool for clinical and training facilities without access to highly professional kinematic systems.

ACKNOWLEDGEMENTS

- 1. Phan X et al, J. Sports Sci. 2000, pp. 13, 2016
- 2. Wang C. et al, Sensors (Switzerland), 16, 12, 2016.
- 3. Tate JJ and Milner CE, J. Orthop. Sports Phys. Ther. 47, 8, pp. 565c569, 2017.
- 4. Riwurohi J. et al, Int. J. Comput. Sci. Netw. Secur., 18, 4, pp. 28c35, 2018.



Complexity of isometric force production - effect of age

Peter C. Raffalt¹, Jennifer M. Yentes², Svend S. Geertsen^{3,4} and Meaghan E. Spedden⁴

¹ Department of Physical Performance, Norwegian School of Sport Sciences, Oslo, Norway

²Department of Biomechanics and Center for Research in Human Movement Variability, University of Nebraska at Omaha,

Omaha, NE, USA

³ Department of Neuroscience, University of Copenhagen, Copenhagen, Denmark

⁴ Department of Nutrition, Exercise and Sports, University of Copenhagen, Copenhagen, Denmark

Email: peter.raffalt@nih.no

Summary

The present study investigated the complexity of the isometric force produced during plantar- and dorsiflexion in children, adolescents, young adults and older adults. The complexity was highest in the young adults and appeared to follow an inverted U-shape relationship with age.

Introduction

The 'Loss of Complexity' theory by Lipsitz and Goldberger [1] and the later 'Optimal Movement Variability' theory by Stergiou [2], suggest that the complexity of human movements is subject to change following maturation, aging, diseases and injuries. In support of these theories, it is well established that movement complexity is reduced in older adults [3]. However, the theories would also predict that movement complexity is lower in children and adolescents compared to adults. The aim of the present study was to investigate the complexity of isometric force during plantar- and dorsiflexion in healthy children, adolescents, young adults and older adults. Prior to quantification of complexity, the present study investigated whether the structure of the force signals was generated by a linearly auto-correlated Gaussian process, which would suggest a non-deterministic underlying control process.

Methods

Twelve healthy children (male/female: 5/7; mean±SD age: 9.6±2.2 yrs; height: 1.46±0.18 m; mass: 34.5 ± 9.0 kg), thirteen adolescents (male/female: 9/4; mean±SD age: 15.5 ± 1.8 yrs; height: 1.74 ± 0.09 m; mass: 64.6 ± 10.1 kg), fourteen young adults (male/female: 6/8; mean±SD age: 22.1 \pm 1.7 yrs; height: 1.76 \pm 0.08 m; mass: 72.5 \pm 16.4 kg), and fifteen older adults (male/female: 7/8; mean±SD age: 68.3±2.7 yrs; height: 1.73±0.11 m; mass: 81.5 ± 14.1 kg) were recruited for the present study. The participants completed 2 minutes isometric plantar- and dorsiflexion at 10% of their maximal voluntary contraction force in a seated position with an ankle dorsiflexion angle of approximately 120°. Complexity was quantified using multiscale entropy [5] and surrogate analysis was used to evaluated if the structure of the force signals was generated by a linearly auto-correlated Gaussian process. A one-way ANOVA with group as an independent variable was applied. In case of a significant effect of group, a quadratic regression analysis was completed with age as independent variable and complexity as dependent variable. The overall percentage of variance accounted for by the regression (r^2) was determined. Additionally, Holm-Sidak post hoc test was applied to evaluate between-group differences.

Results and Discussion

For both tasks, the young adults had significantly higher complexity compared to the two younger groups and the older group (Figure 1). The quadratic regression analysis revealed a significant (dorsiflexion: p<0.001; plantarflexion: $p^2=0.359$; plantarflexion: $r^2=0.285$). This supports the notion that aging is associated with a loss of movement complexity due to the gradual deterioration of the neuromuscular system. Additionally, it suggests that maturation increases the complexity which has been linked to a reduced determinism in the executed motor control [4]. The surrogate analysis revealed that for all participants and all trials, the structure of the force signals did not originate from a linearly auto-correlated Gaussian process.



