Footwear Traction Device with Biomechanical Loading Conditions

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Friday 11th November 2022

Department of Animal and Veterinary Sciences

University of Copenhagen

DBS

Dansk Biomekanisk Selskab

Program

14th Annual Meeting of the Danish Society of Biomechanics Program

9:00 – 9:40	Poster Mounting, Registration, coffee
9:40 – 9:45	Welcome by the organizers
9:45-10:45	Podium Presentations (Session 1)
10:45-11:30	Steno Lecture
11:30-11:45	Break
11:45-12:55	Podium Presentations (Session 2)
12:55-14:00	Lunch
13:05 -13:25	General Assembly
14:00-15:10	Podium Presentations (Session 3)
15:10-16:00	Posters and coffee
16:00-16:10	Student Award
16:10-16:15	Official closing
16:15-17:00	Refreshments and networking

Friday 11 November: Podium presentations session 1 (9:45 - 10:45)

Chair: Jessica Pingel

9:45-9:55 — S01-1 **3D Synchrotron imaging of muscle tissues at different atrophic stages in stroke and spinal cord injury: a proof-of-concept study**
Jessica Pingel, University of Copenhagen

9:55-10:05 — S01-2 **On the incluence of the initial guess when estimating knee ligament properties via optimization procedures**
Ilias Theodorakos , Aalborg University

10:05-10:15 — S01-3 **A field evaluation of a passive upper-extremety exoskeleton for manual material handling in blade manufacturing**
Bo E. Seiferheld , Aalborg University

10:15-10:25	S01-4 *Student Competition **– Categorizing Movement in Handball using inertial measurement Units with XGBoost** Nicki Lentz-Nielsen, Aalborg University
10:25-10:35	S01-5 *Student Competition **– Assessment of the effects of external pressure applied on the skin during ultrasound measurements of muscle thickness, echogenicity and pennation angle** Federica Rapelli, University of Copenhagen (S01-6 in abstract book)

Friday 11 November: Steno Lecture (10:45 - 11:30)

Chair: Henrik Koblauch

10:45-11:30	ST-1 **Steno Prize recipient Ernst Albin Hansen** Aalborg University

Friday 11 November: Podium presentations session 2 (11:45 - 13:05)

Chair: Peter Raffalt

11:45-11:55	S02-1 **Use and familiarization of a passive shoulder-exoskeleton in manual materials handling – A field study** Lasse Schrøder Jakobsen, Aalborg University
11:55-12:05	S02-2 **Biomechanical testing of tension and creep in the Patellar ligament: A Canine post-mortem study** Adrian Harrison, University of Copenhagen
12:05-12:15	S02-3 **Avoiding intra-subject variability during experimentally induced trips** Mathias Munk-Hansen, Aalborg University
12:15-12:25	S02-4 **Biomechanical evaluation of bone screw stability using acoustic modal analysis and conventional pull-out: An animal study** Mohammadjavad Einafshar, Aalborg University
12:25-12:35	S02-5 *Student Competition **– The Effect of six weeks of back Squat training on dynamic strength index** Frederikke Spedsbjerg, Aalborg University
12:35-12:45	S02-6 *Student Competition **– Simulated increase in monoarticular hip muscle strength reduces the first peak of knee compression forces during walking in healthy individuals** Elisa Jolas, Aalborg University
12:45-12:55	S02-7 *Student Competition **– The Equine Lateral Raphe: Multimodal verification and biomechanics** Mathilde Gad, University of Copenhagen

Friday 11 November: Podium presentations session 3 (14:00 - 15:15)

Chair: John Rasmussen

14:00-14:10	S03-1 **Dynamic lower limb alignment in preschool children** Steen Harsted, Aalborg University & University of Southern Denmark
14:10-14:20	S03-2 **Electro-suit treatment of children with unilateral cerebral palsy alters nonlinear dynamics of walking** Peter Raffalt, University Of Southern Denmark
14:20-14:30	S03-3 **Comparison of MRI sequences for the automatic segmentation of knee structures** Yunsub Jung, Aalborg University
14:30-14:40	S03-4 **The effect of fatigue on dynamic stability control during stair descent** Gong He-Zhao, Aalborg University
14:40-14:50	S03-5 **Differences in the fascia between dogs and horses and their impact on the biomechanics** Vibeke Sødring Elbrønd, University of Copenhagen
14:50-15:00	S03-6 *Student Competition **– Does the Choice of lower body strength test matter when calculating dynamic strength index?** Mads Præstegaard Sørensen, Aalborg University (S01-5 in the Abstract book)
15:00-15:10	S03-7 *Student Competition **– The association between dynamic strength index and measures of sprint, change of direction and jumping ability** Sebastian Svane, Aalborg University

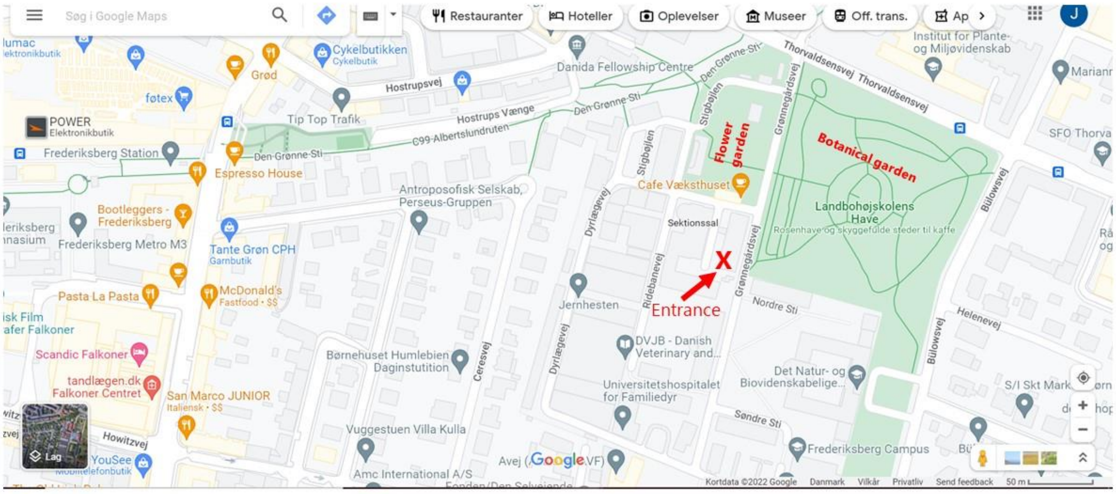
Friday 11 November: Poster session (15:10 - 16:00)

Poster 1	P01-1 **Custom-made foot orthoses for Rheumatoid arthritis: Looking at responders and no responders** Morten Bilde Simonsen, Aalborg University
Poster 2	P01-2 **Non-invasive measurements of the mechanical properties of muscle tissue in canine and equine athletes using the Myoton Pro device** Jessica Pingel, University of Copenhagen
Poster 3	P01-3 **The freely chosen cadence is increased during repeated bouts of submaximal cycling** Ernst A. Hansen, Aalborg University

Poster 4	P01-4 **Age-related decline in power output reflecting aerobic potential in trained cyclists** Magnus K. Hyttel, Aalborg University
Poster 5	P01-5 **Calculating sample entropy from isometric torque signals: Methodological considerations and recommendations** Peter Raffalt, University of Southern Denmark Odense
Poster 6	P01-6 **Footwear traction device with biomechanical loading conditions** L. Jakobsen , Technical University of Denmark (DTU)
Poster 7	P01-7 **The efficacy of intermittent long-term bell boot application for the correction of muscle asymmetry in equine subjects** Adrian Harrison, University of Copenhagen
Poster 8	P01-8 **The effects of three strength training methods on the lower extremety biomechanics and performance of sprinters during start acceleration** Xiao-Zhou Luo, Aalborg University
Poster 9	P01-9 **Effects of leg fatigue on pelvis and trunk kinematics during stair ascent** Gong-He Zhao, Aalborg University
Poster 10	P01-10 **Equine myodural bridges - An Anatomical and integrative and functional description of myodural bridges along the spine of horses: Special focus on the atlanto-occipital and atlanto-axial regions of leg fatigue on pelvis and trunk kinematics during stair ascent** Vibeke Sødring Elbrønd, University of Copenhagen

Venue

Frederiksberg Campus



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14th Annual Meeting of the Danish Society of Biomechanics

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Abstracts

S01-1

3D synchrotron imaging of muscle tissues at different atrophic stages in stroke and spinal cord injury: a proof-of-concept study

Jessica Pingel[1]*, Hans Martin Kjer[2]*, Fin Biering-Sørensen[3], Robert Feidenhans'l [4,5], Tim B. Dyrby [2,6]

1) Department of Neuroscience, University of Copenhagen, Copenhagen Denmark, 2) Department of Applied Mathematics and Computer Science, Technical University of Denmark, 3) Section for Spinal Cord Injuries, Department for Brain and Spinal Cord Injuries, Rigshospitalet and Institute of Clinical Medicine, University of Copenhagen, Denmark, 4) Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark 5) European X-ray Free Electron Laser, Schenefeld, Germany 6) Danish Research Centre for Magnetic Resonance, Copenhagen University Hospital Hvidovre and Amager, Denmark.

*Presenting Author: Associate Professor PhD. Jessica Pingel

INTRODUCTION

Synchrotron X-ray computed tomography (SXCT) allows 3D imaging of tissue with a very large field of view and an excellent micron resolution and enables the investigation of muscle fiber atrophy in 3D.
The study aimed to explore the 3D micro-architecture of healthy skeletal muscle fibers and muscle fibers at different stages of atrophy (stroke sample = muscle atrophy; spinal cord injury (SCI) sample = severe muscle atrophy).

METHODS

Three muscle samples: a healthy control sample; a stroke sample (atrophic sample), and an SCI sample (severe atrophic sample) were imaged using SXCT, and muscle fiber populations were segmented and quantified for microarchitecture and morphology differences.

Acquisition of data

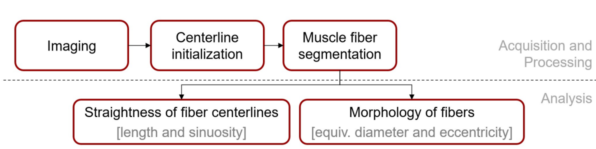
The 3D imaging of the intact muscle sample was done at the TOMCAT beamline at the Swiss Light Source using synchrotron X-ray computed tomography (SXCT). The central part of the biopsy was imaged with a cone beam at 25 keV energy using 1500 projections covering a 180° rotation.

Data Processing

The complete processing of the muscle fibers after the imaging required two steps as outlined in Figure 1: First, the initial identification of each muscle fiber centerline, and secondly, a voxel segmentation of muscle fibers.

Data Analysis

Each segmented muscle fiber was characterized based on the centerlines using the fiber length and straightness, and from the segmentation mask along the centerline, we derived metrics such as cross-sectional local thickness and roundness (Figure 1).