Figure 1: Complexity index for isometric force during dorsal (left graphs) and plantar (right graphs) flexion as function of age (top graphs) and average across age groups.

References

- Lipsitz LA and Goldberger AL (1992). Jama, 267, 1806-1809.
- [2] Stergiou N, et al. (2006). J Neurol Phys Ther, 30, 120-129.
- [3] Goldberger AL (1997). Perspect Biol Med, 40, 543-561.
- [4] Deutsch KM and Newell KM (2003). Dev Psychobiol, 43, 335-345.

A PARAMETRIC BIOMECHANICAL MODEL OF RUNNING

John Rasmussen¹ and Morten Enemark Lund² ¹Department of Materials and Production, Aalborg University ²AnyBody Technology A/S

INTRODUCTION

Novice runners have an injury incidence of 17.8 per 1000 hours of running [1], i.e. few runners make it through the novice state without sustaining an injury, and many give up because overuse injuries tend to be recurring and require long-lasting rehabilitation and professional intervention.

Musculoskeletal modelling can potentially recover the muscle and joint forces leading to overuse injuries in runners as a function of running style, but the current modelling paradigm requires individualized models with detailed input, such as optical motion tracking, three-dimensional force platforms, and 3-D medical imaging. These requirements are intractable for the recreational runner. Individual running information is, however, available from an increasing number of mobile gadgets such as running watches, inertial measurement units (IMU), GPS devices, and smartphones in general, and technologies related to the Internet-of-Things machine learning, data mining and artificial intelligence are presenting new opportunities for biomechanical modelling. We show how these technologies in concert provide a new generation of biomechanical running models.

METHODS

Marker trajectories from 180 running trials are processed by the AnyBody Modeling System to anatomical joint angle variations and to anatomical body parameters [2]. By the same method, functional anthropometrical parameters from the ANSUR databases [3] are converted to anatomical parameters. The resulting data contain correlations between anatomical joint motions and anthropometric parameters that characterize the variability of running patterns on the recorded population. The anatomical joint angles are parametrized by Fourier series. Preliminary investigations indicate that one running trial can be adequately described by approximately 600 parameters. The problem is reduced and orthogonalized by principal component analysis (PCA) (Figure 1). The result is a model whose independent parameters represent all forms of running.



Fig. 1 Data processing.

Measured input data for a specific runner is functional anthropometry and IMU data. An optimization process will identify the set of model parameters that reproduce the measured data, thus identifying the runner as well as the motion pattern. The resulting running model can be subjected to musculoskeletal analysis estimating body loads, running economy etc. The entire method is implemented into an app-like interface.

RESULTS AND DISCUSSION

The method generates realistic running patterns and seems capable of plausible extrapolation beyond the data used to train the model, i.e. the 180 runners. For instance, the fastest runner in the training data runs at 18 km/h, but the model reproduces features of full sprint when asked to run 30 km/h (Figure 2). Validation of reproduced running patterns against optical motion data remain.

- 1. Videbæk S, et al., *Sports Medicine*, **45**: 1017–1026, 2015. 2. Andersen MS, et al., *Comp.Meth.Biomech.Biomed.Eng.*,
- 13: 2010.
- 3. Gordon CC, et al., Anthropometric Survey of U.S. Army Personnel: Summary Statistics, 1989.



Fig. 2 Artificially generated running models. Top: A slow jog at 6 km/. Bottom: Full sprint at 30 km/h.