RESULTS AND DISCUSSION

Muscle fiber compositions Muscle fiber segmentations revealed a large difference between the total number of muscle fibers for each category of muscle atrophy. Healthy control sample: volume fraction was 74.7%; Stroke sample (atrophic sample) contained 2.3 times more fibers, which were 1.5 times smaller in diameter and a volume fraction of 70.2%. The SCI sample (severe atrophic sample) contained 0.46 times fewer and loosely packed fibers and a volume fraction of only 35.3%.

Morphological changes: The SCI sample (severe atrophic sample) showed several examples of fibers that were broken into multiple disjoint segments (Figure 3a), cavities or bubbles within the muscle (not shown), and even the appearance of fiber splitting (Figure 3b and 3c).

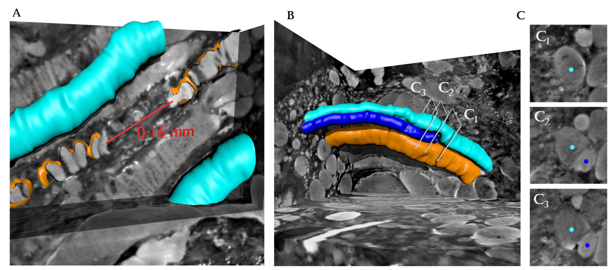


Fig. 2: 3D visualization of breaking and splitting fibers within the spinal cord injury sample.
Muscle fiber Buckling was observed in 3D but not in 2D segmentations

Fiber buckling: In the stroke sample (atrophic sample), the 3D trajectories of single muscle fiber centerlines revealed fiber buckling. Furthermore Figures 3b and 3c showcase two cross-sectional slices (2D) from the 3D reconstruction. In 2D, the bulking effect would incorrectly be classified as the trajectories of multiple closely neighboring muscle fibers.

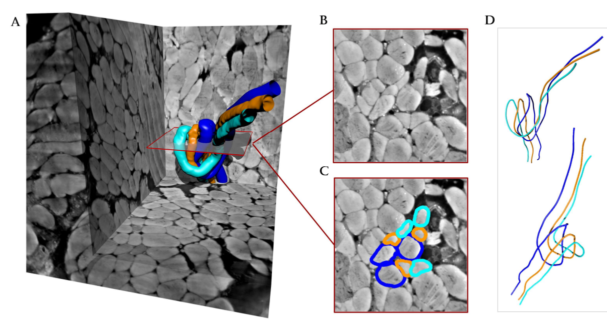


Fig. 3: Buckling fiber visualization

CONCLUSIONS

3D muscle fiber population analysis revealed new insights into the different stages of muscle fiber atrophy not to be observed nor quantified with a 2D histological analysis including fiber buckling, loss of fibers and fiber splitting.

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ON THE INCLUENCE OF THE INITIAL GUESS WHEN ESTIMATING KNEE LIGAMENT PROPERTIES VIA OPTIMIZATION PROCEDURES

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INTRODUCTION

Laxity measurements combined with computational models and optimization procedures are used to provide estimations of ligament properties [1]. This procedure is indirectly evaluated by comparing the experimental laxity against the one computed with the optimized ligament values [2]. Literature values are used as initial guess of the optimization procedure. However, these values often come from studies with small sample sizes [3], which do not represent the population variability. Thus, it is important to investigate how initial optimization guesses influence the estimated ligament values. This study provides an initial evaluation of the initial guess effects on the optimized ligament properties.

METHODS

A knee computational model was developed in the AnyBody Modeling System (AMS), using subject-specific tibial and femoral geometry as segmented from an individual's MRI scans. The model included the anterior and posterior crucial ligaments (ACL, PCL) and the medial and lateral collateral ligaments (MCL, LCL), as single elements. A non-linear law was used to simulate ligaments' mechanical behavior [1].

This model was used to generate a series of artificial laxity measurements. An initial set of properties (stiffness (k) and reference strain (e_r) per ligament; Table 1) was assigned to the ligaments and then laxity measurements were simulated by applying external load on the tibia. Anterior translation [0, 150] N, internal external rotation [-10, 10] Nm and varus valgus [-10, 10] Nm tests were simulated. The simulations were repeated for 0, 30 and 60° knee flexion angles. This set of simulations represented our experimental simulations.

Subsequently optimization procedures were performed using the Complex Optimization Method [4] with different initial guesses for every run (Table 1). The optimized material properties and the resulting joint kinematics were compared against the experimental material properties and kinematics.

RESULTS AND DISCUSSION

The results show that the predicted material properties were less accurate when worse initial guesses were provided (Figure 1). Most of the optimized values were close to their respective initial guess. Translation errors less than 1 mm and internal/external, varus/valgus rotational errors less than 1.5° were achieved for 3 out of 4 sets for all simulated knee flexions (Figure 2). On the other hand, the set 4, with the initial guess that predicted the least accurate ligament properties demonstrated errors more than 2 mm and 2°.

Table 1. Ligament k (kN) and e_r [%] values for experimental simulations and optimization initial guesses.

Sets	ACL		PCL		LCL		MCL	
	k	**e_r**	**k**	**e_r**	**k**	**e_r**	**k**	**e_r**
Exp	10	8	18	-4	6	2	8.25	4
Set 1	10	8	18	-4	6	2	8.25	4
Set 2	9.5	7.5	17.5	-3.5	6.5	2.5	8	4.5
Set 3	9	7	17	-3	7	4	7	5
Set 4	8	4	8	4	8	4	8	4

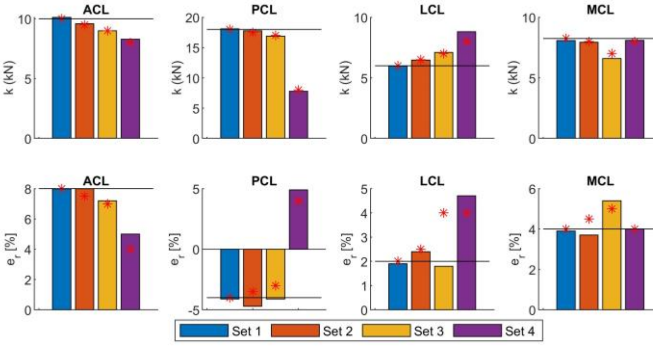

Fig. 1 Optimized ligament properties for different sets of initial guesses. The black line demonstrates the experimental values, while the red asterisks show the initial guess values.

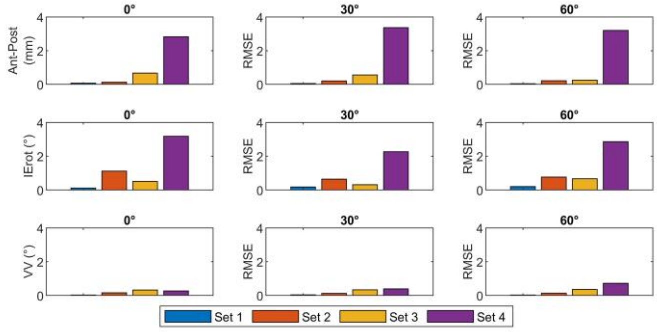

Fig. 2 The resulted kinematic error for the different sets of initial guesses and different knee flexion angles.

Our results show that it is possible to provide accurate knee ligament properties when good initial guesses are provided. However, estimated values different than the true properties might be provided due to poor initial guesses. Optimization procedures resulted in sub-optimal solutions, with values close to the initial guess. This is attributed to the complexity and the non-linearity of the problem, which might lead to local minima. Also, different combinations of the ligament properties might result in similar biomechanical behavior for a given task leading the optimization procedure to provide wrong material properties. It is alarming that the set 4, with the poorest properties estimation, demonstrated similar kinematic errors as previously reported models [2].

CONCLUSIONS

Future research should explore experimental and computational methodologies for obtaining accurate and reproducible ligament properties. Until then, researchers should be cautious when employing such procedures for predicting ligament properties and be aware of the effects wrong ligament properties might have on applications other than the ones used to optimize the properties.

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A FIELD EVALUATION OF A PASSIVE UPPER-EXTREMITY EXOSKELETON FOR MANUAL MATERIAL HANDLING IN BLADE MANUFACTURING

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INTRODUCTION

Recently, manufacturing firms with labour-intensive tasks started to focus on the technological evolution of collaborative equipment, such as passive upper-extremity exoskeletons (PUEXO) in their potential to reduce work-related musculoskeletal disorders (WMSDs) [1]. Therefore, the purpose of this study, which took place in the blade manufacturing facilities at Siemens Gamesa Renewable Energy (SGRE), was to evaluate acute effects of wearing a specific type of PUEXO (i.e. ShoulderX) on muscle activity, movement kinematics during the task execution as well as subjective evaluations.

METHODS

Seven healthy workers (3 men, 4 women) at SGRE participated in a 3-week long testing period. Participants manipulated fiberglass rugs for blade manufacturing, at baseline, at T1 (3-4 days after baseline), and at T2 (2 weeks after T1). The task consisted of lifting the fiberglass rug and carrying it towards a molding pit and subsequently placing it with manual adjustments to ensure an accurate placement.

While participants performed the task, with (and without) ShoulderX, (95th percentile) and median muscle activity was measured bilaterally with surface electromyography (sEMG) for shoulder and lower back muscles (Noraxon telemyo 2400 G2) at a sampling rate of 3000 Hz. Simultaneously, and synchronized with an inertial measurement unit (IMU) motion capture system, Xsens Awinda (Xsens Technologies BV) sampling at 60 Hz, used to capture task kinematics.

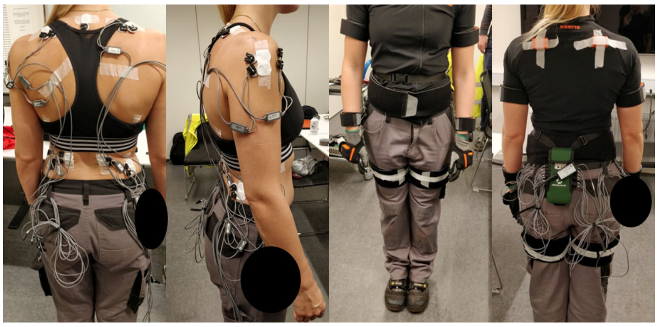

Fig 1. Experimental setup with sEMG and IMU sensors.

RESULTS AND DISCUSSION

Performing the task with the exoskeleton was associated with a reduced shoulder flexor muscle activity by up to 53.5% and was not associated with increased activity in the lower back. A rather large variability in muscle activity was present (cf. Figure 2), indicating that the relative workload was highly dependent on subjective factors such as work technique. Consequently, exoskeletal work was concomitant with altered kinematic pattern of task execution as ~10.3° additional shoulder abduction was observed. Thus, more muscle contribution to maintain equilibrium is required this, however, is if the support from the exoskeleton arms is disregarded. Therefore, abduction might not impose greater risks of WMSD due to the observed decrease in muscle activation which suggests overall shoulder joint alleviation.

The participants a SGRE adapted well to the usage of the exoskeleton and generally reported less discomfort and exertion when the task was performed with the exoskeleton. Additionally, all participants reported that they would recommend the exoskeleton to a colleague and were motivated to further use it during daily work.

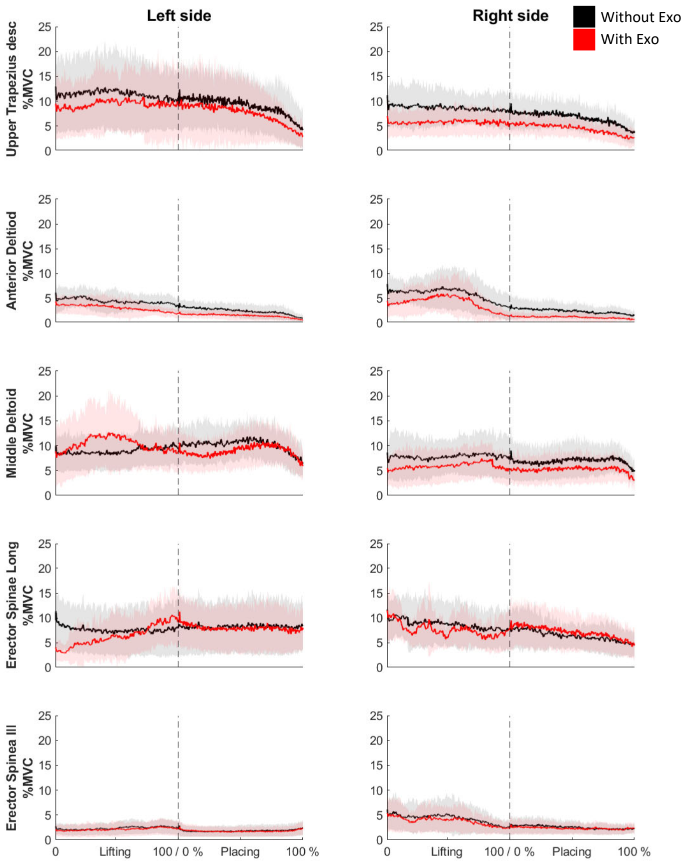

Fig. 2. Median normalized RMS values and corresponding standard deviation of working without (black) and with the exoskeleton (red) for included muscles measured bilaterally.

CONCLUSIONS

ShoulderX had a beneficial effect on muscle workload without applying additional strain to the lower back showing its potential to reduce WMSDs. Additionally, participants reported a high level of satisfaction and motivation towards the use of exoskeletons at their daily work.

ACKNOWLEDGEMENTS

A special thanks to SGRE and their workers for being cooperative and helpful.

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S01-4

Categorizing Movement in Handball Using Inertial Measurement Units with XGBoost

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[1]Department of Health Science and Technology, Sports Science – Performance and Technology, Aalborg University, Denmark
[2]Catapult Group International Ltd., Melbourne, Australia
*Student

INTRODUCTION

It is important in sports to gain knowledge of the physical demands from training and matches to optimize performance. One of the most common technologies used for monitoring player movements, is the global positioning system (GPS). However, GPS only provide the average linear velocities, which are not applicable to correctly capture the high intensity from low velocity movements such as change of directions [1]. In contrast, inertial measurement units (IMU) are capable of measuring accelerations and rotations, therefore allow capturing such movement patterns. Using machine learning techniques together with IMU measurements have proven to be a strong combination to predict different locomotion types in sport and general human activity recognition [2]. Therefore, the aim was to investigate the usefulness of classifying handball events with focus on throwing and locomotion events during a match.

METHODS

Five males and seven females participated in the study. They all had a high level of experience in physical activity, although they had varying levels of experience with handball, ranging from beginner- to former youth elite level players. They wore a west with an IMU fixed to the back between the scapulae. Synchronously, a video stream from both ends of the court during the match was recorded. The video recordings was used to annotate four types of events; low intensity, dynamic, running and overhead throws.

Due to a small sample size, all modeling and feature selection approaches were done using a leave-one-subject-out approach, resulting in 12 trained models.

Over 100 different features were extracted based on the IMU data, and 35 of them were selected based on recursive feature elimination.

A 10-fold cross validation was used on the training set for hyperparameter tuning of an Extreme gradient boosted tree, *xgboost.* The best performing model was chosen based on the highest F1-score across the 10 folds.

RESULTS AND DISCUSSION

The F1-score of the xgboost was between 0.65-0.93 with some variation between the models (Table 1). The F1-score for throw showed promising results whereas dynamic seemed the most difficult to classify. Which was also revealed in Figure 1 displaying 86% agreement for throw and only 64% for dynamic events.

The F1-score, sensitivity and specificity for throw events in the current study was similar or higher than previous studies that only focused on throw events [3-4]. As both studies only accounted for throws and placed the IMU on the wrist, their solution is limited to this purpose and will not generalize well to the identifying of full body acceleration and locomotion in the future [5].

Table 1 Model performance metrics for each event showed as means ± sd across all subjects using one-versus-all.

Metrics	**Low intensity**	**Dynamic**	**Running**	**Throw**
F1-score	0.93 ± 0.02	0.65 ± 0.06	0.86 ± 0.06	0.88 ± 0.11
Sensitivity	0.94 ± 0.02	0.69 ± 0.13	0.86 ± 0.06	0.86 ± 0.12
Specificity	0.89 ± 0.04	0.93 ± 0.03	0.97 ± 0.02	1.00 ± 0.00

The increased performance in the current study may be explained by the use of machine learning and the feature engineering approach. Skejø et al. [3] have applied a simple threshold to acceleration and angular velocities from the wrist to distinguish between throws and none-throws. Van den Tillar et al. [4] investigated a different set of features in their modeling, but those features were different from the feature set selected in this study [4]. Where features such as range and peak power of kinematic characteristics of the movement was found to be the most frequently selected features across almost all the time domain-features.

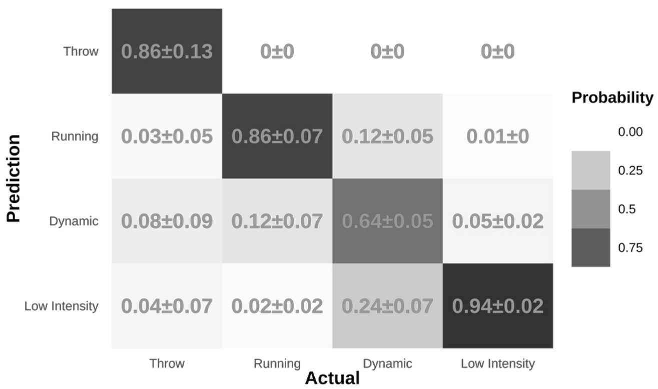

Figure 1 Confusion matrix of the mean ± sd probability that a given event was predicted relative to the actual.

CONCLUSIONS

It was possible to develop a machine learning model capable of classifying locomotion and throw events. It is recommended to create a thorough workflow of the feature engineering plan where features such as range and peak power are used to enhance the model's performance.

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ASSESSMENT OF THE EFFECTS OF EXTERNAL PRESSURE APPLIED ON THE SKIN DURING ULTRASOUND MEASUREMENTS OF MUSCLE THICKNESS, ECHOGENICITY AND PENNATION ANGLE.

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Student

INTRODUCTION

Skeletal muscle is a highly organized tissue, containing muscle fascicles, encapsulated by the extracellular matrix. Ultrasound imaging of skeletal muscle is a valid, non-invasive technique based on echo reflection. Ultrasound enables the assessment of muscle mass, architecture and composition [1]. However, ultrasound imaging is vulnerable to observer bias and big inter-observer variation in terms of the pressure applied by the probe [2]. The purpose of this study was to assess how controlled pressure applied on the skin with the probe affects the ultrasound images. The images were analysed in terms of muscle thickness, pennation angle and echogenicity, evaluated based on the visible shades of grey.

METHODS

An ultrasound machine was used on 22 subjects (28.32 y/o ± 8.3), 10 males and 12 females (BMI: 22.27 Kg/m² ± 2.42). A linear probe was used to take images of the longitudinal and transversal sections of both the muscles considered: Vastus Lateralis and Medial Gastrocnemius muscle. Three methods have been adopted for ultrasound imaging. As first, ultrasound images were taken holding the probe of the machine by hand and applying no-pressure on the skin and the maximal pressure possible for the operator. For the other two methods, two systems, sensitive to the pressure, were built using a digital dynamometer and a strain gauge pressure sensor. The systems could determine the intensity of the force impressed by the probe on the skin at the time of measurement. The images were captured considering the applied pressure, firstly without applying any pressure and then applying it gradually at certain pressure values (Newton (N)). Figure 1 shows ultrasound images of the longitudinal section of the vastus lateralis muscle from one participant the three methods. ImageJ was used for the image analysis, the muscle thickness, pennation angles and echogenicity were analysed for all the three methods.

RESULTS AND DISCUSSION

The main finding of the present study was that applying pressure on the skin with an ultrasound transducer during imaging has a significant impact on all measured parameters including muscle thickness, pennation angle and echogenicity. Significant changes were observed for all considered parameters between the images taken without applying pressure on the skin and those taken applying any kind of pressure. It was noticed that even a small amount of pressure (~3N) was enough to significantly change the outcomes of the variables.

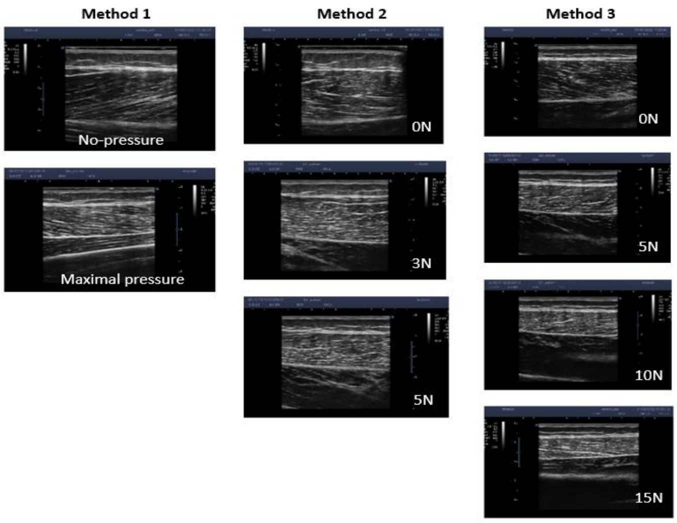

Figure 1: Examples of ultrasound images of the longitudinal section of the vastus lateralis muscle related to the three methods. Method 1 (no-pressure and maximal pressure applied); Method 2 (0 N, 3 N and 5 N applied); Method 3 (0 N, 5 N, 10 N and 1 5N applied).

CONCLUSION

This study demonstrates that pressure is a key factor for observer bias and inter-observer variation. Even small changes in pressure have shown to affect the outcome of all measured parameters. The development of a pressure sensitive ultrasound imaging system would improve training of novice users of various medical fields and researchers, thus enabling reliable ultrasound imaging with minimal observer bias.