A novel human motion detection method and its application in hand exoskeleton control Muhammad Raza UI Islam¹, Shaoping Bai² ¹Research Assistant (<u>mraza@mp.aau.dk</u>), ²Associate Professor (<u>shb@mp.aau.dk</u>) Department of Materials and Production, Aalborg University

Abstract:

Humans are able to perform arm movements and lifts/carry payloads by varying the activity level of specific muscle groups. The change in muscle activity level can be interpreted in terms of muscle hardness [1]–[3], which causes a lateral force. This lateral force hereafter is termed as muscle contraction-induced force (MCI). In forcemyography MCI force is read through force sensitive resistor (FSR) sensors, which are able to measure the force applied on them. In order to read MCI force these sensors are placed inside an elastic fabric and wrapped around the targeted muscle group, as shown in Figure 1. The new sensing technology can be used to control upper-limb exoskeleton in several ways i.e. forearm motion classification, elbow joint angle estimation, muscle effort estimation, payload load estimation, hand gesture recognition and grasping force estimation.

In this presentation, the biomechanics based detection method is introduced. A system for hand motion and muscle activity was developed, tested and validated. The system was used to the control of soft hand exoskeleton 'SEM glove', as shown in Figure 2, for which muscle contraction data is processed through Neural Network based classification algorithm to detect the grasping action. With the detection of the grasping task, the exoskeleton follows the grasping action to assist human in holding an object.



Figure 1. Sensor band placement



Figure 2. SEM glove control through sensor band

- J. L. Gennisson, C. Cornu, S. Catheline, M. Fink, and P. Portero, "Human muscle hardness assessment during incremental isometric contraction using transient elastography," *J. Biomech.*, vol. 38, no. 7, pp. 1543–1550, Jul. 2005.
- [2] M. Ashina, L. Bendtsen, R. Jensen, F. Sakai, and J. Olesen, "Measurement of Muscle Hardness: A Methodological Study," *Cephalalgia*, vol. 18, no. 2, pp. 106–111, Mar. 1998.
- [3] T. Uchiyama, R. Kato, and M. Murayama, "Relationship between Muscle Tension and Hardness in Isolated Frog Muscle with Electrical Stimulation," in 2007 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 2007, vol. 2007, pp. 4818–4821.

ASSESSMENT OF SCAPULAR MUSCLES THICKNESS AND ELECTROMYOGRAPHY IN HEALTHY PEOPLE

Dario Sciacca 1, Arna Dýrfjörð 1, Christian Couppé 2, Ann Cools 2.3, T. Alkjær 1 1 Department of Biomedical Sciences, University of Copenhagen, Copenhagen, Denmark 2 Department of Physical Therapy, Bispebjerg Hospital, Copenhagen, Denmark 3 Department of Rehabilitation Sciences, Ghent University, Ghent, Belgium

INTRODUCTION

Handedness is defined as the arm that is preferred to be used [1]. Despite handedness being the main topic of many studies, its association with muscle thickness is not well known. This study aimed to investigate the presence of side-to-side differences in scapular muscles thickness and electromyographic (EMG) activity.

METHODS

The muscle thickness was measured using ultrasound machine (Hitachi Ascendus scanner, serial number KE 1075804). The first part of the study consisted of a reliability test, aimed at quantifying the day-to-day variation for the thickness of three scapular muscles: upper trapezius, lower trapezius and serratus anterior. The test was conducted on 15 healthy participants (7 females, 8 males). Absolute and relative reliability was calculated. Heteroskedasticity was also tested in order to assess the presence of any bias in the standard errors. Only those muscles that showed high reliability were included in the second part of the study. Here, 24 healthy participants (13 females, 11 males) were included. Besides scapular muscle thickness assessments the EMG activity was recorded using EMG bipolar Ag/AgCl surface electrodes (N-00-S, Ambu A/S, 2750 Ballerup, Denmark) during two maximum voluntary contractions (abduction at 0° and 90°). For both muscle thickness and EMG activity, the side-to-side difference was investigated using a simple paired t-test, with the level of significance set to 0.05.