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Use and familiarization of a passive shoulder-exoskeleton in manual materials handling. A field study

Lasse Schrøder Jakobsen[1*], Mark de Zee[1] Afshin Samani[1], Kévin Desbrosses[2], and Pascal Madeleine[1]

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*PhD student

INTRODUCTION

Manual materials handling retains to have a major role in the logistics sector due to low level of automation. Further, it often includes strenuous tasks increasing the risk of work-related musculoskeletal disorders (WMSDs). WMSDs can be accompanied by neck-shoulder pain, caused by heavy workload, awckward postures, and repetitive arm movements [1]. Exoskeletons are seen as an attractive solution to lower the biomechanical load of workers, since lower muscle activity has been reported [2]. Yet, in-field use of exoskeletons to reflect real-life settings has almost never been investigated [3]. The aim of this study was to investigate in-field changes in muscle activity and kinematics using a passive shoulder-exoskeleton pre and post to a 5-week familiarization.

METHODS

Twenty workers from a Danish logistics company (31.6 ± 7.7 years, 181.0 ± 8.6 cm, 84.9 ± 13.6 kg) were equally distributed into a control and intervention group using stratified randomization. The intervention group underwent a 5-week familiarization period of progressive use of a passive shoulder-exoskeleton (from 7.5 h/week to 37 h/week). The exoskeleton used in the present study was the ShoulderX_V3 (SuitX Inc., dba Ottobock bionic exoskeletons). All workers were tested pre and post to the familiarization. On test days, the workers performed four lifting tasks: 4.6 and 17.6 kg from 15-100 and 100-170 cm. All tasks included lifting the merchandise from a shelf to a truck in a rotational movement and were all conducted four times with and without the exoskeleton. Full-body 3D kinematics were captured using an IMU-based system (Xsens Awinda, 60 Hz) and muscle activation of erector spinae, deltoideus anterior, and upper trapezius were measured bilaterally using surface electromyography (sEMG) (Noraxon, 1500 HZ). Additionally, perceived effort was subjectively estimated using a 10-index Borg scale.

The sEMG signals were filtered and normalized to maximal isometric voluntary contraction. Subsequently, the 90th percentiles of the RMS values were calculated before initiating the statistical analysis. A three-way repeated measures analysis of variance (ANOVA) was conducted to assess the effects of the exoskeleton, familiarization, and groups. Paired sample t-tests were used to assess the ratings of the 10-index Borg scale ($\alpha = .05$).

RESULTS

Use of the exoskeleton induced significant decreases across both groups and tests of the sEMG RMS 90th percentile found for the right and left anterior deltoid when lifting 4.6 kg from 100-170cm, 4.6 kg from 15-100cm, and 17.6 kg from 100-170cm. Furthermore, the sEMG RMS 90th percentile decreased for the right anterior deltoid when lifting 17.6 kg from 15-100cm. Additionally, a significant decrease of the sEMG RMS 90th percentile was seen for the right upper trapezius when lifting 17.6 kg from 15-100cm. No significant effect of the exoskeleton was found for the erector spinae muscles (Fig. 1).

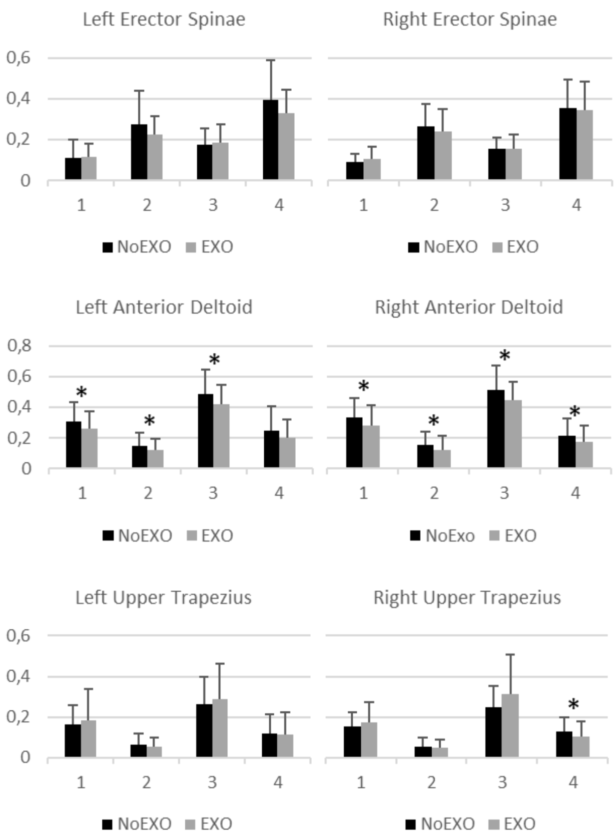

Fig. 1. Mean and standard deviation of the 90th percentile normalized root mean square values of left and right erector spinae, anterior deltoid, and upper trapezius without (black bar) and with (grey bar) exoskeleton. The four lifts: 1) 4.6 kg from 100-170cm, 2) 4.6 kg from 15-100cm, 3) 17.6 kg from 100-170cm, and 4) 17.6 kg from 15-100cm are presented left to right. * Indicates significant differences ($\alpha = .05$). Pre and posttests of both groups are included.

The perceived effort decreased significantly for the 100-170cm lifts with both 4.6 kg and 17.6 kg for the EXO condition compared with the NoEXO.

DISCUSSION AND CONCLUSIONS

The sEMG results underline that the passive shoulder-exoskeleton can lower the muscular activity around the shoulder girdle by 15-23% during simulated daily work tasks without affecting the activity of the back and neck muscles. These results were in line with the perceived effort ratings during the high lifting conditions. However, no effect of the familiarization was found, which could be a result of a low adherence to the familiarization protocol (approx. 20%).

ACKNOWLEDGEMENTS

The project was funded by Dagrofa Logistics A/S, who also provided facilities, personnel, equipment, and general organizational support.

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BIOMECHANICAL TESTING OF TENSION AND CREEP IN THE PATELLAR LIGAMENT: A CANINE POST-MORTEM STUDY.

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INTRODUCTION

Knee joint disorders are major reasons for welfare issues and performance deprivation in dogs and represent economic challenges for dog owners [1]. In particular, small breeds suffer from knee joint instability with resulting overload of the ligamentous apparatus [2].

METHODS

19 pairs of hind limbs from small dog breeds with an average body weight of 7.25 ± 3.2 kg were used (11 males, 8 females). The medical record was not available. They were collected at the Institute of Veterinary Anatomy, Histology and Embryology, Faculty of Veterinary Medicine, Leipzig University after the dissection course and stored at -20°C until further used (Ethics ID 2018-15-0201-01462).

The medial part of the patellar ligament was split in two and both halves were sutured to arterial clamps and mounted in a force transducer setup (Grass Instruments Inc.), where they were subjected to three subsequent rotations of a tension device that resulted in a stretch of 0.1 cm for each rotation. This gave rise to a "low", "medium" and "high" level of tension with mean values of 400, 700 and 1000 g, respectively.

Samples were bathed in deionized H_2O, 0.9% NaCl or PBS pH7.4 and maintained at a temperature of 38.5-39.0°C. The samples were allowed to acclimatize to the bathing solution for 30 minutes. The tissue was subsequently tensioned in sequential 0.1 cm steps and both tension and creep were recorded (sampling rate of 1000/sec) using a PowerLab (8/30 AD Instruments, AU) and MacBook Pro computer, and LabChart software (v 8.1.17 was used to analyze the data.

RESULTS AND DISCUSSION

Recently, it was shown that not only is muscle affected by changes in Ca^{2+} and Mg^{2+}, but that the mechanical and structural properties of collagen can be affected too [3].

Fig. 1 The effect of Ca^{2+} and Mg^{2+} on the tension (g) of patellar ligament sections at three levels of tension.

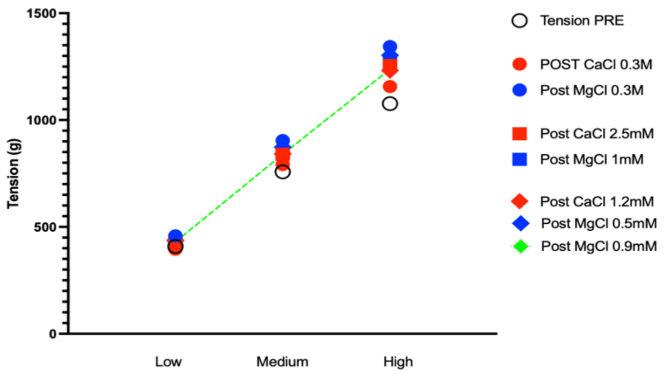
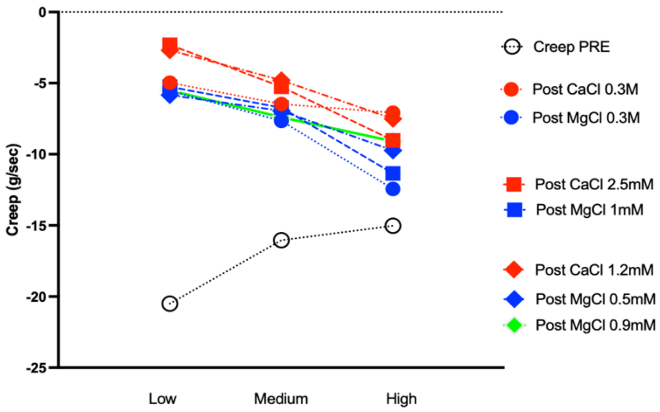


Fig. 2 The effect of Ca^{2+} and Mg^{2+} on the creep (g/sec) of patellar ligament sections at three levels of tension.



In Figures 1 and 2 you can see how tension generated under stretch tends to increase slightly compared to values in deionized water or 0.9% saline upon addition of Ca^{2+} and Mg^{2+} whilst remaining linear, and how there is a considerable loss of creep in the patella ligament upon addition of these two ions.

CONCLUSIONS

Our preliminary findings with intact ligaments from dogs support the findings of [3]. We have been able to show that both tension and creep parameters are affected by Ca^{2+} and Mg^{2+} ions, even under physiological conditions. It would seem that the effect of these two ions is through electrostatic charge interactions with the ligament structure.

ACKNOWLEDGEMENTS

We would like to thank our colleagues for their kind help, the dog owners for their generous donation and the Library of the University of Leipzig for their help in open access publishing. FCW was partially founded by a travel grant from Leipzig University.

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S02-3

AVOIDING INTRA-SUBJECT VARIABILITY DURING EXPERIMENTALLY INDUCED TRIPS

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INTRODUCTION

Unexpected perturbations affecting dynamic balance causing trips can lead to falls. When trips are provoked in experimental conditions, it is important to avoid intra-subject variability [1]. Several studies have developed methods to induce trips [1,2,3]. However, these approches have limitations when testing the effect of different shoe types on trips. The aim of this study was to design and test an experimental method inducing a unexpected trip without causing intra-subject variability, so it is possible to test the biomechanical effects of shoewear during trips. For that purpose, multiple trips were induced and the intra-subject variability both prior and after the trip was assessed. This method contributes to future studies investigating how the shoe type affects trips recovery.

METHODS

In this randomized controlled crossover study, 23 asymptomatic young adults (♀: 7, ♂: 16) participated (mean ±SD: 26.1±4.2 yrs., 1.77±0.08 m 79.5±13.2 kg). The experimental setup was created around a treadmill (Split70/157/ASK, Woodway) with a perturbation system placed lateral to the treadmill (Figure 1).

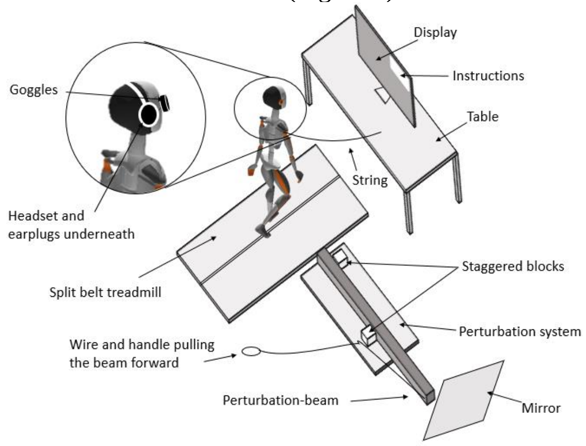

Figure. 1 Exsperimental setup.

To induce a trip, a wire attached to a perturbation-beam was manually pulled, to drag the beam out in front of the swing leg, creating a trip. Kinematic 3D data was collected using Xsens (Xsens Technologies, 240 Hz) and linear momentum of the foot was extracted. Data was gathered in a total of eight trials with a trip, four trials for two different types of shoes, i.e., safety shoes and everyday shoes. The participants used earplugs and a noise-cancelling headset (Sony WH-1000XM4) to eliminate audio cues from the perturbation system. They also wore googles blinding the peripheral view [1] to the trips occurring during mid-swing (52±5.6 %), at a random time between 180 and 480 s. Statistical nonParametric Mapping was performed on the normalized vertical position of center of mass (COM) to test the intra-subject variability within the four trials wearing both shoe types. Moreover, a potential carry-over effect between the initial four trials and the last four trials was assessed.

RESULTS AND DISCUSSION

The vertical position of CoM was significantly higher in trial 1 compared to trial 3 when wearing safety shoes but not for everyday shoes. However, this difference was not seen at trial 4 and was only relevant for 2 % of gait cycle 5 (Figure 2). Moreover, the method did not result in a carry-over effect. Further the linear momentum of the foot and whole leg was significantly increased before, during and after the perturbation when wearing safety shoes compared to wearing everyday shoes.

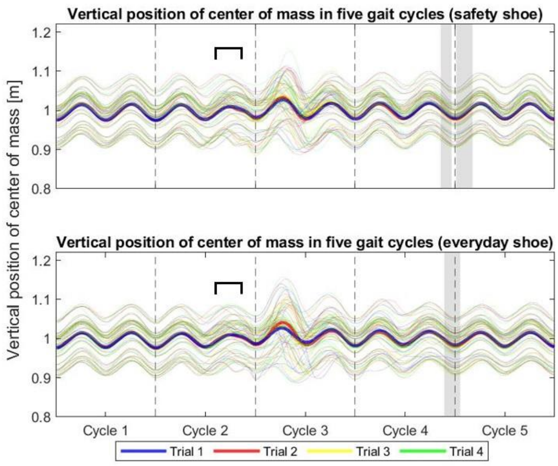

Figure. 2 Statistical nonParametric Mapping of the normalized vertical position CoM - four trials for each shoe type. The perturbation is indicated by the bold square bracket. Bold blue, red, yellow, and green lines represent the average for each trial. Thin blue, thin red, thin yellow and thin green lines represent each participant trials. Gray shaded areas represent supra-clusters with a significant difference ($P < 0.05$) between the trials.

CONCLUSIONS

In conclusion, the developed method can induce trips in a reliable manner that perturbate gait without inducing intra-subject variability. This method opens opportunities for testing of recovery strategies and the effect on the momentum when wearing different footwear.

ACKNOWLEDGEMENTS

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Biomechanical Evaluation of Bone Screw Stability Using Acoustic Modal Analysis and Conventional Pull-out: An Animal Study

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INTRODUCTION

Primary and secondary stabilities are two key elements in achieving osseointegration. Conventional techniques such as pull-out test and insertion torque previously have been utilized to evaluate the screw stability [1,2]. However, they have been found to be non-repeatable and unfeasible for clinical applications. To assess the screw stability in an in-vivo testing condition, the aim of this study was to apply acoustic modal analysis and compare the results with the conventional pull-out test.

METHODS

A titanium self-taped of 1.4 mm outer diameter embedded in right and left proximal tibia of 6 rabbits (Fig.1 a,b,c and e). The conventional pull-out and non-destructive acoustic modal analysis (AMA) [3,4] methods were used to examine and quantify the peak pull-out force (PPF) and natural frequency (NF), respectively (Fig1. D and f). To compare the secondary stability, the NF extracted from the AMA and the pull-out force were compared at 4 and 8-weeks euthanization after implantation. In AMA, the tapping sound was measured and transformed into the frequency domain using the fast Furrier transform (FFT) function and the fundamental frequency results were compared to other test method.

RESULTS AND DISCUSSION

The primary, 4-week and 8-week PPF were calculated 98.4±12.1, 219.8±34.6, 289.4±28.1 N, respectively. Similarly, the primary and secondary NF were obtained 2434±67, 3408±45, 3613±31 Hz, respectively. Significance levels of these data show that the osteointegration was mainly achieved in the 4th week (Fig.1 g).

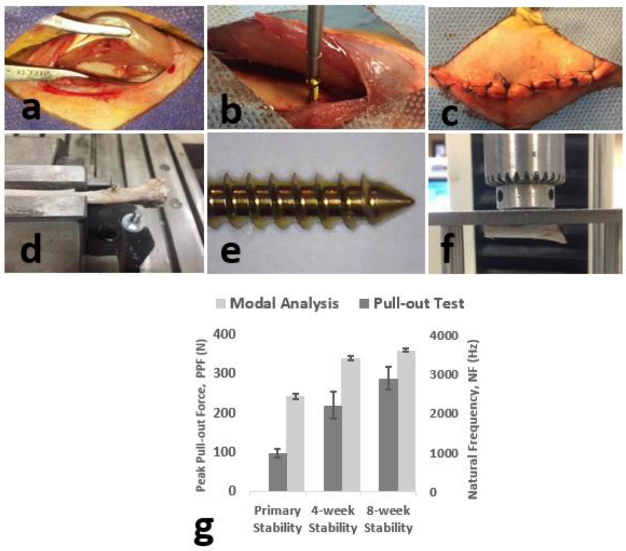

Fig. 1. *a) bone preparation, b) screw insertion, c) site closure, d) modal analysis, e) bone screw, f) pull-out test, g) peak pullout force and natural frequency versus primary and secondary stabilities*

CONCLUSIONS

Significant differences were observed between primary and both secondary stabilities which reveals the fact that the osteointegration was mainly achieved in the 4-week-duration group. AMA could quantify the primary and secondary stability as the pull-out force did. Moreover, the AMA method is a non-destructive method with the potential of using in-vivo [1,2].

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S02-5

THE EFFECT OF SIX WEEKS OF BACK SQUAT TRAINING ON DYNAMIC STRENGTH INDEX

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INTRODUCTION

Dynamic strength index (DSI) is a reliable method to measure the overall performance status of athletes (1). It is suggested in the literature that a DSI below 0.6 indicates the need for developing explosive strength, whereas a DSI above 0.8 indicates the need for developing maximal strength (1). The aim of this study was to investigate if a back squat training intervention would affect the DSI.

METHODS

Eighteen moderately physical active people (female; n=5, male; n=13, age of 23.6±2.3 years, height of 1.73±0.08 m, body mass of 74.9±17.5 kg) participated in the study. All participants had no previous experience with heavy resistance training, were physically active 1-4 times per week and had no records of injuries three months prior to the study. Participants were divided into two groups, intervention (INT) and control (CON). Groups were stratified based on DSI score obtained at the pretest and gender. Pre- and posttests included testing of isometric mid-thigh pull (IMTP), isometric squat (IS), 1RM back squat, and counter movement jump (CMJ). DSI was computed as ratio between maximal- and explosive strength (2).
The IMTP was conducted by having the participants grab an immovable barbell with straps and placing their heels on markings on the force platform. Participants were instructed to push their heels into the ground and pull "as fast and hard as possible". The IS was conducted similarly to the IMTP with the only difference being pushing up against the immovable bar instead of pulling. The participants were instructed to perform the CMJ "as fast and hard as possible" as they could while keeping arms akimbo. Prior to the training intervention all participants were thoroughly familiarized with the back squat exercise.
For the training intervention the participants attended 12 sessions with increasing intensity throughout the six weeks. All sessions were supervised.

RESULTS AND DISCUSSION

Fifteen out of 18 participants completed the study. All three dropouts were part of CON.
No significant change was revealed for DSI IMTP (p=0.787) (figure 3a and c). No significant change was revealed for DSI IS (p=0.5) (figure 3b and d), though a decrease in DSI IS (p=0.04) was revealed when CON and INT were considered one group.
No change in PF was revealed for IMTP (p=0.27) and IS (p=0.32)
A 41% increase in 1RM back squat was revealed.

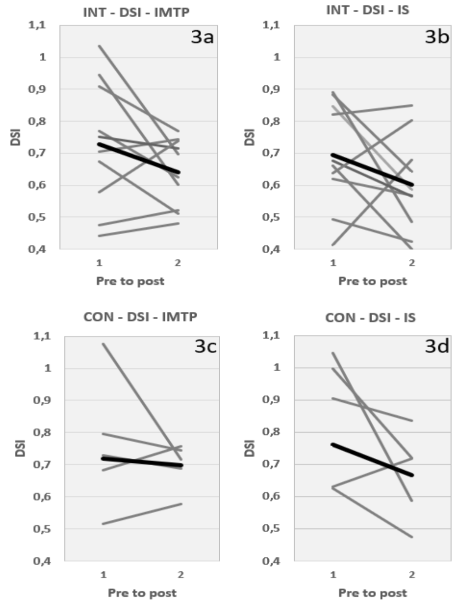

Fig. 1 Shows the individual dynamic strength index (DSI) for isometric midthigh pull (lMTP) and DSI isometric squat (IS) for intervention (INT) and control group (CON). The black line shows the mean DSI in all the figures.

The lack of significance in DSI IMTP and IS might be due to the low sample size and large SD. The decrease in DSI IS when CON and INT were considered as one group, shows that both the INT and CON increased their IS PF, thus explaining why no interaction effect was found for DSI IS. The fact that we did not find any change in IMTP or IS PF for INT group, but in 1RM back squat strength might be due to the poor transferability between isometric and dynamic strength (3).

CONCLUSION

The 6-week training intervention did not affect DSI IMTP or DSI IS. It should be noted that the 1RM increases with 41%, which indicates an effect of the training intervention. The reason why it did not show an effect on DSI can be due to the low sample size and large SD. And the fact that transferability between isometric and dynamic strength is not 1:1.