to-side difference (Table 1). No heteroskedasticity was found for this muscle. Regarding the lower trapezius and serratus anterior, a systematic bias was found between the measurements of the two days and reliability was not established. Therefore, these muscles were not included in the second part of the study. This entails the need of modifying the protocols established for the lower trapezius and serratus anterior. No statistically significant differences in muscle thickness or muscle activity were detected between the dominant and non-dominant sides (Table 2). This may be explained by the fact that everyday activities are not high load activities. Furthermore, a complete handedness, meaning that all the activities are performed with the dominant side, is rare. Consequently, the overall load applied on both sides during the tasks of daily living may be very similar. However, further research on a larger population are necessary to verify our results.

CONCLUSIONS

The protocols established for the upper trapezius showed excellent reliability. No statistically significant side-to-side differences were found for the thickness and EMG activity of the upper trapezius.

REFERENCE

- 1. Tanuj Kanchan et al. "Handedness in skeletal remains". In: JIAFM 29.1 (2007), pages 0971–0973.
- 2. Joseph L Fleiss. Design and analysis of clinical experiments. Volume **73**. John Wiley & Sons

RESULTS AND DISCUSSION

Reliability turned out to be excellent for the upper trapezius [2], which was the only muscle to be investigated for the side-

Table 1 Relative and absolute reliability for muscle thickness measurementsUT = Upper Trapezius, ME = Measurement Error, ICC = Intraclass Correlation Coefficient, het = heteroskedasticity

Variable	ME	ICC (1,1)	ICC (3,1)	Pearson's r	T-test for het
UT Dominant [mm]	0,46	0,98	0,98	0,49	0,06
UT Non Dominant [mm]	0,24	0,99	0,98	-0,24	0,40

Table 2 Paired samples test- results for muscle thickness and EMG activity.

UT = Upper Trapezius, MVC0 = Maximum Voluntary Contraction 0°, MVC90 = Maximum Voluntary Contraction 90°, Dom = Dominant, diff = difference, SD = Standard Deviation, CI = Confidence Interval

	Mean diff.	SD	95% CI		t	P value
			Lower	Upper		
UT Dom – UT Non Dom [mm]	0,48	1,21	-0,03	0,99	1,93	0,07
MVC0 Dom – MVC0 Non Dom [µV]	-52,91	444,16	-240,46	134,64	-0,58	0,57
MVC90 Dom – MVC90 Non Dom [µV]	-19,72	565,96	-258,70	219,26	-0,17	0,87

A thoracolumbar multibody model capable of simulating scoliosis deformities

Hamed Shayestehpour^{1,*}, John Rasmussen¹ and Christian Wong² ¹Department of Materials and Production, Aalborg University, Aalborg East, Denmark ²Department of Orthopedics, University Hospital of Hvidovre, Hvidovre, Denmark *Ph.D. student, hs@mp.aau.dk

INTRODUCTION

Adolescent Idiopathic Scoliosis (AIS) is identified as a multifactorial disease. Several studies have been conducted to unravel the aetiologies and pathogenesis that underlie AIS [1-3]. However, the aetiopathogenesis behind AIS has remained controversial [2-3].

We hypothesize that musculoskeletal modelling can offer an insight into the matter. A previously developed thoracolumbar spine model [4] is able to reconstruct large spine deformations, albeit with a kinematically indeterminate driver strategy, which makes it difficult to uncover the mechanical mechanisms behind spinal and thoracic deformity. This works presents an improved and kinematically determinate model.

METHODS

The model was created using the AnyBody Modeling System (AMS, v. 7.2), which is commercial software (Any-Body, Aalborg, Denmark) for three-dimensional multibody dynamics simulation. The previously presented lumber spine model [5] together with a thoracolumbar spine model with articulated ribcage [4] form the basis for development of the new multibody spine model.