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SIMULATED INCREASE IN MONOARTICULAR HIP MUSCLE STRENGTH REDUCES THE FIRST PEAK OF KNEE COMPRESSION FORCES DURING WALKING IN HEALTHY INDIVIDUALS

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INTRODUCTION

Knee osteoarthritis (KOA) is a leading cause of disability worldwide. One factor responsible for the progression of KOA is abnormal load distribution in the knee joint, often quantified using the first and second peaks in knee joint compressive forces during gait (KCF_{p1} and KCF_{p2}) [1]. Studies have focused on identifying simple changes in muscle coordination through modelling to reduce KCF_{p2}, by reducing the activation of the gastrocnemius in favour of the soleus [2]. The reduction of KCF_{p1}, on the other hand, has not achieved the same amount of attention. A previous study indicated that the KCF_{p1} could be reduced by applying a hip flexion/extension moment (M_{HFE}) [1]. The present study aimed to identify which monoarticular hip muscles could compensate for the M_{HFE} to reduce KCF_{p1} using musculoskeletal modelling.

METHODS

Experimental data: 24 healthy participants (12 males and 12 females, 23.3± 3.2 years) performed three trials of walking at their own pace. An eight-camera Qualisys system (Qualisys, Gothenburg, Sweden) recording at 100Hz, 32 reflective markers placed on the lower extremity, and two force plates recording at 1000Hz (AMTI, Watertown, USA) were used to collect data from gait trials.

Musculoskeletal models: The anatomical landmark scaled musculoskeletal model [3] was applied using the AnyBody Modelling System (AMS; AnyBody Technology A/S, Aalborg, Denmark). Then, AMS was used to perform an inverse dynamic analysis of each gait trial without an applied moment (*Normal*) and with an externally applied moment to compensate 100% for the moment generated by the muscles creating the flexion/extension rotation around the hip joint (*Comp100%M$_{HFE}$*). The force data of all hip muscles, the total compressive knee joint force (tKCF), the knee flexion/extension moments (M_{KFE}) and M_{HFE} were computed during the stance phase for both load cases. These initial results were used to select potential muscles for further study with a 30% increase in their "ideal strength" (F0) to see the effect on KCF_{p1}.

Data Processing and Statistical Analysis: The stance phase was isolated for each trial and normalized in the time domain. It started when the heel struck the force plate and ended when the toes left it (beginning of the swing phase). The data were normalized to percentages of body weight (%BW). After identifying KCF_{p1}, each variable's values corresponding to this peak were retrieved. A statistical cluster analysis was performed with M_{HFE} and M_{KFE} during KCF_{p1} as input data to identify potential clusters. The differences between clusters and load cases were statistically evaluated using a two-way analysis of variance.

RESULTS AND DISCUSSION

As in previous studies [4], cluster analysis revealed two groups with significantly different M_{HFE} and M_{KFE} during KCF_{p1} ($p<0.001$): **M_{KFE}+ group** (M_{HFE}=1.71±1.16%BW, M_{KFE}=-7.47±3.35%BW, and **M_{HFE}+ group** (M_{HFE}=3.81± 1.19%BW, M_{KFE}=-4.61 ±1.59%BW). The results concerning the evolution of KCF_{p1} according to the different load cases are presented in table 1. Although a reduction in KCF_{p1} was observed with *Comp100%M$_{HFE}$* in both groups, as in the study by Stoltze et al. [1], it was significantly greater in the M_{HFE}+ group. Indeed, the total unloading of the hamstrings can explain this reduction at KCF_{p1}, but the M_{HFE}+ group used the hamstrings preferentially in this phase, while the M_{KFE}+ group used them less with a higher force developed by the quadriceps. Thus, strengthening of the gluteus medius (GlutMed) and gluteus maximus (GlutMax) was performed to re-distribute the relative loads of the mono and biarticular muscles crossing the hip, which led to a greater reduction in KCF_{p1} in the M_{HFE}+ group than in the M_{KFE}+ group.

CONCLUSIONS

According to the simulations, it would be possible to considerably reduce KCF_{p1} in the M_{HFE}+ group using strengthening exercises targeting the gluteus maximus and medius (e.g., clamshell exercise). In the M_{KFE}+ group, focusing on changing their walking strategy to approach that of the M_{HFE}+ group could be a first step in reducing KCF_{p1}. Future studies could investigate the effect of specific training of the hip muscles on tKCF and patient-reported outcomes.

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Table 1: Evolution of KCF_{p1} (in %BW) compared to the Normal condition according to the load cases

Load Case	M_{KFE}+ Group	M_{HFE}+ Group
Normal	**333.57±107.63**	**284.67±53.82**
Comp100%M$_{HFE}$	**312.18±116.18 (-7.79±8.22 %)**	**220.35±50.73 *** (-22.79±8.16 %)**
+30%F0 GlutMax	328.17±107.73 (-1.80±1.16 %)	275.65±53.45 (-3.27±1.01 %)
+30%F0 GlutMed	327.91±107.39 (-1.83±1.07 %)	275.61±51.63 (-3.13±0.75 %)
+40%F0 GlutMax and +30%F0 GlutMed (e.g. clamshell exercise [5])	323.35±107.99 (-3.39±2.15 %)	266.88±51.74 (-6.34±1.41 %)

*Difference from the Normal condition : p<0.05 * ; p<0.01 ** ; p<0.001 ****

THE EQUINE LATERAL RAPHE: MULTIMODAL VERIFICATION AND BIOMECHANICS

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INTRODUCTION

Low back pain in humans has been shown to be correlated to an imbalanced and dysfunctional Lateral raphe (LR) [1]. The human LR is defined as a thickened complex of dense connective tissue, extending from the 12th Costa to Crista iliaca. It marks the junction of the paraspinal retinacular sheath (PRS) and the common aponeurosis of M. obliquus internus abdominis (IO) and M. transversus abdominis (TrA). This triangular unification of fascial sheaths has a fat-filled core named the lumbar interfascial triangle (LIFT) [1,2]. Biomechanically, the LR assures that forces are spread from one to several vertebral segments in the lumbar region [2]. Horses often suffer from lumbar pain and dysfunction. Therefore, the hypothesis of this study was i) to investigate the presence of an equine lateral raphe corresponding the description of the human LR, and ii) to validate methods to visualize and define the LR. This including 3D interactive dissections, histology, diagnostic modalities such as ultrasound scanning (US), and biomechanical property testing such as force traction and stress adaptation.

METHODS

Eighteen horses (of different age, breed, and gender) were euthanized due to other reasons than the studies (Ethics ID 2018-15-0201-01462). Dissections were performed in the sagittal and transverse plane at the level of L3/L4. One horse was US examined before euthanasia and dissected afterwards for verification. In five live horses, systematic US examinations were performed at three levels (L1, L3, L5). A real-time US machine with a convex transducer of low-medium frequency was used. On three cadavers traction was applied to each of the abdominal myofascia, and the effect on the LR was evaluated macroscopically and with US. Histological samples were collected from four horses and stained with resorcin-fuchsin and alcian blue.
Furthermore, the lateral and medial side of the LIFT were mounted in a force transducer setup (Grass Instruments Inc.) and measurements were performed during force traction.

RESULTS AND DISCUSSION

The equine LR was identified as a dense, fibrous raphe ventrolateral to the lumbar vertebrae, extending from 18th Costa to Tuber coxae. It marks the unification of the Dorsal fascia layer (DLF) of the Thoracolumbar fascia (TLF) with the middle (MLF) and the Ventral fascia layer of the Deep fascia, thereby forming the triangular LIFT with a core of adipose tissue (figs. 1 and 2). Dissections showed that the cross-sectional area of the LIFT was reduced from cranial to caudal. The LR was able to transfer forces from the TrA, the IO and the EO to the layers of TLF. The TrA appeared to be the most efficient muscle to transfer force through the MLF. The sides of the LIFT consisted of transversal orientated, dense, regular collagen and longitudinal orientated, elastic fibres in several layers (fig. 3). A collagenous and elastic trabecular network was present in the LIFT. The biomechanical studies showed that the medial side of the LIFT had the highest stress adaptability and creep, whereas the lateral side had a low force tolerance.

CONCLUSIONS

3D dissections, histology studies and US scans confirmed the presence of an equine LR corresponding to the human definitions. The biomechanical studies verified specific biomechanical properties of the LR.

ACKNOWLEDGEMENTS

We would like to thank our colleagues for their kind help, and the horse owners for their generous contributions and donations.

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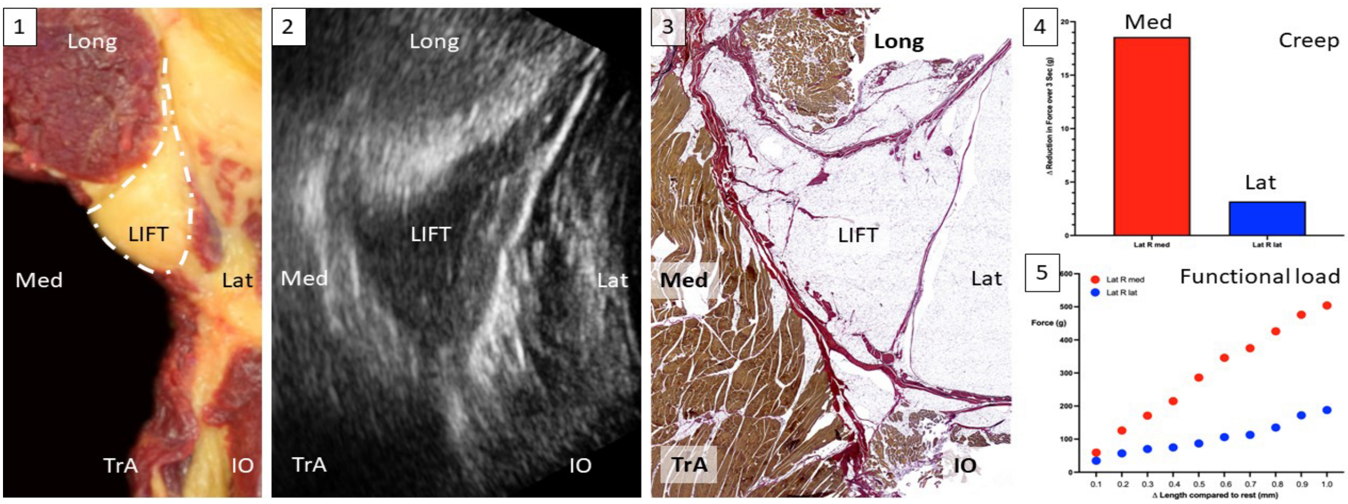
Figures: 1-3 different visualization techniques to validate the presence of the LR at L3/ L4. Fig 4-5: Force traction studies.
Fig. 1*:Macroscopic cross-section.* ***Fig. 2****:US image.* ***Fig.3****:Histological overview.* ***Fig. 4****: Force reduction after tension, Creep.* ***Fig. 5****:Force related to length. Long: M. longissimus lumborum.*



DYNAMIC LOWER LIMB ALIGNMENT IN PRESCHOOL CHILDREN

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INTRODUCTION

During early childhood it is normal to have pronounced static valgus alignment of the lower limb[1], but the natural development of dynamic lower limb alignment (DLLA) during this age period is poorly understood. This study aimed to examine the dynamic lower limb alignment of a large sample of preschool children performing multiple jumps. The specific objectives were to a) describe the distribution of DLLA in the sample; b) examine age and sex differences related to DLLA; and c) examine the possible relationship between DLLA and motor performance.

METHODS

DLLA, measured as knee-to-ankle separation ratio (KASR) at impact, was estimated in 605 preschool children aged 3 to 6 years, who performed two standing-broad-jumps, two drop-landings, and four additional performance tests. The jumps were recorded using a markerless motion capture system with 8 RGB cameras recording with 50 fps. We grouped the children into three kinematic groups ('Valgus', 'Neutral', and 'Varus') based on their KASR scores at impact. We used Chi-square tests of goodness-of-fit to determine if the boys and girls were equally distributed within the three kinematic groups, and sex-stratified linear regression models to examine the relationships between the kinematic groups and age and performance, respectively.

RESULTS AND DISCUSSION

For both the standing-broad-jumps and the drop-landings, more than 75% of the children had KASR scores below 1.0, indicating some level of valgus DLLA. Sex was not equally distributed among the three kinematic groups ($\chi2$(df: 2, N = 605) = 12.16; p = .002)), as 67% and 38% of the children in 'Valgus' and 'Varus' groups, respectively, were girls (Figure 1). By contrast, the age models only explained a small, statistically non-significant, proportion of the variance (p > .1, r2 = 0.01) (Figure 2). The 'Valgus' group had consistently lower motor performance than the 'Varus' group in both sexes, but the age-adjusted differences were small and only statistically significant for jump height and length.

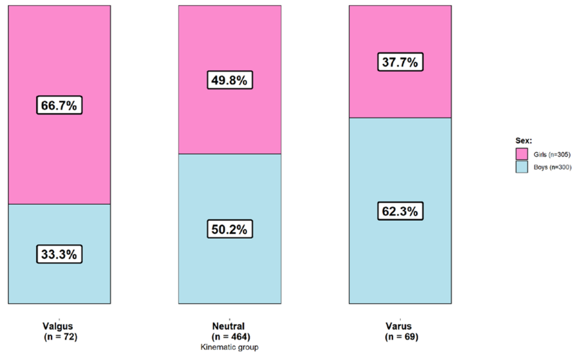

Fig. 1 Sex distribution between the three kinematic groups

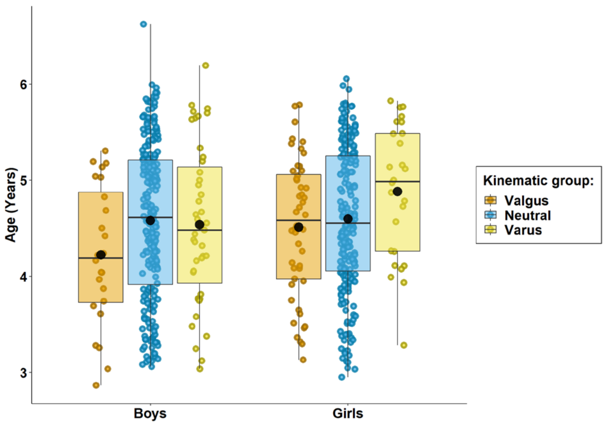

Fig. 2 Age distribution between the three kinematic groups

CONCLUSIONS

A dynamic lower limb valgus alignment during jump-landings is a normal finding among preschool children of both sexes, but roughly 2/3 of the children with the most extreme dynamic valgus alignment are girls. Overall, we did not find dynamic lower limb alignment to change with age during preschool years from 3 to 6 years of age, neither in the entire sample nor within each sex. Our results indicate a minor relationship between dynamic lower limb alignment and motor performance.

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ELECTRO-SUIT TREATMENT OF CHILDREN WITH UNILATERAL CEREBRAL PALSY ALTERS NONLINEAR DYNAMICS OF WALKING

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INTRODUCTION

Cerebral palsy (CP) is a disorder initiated by a non-progressive brain lesion associated with mild to severe motor impairments including reduced gait function [1]. As a non-invasive treatment of spasticity, a new intervention, the whole-body electro-suit named Exopulse® has been developed to reduce spasticity using electrical stimulation during normal daily life activities in home settings. The purpose of the present study was to investigate the effect of systematic treatment with the Exopulse® suit on the nonlinear dynamics and variability of trunk accelerations during walking in children with unilateral CP.

METHODS

Twelve patients (mean age: 12 years, range 7–17 years) with unilateral CP (GMFCS level 1 and 2) received 24 weeks Exopulse® suit treatment with patient-specific muscle stimulation. Before and after the treatment, the patients completed 4 minutes treadmill walking while trunk accelerometry was obtained. The nonlinear dynamics was quantified by the largest Lyapunov exponent and the complexity index from the multiscale entropy and movement variability was quantified by the root mean square ratio. Pre- vs post-treatment differences were evaluated by a paired Student's t-test.

RESULTS AND DISCUSSION

The largest Lyapunov exponent (p-value=0.041, Fig. 1) and the complexity index (p-value=0.030, Fig. 2) of the acceleration in the anterior-posterior direction was significantly lower post-treatment. No other between-trial differences were observed. These results suggest that 24 weeks of Exopulse® suit treatment alters the nonlinear dynamics but not the variability of the trunk accelerations during walking in children with unilateral CP.

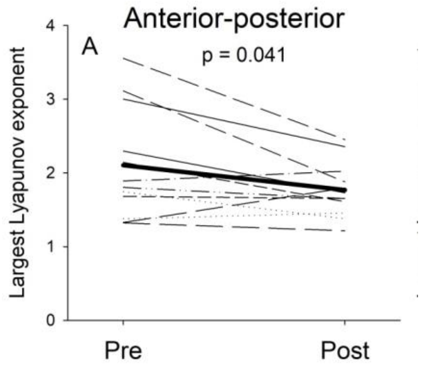

Fig. 1 The largest Lyapunov exponent for the trunk acceleration in the anterior-posterior direction for individual patients and group average (thick line).

CONCLUSIONS

The temporal structure of the trunk acceleration in the anterior-posterior direction during treadmill walking was altered towards that of healthy individuals [2]. Thus, the present study supports the therapeutic use of electrical muscle stimulation in children with CP with the purpose of improving gait function.

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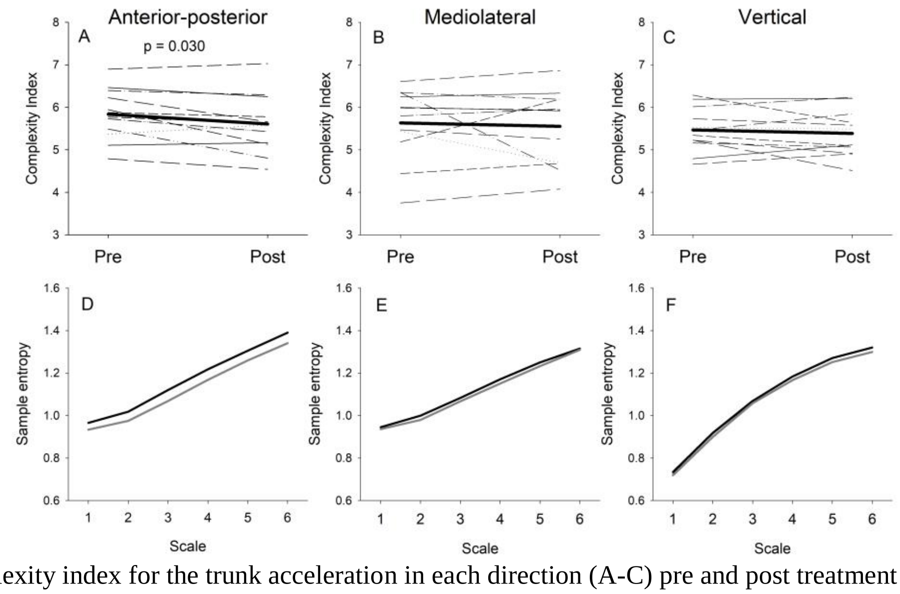

Fig. 2 The complexity index for the trunk acceleration in each direction (A-C) pre and post treatment for each patient and group average (thick line). P-value indicates pre-post difference. The group average sample entropy across the six scales for the trunk acceleration in each direction (D-E) pre and post treatment.

COMPARISON OF MRI SEQUENCES FOR THE AUTOMATIC SEGMENTATION OF KNEE STRUCTURES

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INTRODUCTION

Medical imaging is increasingly being used to make person-specific musculoskeletal models within the biomechanics field. Specifically, magnetic resonance imaging (MRI) images are used for extracting anatomical structures such as bone and cartilage [1]. However, manual segmentation of these structures is a bottleneck for further advancement in the field. Automatic segmentation has the potential to change this. However, MRI image characteristics are very different according to sequences, so it is important to select an optimal sequence for automatic segmentation [2]. This study aims to find the most suitable MRI sequence for segmentation through edge evaluation.

METHODS

Analysis was performed using the T1, PD, and SPGR sequences scanned from the knee of the same participant (Fig. 1). After selecting the same location in each sequence of images, the cortical bone, cancellous bone, and cartilage edges were manually drawn on the selected images. After generating a normal vector at the edge line of the cortical bone, the points (E_{CT}: between cartilage and tissue, E_{BC}: between bone and cartilage, E_{BB}: between cortical and cancellous bone, E_{BT}: between bone and tissue), where the normal vector meets the obtained edge line were calculated (Fig. 2).

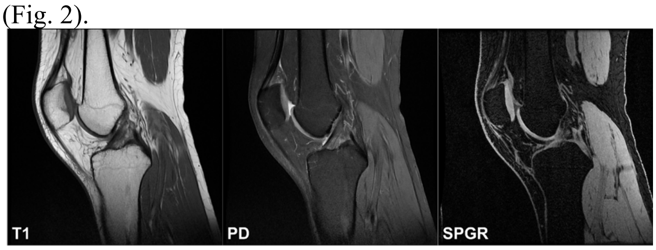

Fig. 1 Three MRI sequences from the same subject. (T1: T1 weighted, DP: proton density, SPGR: spoiled gradient recalled acquisition in the steady state)

We designed the metric to evaluate the edge characteristic. The metric is calculated as the ratio of the average of both regions through which the normal vector passes, at each point selected. The evaluation was conducted using data from a total of 10 healthy participants.

RESULTS AND DISCUSSION

As a result of the experiment using the evaluation metric (Table 1), the E_{BB} and E_{BT} was the most distinct in the T1 sequence. Also, the SPGR sequence showed the most distinct edge at E_{BC} and E_{CT}.

Since it is difficult in practice to scan multiple sequences on the same participant, we only used three sequences known to have good contrast for bone and cartilage. Therefore, further studies on additional sequences are required. In addition, we experimented with only a single image in a femur region. An evaluation using more data in various bone areas is required through future research.