Scoliosis deformities and severity can be described by clinically accepted measures and anatomical degrees-of-freedom (DOF), including 3-DOF Vertebral Rotation (VR) forming the Cobb angle, Rib-Vertebral Angle Difference (RVAD), Vertebral Translation compared to sternum (VT), Rib Hump index (RH), Sternum Translation (ST) and Rotation (SR) compared to a vertebra. These variables calculated after placement of anatomic landmarks at osseous elements on medical imaging data.

A detailed study of clinical data describing ribcage deformation led to decoding of the inherent kinematic constraints in the human thoracolumbar system and implementation of these constraints into the model. Several modifications of joint definitions compared to previous models were performed. Intervertebral joints in the entire spine were defined as spherical joints. Articulation between ribs and vertebrae, costo-vertebral and costo-transverse, were modeled as universal joints. Articulation between ribs and the sternum, costo-sternal, were defined as spherical joints for all ribs, except the ninth and tenth pairs, which were modeled as 4-DOF joints allowing 3-DOF rotation and 1-DOF anteriorposterior translation. These modifications led to a kinematically determinate model that is drivable by clinically accepted measures. The proposed thoracic model, including T10 to T1 vertebrae, non-floating ribs and sternum, has 17 DOF after implementation of the kinematic constraints.

RESULTS AND DISCUSSION

Figure 1 shows anterior and posterior views of the scoliosis skeletal model in the upright standing posture. The model appears to reproduce VR, RVAD, VT, ST and SR according to typical deformations for scoliosis, thus verifying qualitatively that the model constraints are correct. Forthcoming work will attempt quantitative verification of the deformation patterns. Correct kinematic constraints are a condition for subsequent use of the model to investigate the kinetics of scoliosis aetiology.

The scoliosis model can cast light on the biomechanics of the costo-vertebral and costo-sternal joints and thoracic cage configuration, while modelling the concavity and convexity of the rib hump. If the model can subsequently be shown to reproduce the kinetics of scoliosis, then it can also be used for *in-silico* design of interventions such as advanced orthotics to manage the condition.



Fig. 1 (a) Anterior and (b) Posterior views of the scoliosis skeletal model in the upright standing posture.

CONCLUSIONS

The proposed thoracolumbar model is able to simulate scoliosis deformities and enhance state-of-the-art on scoliosis aetiology as well as biomechanics of the torso.

ACKNOWLEDGEMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. [764644].

- 1. C. Wong, Scoliosis, 10-1, 1-5, 2015
- 2. D. J. Machida M, et al., 1st ed. Springer Japan, 2018
- 3. J. C. Cheng, et al., Nat. Rev. Dis. Prim., 1-1, 2015
- 4. D. Ignasiak, et al., J. Biomech., 49-6, 959-966, 2016
- 5. M. de Zee, et al., J. Biomech., 40-6, 1219-1227, 2007

PREDICTING THROWING SPEED USING ACCELEROMETERS: FIRST STEP TOWARDS MONITORING THROWING LOAD IN HANDBALL

Sebastian Deisting Skejø^{1,*}, Merete Møller², Jesper Bencke³, Henrik Sørensen¹

¹Department of Public Heath, Aarhus University ²Department of Sports Science and Clinical Biomechanics, University of Southern Denmark ³ Human Movement Analysis Laboratory & Dep. Orthopaedic Surgery, Copenhagen University Hospital at Amager-Hvidovre

*Ph.D. student

INTRODUCTION

Shoulder injuries are very common in handball [1]. Despite most shoulder injuries occuring as a result of overuse, only one study has investigated the association between training load and injury occurrence [1]. However, this study used playing time as an indirect measure of the number of throws. A deeper understanding of why shoulder injuries occur requires more accurate measurement of the actual throwing load (the product of throwing speed and volume). Unfortunately, it is not feasible to estimate throwing load using today's technology.

Therefore the purpose of the present study was to develop a novel device that can measure one half of the throwing load equation, namely the throwing speed.

METHODS

We recruited 19 experienced handball players (11 males, 8 females). Each player threw five throws of each of five types: low-speed standing throw without run-up, medium-speed standing throw without run-up, high-speed standing throw without run-up, standing throw with run-up and jump throw. Thus, we recorded 475 throws. We recorded acceleration in three orthogonal directions of the wrist during all throws using a custom-made accelerometer with a range of ± 200 g. We also measured the ball speed of each throw.

For each throw, we found the total acceleration by calculating the Euclidean norm of the three accelerations. We assumed a linear relation between peak total acceleration and ball speed, but found a non-normal distribution of the residuals. Thus, we predicted ball speed based on the logarithm of the peak total acceleration instead.

We predicted ball speeds using 10-fold cross validation. Our performance measures were R^2 , mean absolute error, mean calibration (calibration-in-the-large), weak calibration (calibration slope) and moderate calibration (visual inspection of the calibration plot) [2].

RESULTS AND DISCUSSION

The predictive model was well calibrated (Figure 1; mean calibration: 0.0 m/s, weak calibration: 1.00) and had a satisfying predictive accuracy (R^2 : 0.71, mean absolute error: 1.82 m/s).

While the precision of the method might be unsatisfying for coaches seeking to measure the throwing speed of any individual throw, we believe the precision is sufficient to distinguish between relevant subtypes of throws. For instance, Wagner et al. [3] found that the difference between mean maximal throwing speed of elite and low-level players were 4.3 m/s. Likewise, Plummer et al. [4] found that the difference between throws of 50 and 100% effort was 5 m/s on average. Given that we found a mean absolute error of 1.82 m/s, the present method appear capable of distinguishing between such different subtypes.

Estimating throwing load requires knowing both throwing speed and volume. The present work only addresses the former. Thus, future work should improve the method such that the number of throws can also be accurately determined by a wrist-worn accelerometer.



Fig. 1 Calibration plot comparing predicted ball speed and measured ball speed. The blue line represents the calibration line and the dashed line represents a line with 45° slope.

CONCLUSIONS

We found that it is possible to use accelerometers to predict throwing speed in handball. This is an important step forward in the quest to measure throwing load in handball, which can help elucidate why shoulder injuries might occur.

- 1. M. Møller et al., Br. J. Sports Med., 51 (4): 231–237, 2017.
- B. Van Calster et al., J. Clin. Epidemiol., 74167–176, 2016.
- 3. H. Wagner et al., J. Sports Sci. Med., 9 (1): 15-23, 2010.
- 4. H. A. Plummer et al., J. Strength Cond. Res., **31** (1): 80–87, 2017.

Associations between physical activity and sleep among 75+ community-dwelling Danish older adults

L-T Tsai1, E Boyle E1, JC Brønd1, G Kock1, F D'Oriente2, A Gigliotti2, P Caserotti1 Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Denmark 2 Foro Italico University of Rome, Italy

INTRODUCTION

Older adults (+65) are recommended to sleep 7-8 hours/night. The purpose of this study was to determine whether older adults who slept according to the recommendation had different levels of physical activity compared to those who did not.

METHODS

Data was collected in Odense, Denmark. Physical activity was measured by ActiGraph GT3X/GT3X+ placed on the dominant wrist for 7 days. Physical activity intensity was categorized by counts in vector magnitude: 0-2302 (sedentary behaviour), 2303-4999, 5000-9999, \geq 10000. Sleep duration was self-reported and used to categorize good sleepers (slept 7-8h/night), bad sleepers (slept <7h or >8h/night), and inconsistent sleepers (slept some nights 7-8h). Multinominal logistic regression was used to determine the odds of having higher level of physical activity after adjusting for age, sex, gait speed, and daily nap length. The analysis was repeated for percentage of time spent in different intensities of physical activity.

RESULTS AND DISCUSSION

341 older adults (average age 82±4, 62% women) with an average sleep duration of 8±1 hours/day were included. Participants' mean physical activity level was 2103±592 counts per minutes/day, with $64\pm10\%/day$ spent in sedentary behaviour. Compared to the good sleepers, bad sleepers had slower gait speed (0.78 vs. 0.88 m/s, p=0.014) and were less physically active (average counts/day: 1884±612 vs. 2136±497, p<0.019; % of sedentary behaviour: 63 ± 10 vs. 63 ± 9 , p<0.006; % of intensity 2303-4999: 21±5 vs. 24±6, p<0.022). Compared to good sleepers, bad sleepers had 5% higher odds of accumulating more sedentary behavior (OR 1.05 (1.00-1.09), p<0.025) and 9% lower odds of spending more time in intensity 2303-4999 (OR 0.91 (0.85-0.98), p<0.008).

CONCLUSIONS

For the oldest old, being physically active and less sedentary is associated with having consistently sufficient sleep (7-8 hours/night). Future studies are warranted to explore the casual relationship between physical activity and sleep duration.

ACKNOWLEDGEMENTS

This study was funded by the European Union Horizon 2020 PROMISS Project "PRevention Of Malnutrition In Senior Subjects", Grant agreement no. 678732.

PARTICIPANTS

Anders Holsgaard Larsen Anders Rintza Anna Bjerring Jensen Anne Sofie Malling **Bo Bregenhof** Camilla Marie Larsen Casper Nim Cristina Ioana Pirscoveanu Danish Shaikh Dario Sciacca Dennis Pedersen Ditte Richter Jernskaeg **Emilie Zwicky** Ernst Albin Hansen Gisela Sjøgaard Hamed Shayestehpour Henrik Baare Olsen Henrik Koblauch Jens bojsen-møller Jessica Pingel Joakim Jepsen John Rasmussen Karen Søgaard Kent Klitgaard Kirstina Vestersøe Kristoffer Koch Lars Lyster

Lars Peter Bakkesen Line Lindberg Li-Tang Tsai Lotte N. S. Andreasen Struijk Louise Mattsson Maj Halling Thomsen Meaghan Elizabeth Spedden Mikkel Kolind Muhammad Raza UI Islam Nicolai Terp Holm Niklas Valen Peter C. Raffalt Pia Melcher Samaneh Badri Sebastian Skejø Shaoping Bai Sigridur Magnusdottir Steen Harsted Stefan Skrydstrup Pedersen Strahinja Dosen Søren Gam Team Danmark Thomas Heilskov-Hansen **Tina Dalager** Tine Alkjær Xiaofeng Xiong

EXHIBITORS





ArmeoSpring – exoskeleton for upper-ekstremity rehabilitation:

The **ArmeoSpring**-exoskeleton offers self-initiated, weightsupported repetitive arm and hand therapy in an extensive 3D workspace. The ergonomic and adjustable exoskeleton of the ArmeoSpring embraces the whole arm, from shoulder to hand, and counterbalances the weight of the patient's arm. By providing arm weight support, the ArmeoSpring enables patients to use any remaining motor functions and encourages them to achieve a higher number of reach and grasp movements based on specific therapy goals.

The **ArmeoControl software** offers an extensive library of motivating game-like Augmented Performance Feedback exercises has been designed to train core movement patterns that are commonly used in activities of daily living. The software precisely records how patients perform during their therapy sessions and autosaves all data for progressevaluation

The ArmeoSpring is part of the unique and modular **Armeo Therapy Concept**, the world's first upper extremity concept that covers the whole "Continuum of Rehabilitation" with one software platform throughout a range of devices, each developed for a specific stage of rehabilitation–from early rehabilitation to long-term recovery.

Andago – gait-robot for safe and free overground training:

The **Andago** utilizes mobile robotic technology to sense the patient's movement intention and actively follow, while providing dynamic body weight support and fall-protection. The Andago gaitrobot offers safe and intensive gait training in versatile daily living activities and assists patients to walk naturally which consequently triggers continuous physiological afferent input.