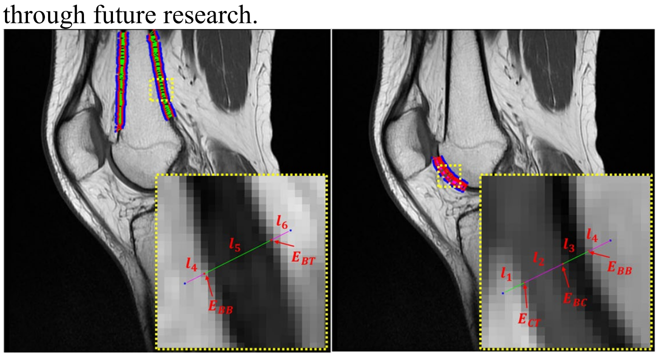

Fig. 2 Evaluation of edge characteristics using the proposed method.

CONCLUSIONS

For the quantitative evaluation of edges, our proposed metric will be a useful method for selecting sequences for automated MRI segmentation studies.

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Table 1 Experimental results using proposed metrics (10 subjects)

Subject	T1				PD				SPGR			
	E_{BB}	E_{BC}	E_{CT}	E_{BT}	E_{BB}	E_{BC}	E_{CT}	E_{BT}	E_{BB}	E_{BC}	E_{CT}	E_{BT}
1	3.47±1.41	1.70±0.57	1.62±0.57	3.83±1.64	1.30±0.49	2.32±1.41	1.26±0.81	2.48±0.92	1.55±0.57	4.81±1.91	3.53±2.88	1.77±0.74
2	4.33±1.05	1.84±0.30	2.38±0.49	4.96±1.14	2.18±0.77	2.97±1.86	1.36±0.71	2.87±0.72	1.63±0.70	3.60±2.44	3.56±2.12	1.78±0.59
3	3.24±1.23	1.33±0.18	1.50±0.32	4.50±2.38	1.57±0.41	3.99±0.95	1.61±0.29	2.80±0.65	1.51±0.48	4.31±1.23	3.05±2.07	3.58±1.07
4	2.73±0.89	1.60±0.22	1.53±0.37	4.15±1.72	1.38±0.37	3.81±0.59	1.24±0.23	2.93±0.86	1.52±0.47	4.42±1.15	4.27±2.19	2.49±1.05
5	4.04±1.18	2.09±0.45	1.59±0.48	4.58±1.90	2.10±0.65	3.84±0.79	1.61±0.63	3.75±1.21	1.93±0.57	3.26±1.02	1.58±0.47	3.04±0.81
6	3.98±1.29	2.19±0.50	1.60±0.58	5.11±1.97	2.18±0.46	6.45±0.78	1.24±0.24	2.40±0.44	1.61±0.55	3.82±1.48	1.59±0.46	2.30±0.65
7	2.92±1.24	1.67±0.15	1.46±0.41	3.19±1.10	1.46±0.35	3.34±0.38	1.41±0.38	2.24±0.80	1.70±0.55	3.22±1.05	1.61±0.47	2.10±0.78
8	3.71±0.96	2.54±0.57	1.61±0.33	5.04±1.97	1.86±0.64	4.42±0.87	1.34±0.24	3.68±1.08	1.67±0.67	4.42±1.52	3.08±1.67	2.09±0.73
9	3.66±1.20	2.17±0.51	1.63±0.53	4.14±1.58	2.55±0.93	4.37±1.36	1.65±0.35	2.22±0.55	1.51±0.50	4.88±1.45	2.19±1.52	1.53±0.46
10	3.89±1.28	2.05±0.30	1.74±0.45	4.65±1.74	2.34±0.63	4.93±1.47	1.47±0.40	3.13±0.82	1.76±0.63	3.74±1.01	1.82±0.33	2.56±1.07

Note.- Mean ± Standard deviation

THE EFFECT OF FATIGUE ON DYNAMIC STABILITY CONTROL DURING STAIR DESCENT

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INTRODUCTION

Stair descent is a challenging daily activity, and the requirements for stability and power exceed those of level walking and stair ascent. Lower extremity fatigue negatively affects stability during level walking, but the effects of fatigue during stair descent have not been examined previously [1]. Margin of stability (MoS) can comprehensively be quantified as the dynamic control of the center of mass (CoM) relative to the base of support under the influence of gait velocity during locomotion [2]. Joint work is important for controlling, moving, and stabilizing the body to prevent a fall during stair descent. Thus, the present study aimed to investigate the effects of fatigue on dynamic gait stability and joint work during stair descent.

METHODS

Twenty healthy young male adults (25.1±1.2yr, 1.75±0.04m, 71.2±7.0kg, right foot dominance) were recruited for the study to perform staircase descent tests before and after fatigue exercises. A 5-step cast iron simulating staircase (tread 17cm, riser 29cm) was used for the experiment. One force plate (Kistler, 1000Hz) was embedded in the second step of the staircase from the bottom to obtain ground reaction force (GRF) and center of pressure (COP) during the stance phase. An 8-camera motion capture system (Qualisys AB, 200Hz) recorded full-body kinematics, and all measurement systems were synchronized.

Subjects were instructed to begin walking from a standing position and entered the staircase with the same foot (right foot on the fourth step) and descended in a step-over-step manner at a self-selected comfortable speed to the end of the bottom, which is 5m from the first riser. Each subject was given a few minutes to practice staircase descent. In the no fatigue session, stair descent data collection was conducted right after practice. In the lower-limb muscular fatigue session, subjects performed a repeated squatting protocol at a frequency of 50 BPM with 1/3 body weight. Fatigue was considered induced when (1) the subjects fell 4 squat cycles behind the set frequency or failed to complete 2 successive squat cycles, or (2) the heart rate went up to 85% maximum heart rate, and then stair descent data collection was started immediately. Each subject underwent 3 trials in each session.

The kinematic and kinetic data were filtered by a fourth-order Butterworth low-pass digital filter at cut-off frequencies of 13.3Hz and 50Hz, respectively, and used to calculate MoS-related variables and joint work in the sagittal plane during the stance phase. The right stance phase on the second step was used for the analysis.

Paired sample t-tests were performed to determine the statistical significance of the differences before and after fatigue. Significance was set at $P \leqslant 0.05$.

RESULTS AND DISCUSSION

The anterior-posterior (A-P) MoS-related variables during right-foot-landing and left-foot-take-off were significantly different between the pre-and post-fatigue (**Table 1**). Fatigue resulted in larger MOS_a, MoS_p, and $vCoM_{ap}$ in both events. However, fatigue did not affect medial-lateral (M-L) MoS. Fatigue resulted in more positive work at the hip and knee, more negative work at the hip, and less positive work at the ankle (**Table 2**).

Table 1 Means±SD of MoS-related variables

	Pre-fatigue	Post-fatigue
Right-foot-landing		
MoS_a (m)	-0.050±0.032	-0.028±0.036*
MoS_p (m)	0.078±0.032	0.090±0.031*
MoS_{ml} (m)	0.112±0.029	0.113±0.025
$vCoM_{ap}$ (m/s)	0.614±0.053	0.637±0.059*
$vCoM_{ml}$ (m/s)	0.077±0.035	0.077±0.032
Left-foot-take-off		
MoS_a (m)	0.061±0.034	0.078±0.034*
MoS_p (m)	0.188±0.025	0.197±0.028*
MoS_{ml} (m)	0.108±0.028	0.108±0.024
$vCoM_{ap}$ (m/s)	0.697±0.068	0.719±0.076*
$vCoM_{ml}$ (m/s)	0.055±0.031	0.058±0.028

Table 2 Means±SD of positive and negative joint work

	Pre-fatigue	Post-fatigue
Positive work		
Hip (J/kg)	0.071±0.031	0.093±0.038*
Knee(J/kg)	0.054±0.043	0.068±0.040*
Ankle(J/kg)	0.094±0.032	0.082±0.022*
Negative work		
Hip(J/kg)	-0.061±0.025	-0.074±0.036*
Knee(J/kg)	-0.866±0.186	-0.846±0.117
Ankle(J/kg)	-0.686±0.133	-0.723±0.104

* $p<0.05$ vs. pre-fatigue

CONCLUSIONS

The results of the current study suggest that fatigue decreases postural stability during stair descent and changes energy generation and absorption at the hip, knee, and ankle.

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DIFFERENCES IN THE FASCIA BETWEEN DOGS AND HORSES AND THEIR IMPACT ON BIOMECHANICS.

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INTRODUCTION

Myofascial treatment of companion animals such as the horse and dog is a discipline, which has increased during the last decade. Knowledge about these structures, their function and interactions is essential for a correct approach to perform a proper myofascial treatment or evaluation of biomechanics. Macroscopic biomechanical interactions such as e.g. the bow string theory, the equine mechanical stay apparatus and shock absorption by the equine flexor tendons are well known and have been taught to veterinary students for many years. What is lacking are detailed studies and information on 3-D myofascial integration in the body not only at the macroscopic but also at the microscopic level. The purpose of this study was to evaluate the myofascia layers and their integration in different regions of the horse and dog and by means of this assess the impact for biomechanics.

METHODS

Eight horses and 5 dogs were euthanized for reasons unrelated to these studies (Ethics ID 2018-15-0201-01462) and full-thickness specimens were sampled at ten different regions for histological examination. The samples were collected from the skin and to the depth of the muscle layer, processed for histology and stained with resorcein and Alcian blue. Two euthanized horses and two dogs were frozen hanging by the hindlimbs or lying prone and were cut into sections guided by vertebral segmentation. Interactive macroscopical dissections were performed on 20 euthanized horses and dogs of various age, breed, and sex.

RESULTS

The impression from the macroscopic dissections is that the equine fascia system is tight, thick, and strong whereas in the dogs it is loose, flexible, and thin. In horses the superficial fascia (SF) on the trunk and the proximal part of the extremities is found to be trilaminar and with few exceptions in close contact to the skin via a specific equine third dermal layer [1, 2] which includes elastic fibres. The three SF layers are arranged obliquely and present typically with crimping of the collagen fibres. This contrasts with the dog in which the SF is multi-layered, irregular and situated underneath a superficial adipose tissue layer (SAT). The SF contacts the skin with smaller trabecular and larger fibrous structures. In both the horse and dog, a deep adipose tissue (DAT) is present underneath the SF followed by the deep fascia (DF). Between the fascia layers, soft irregular and hyaluronan rich connective tissue is located, providing mobility between the layers. The SF and DF interconnect by trabecular structures via the DAT.

DISCUSSION:

The results of these studies show that the horse and dog are different with respect to fascia layers, composition, and architecture. Many differences reflect variations in the biomechanics related to the horse and dog being a prey animal and a predator, respectively. The studies confirm that the horses work with a high level of energy efficiency e.g. by taking advantage of the recoil arrangement in the skin and SF. In the dog the flexibility and the presence of a SAT layer insulates and supports shock absorption in locomotion.

CONCLUSIONS

The results from the present study show that the morphology, at the macroscopical and microscopical level, has an impact on equine and canine biomechanics. The results can be extended into new approaches of the correlation between the 3-D myofascial network and the biomechanics of the horse and dog.

ACKNOWLEDGEMENTS

We would like to thank our colleagues for their kind help and support during these studies. We are also grateful to the owners for their generous donations.

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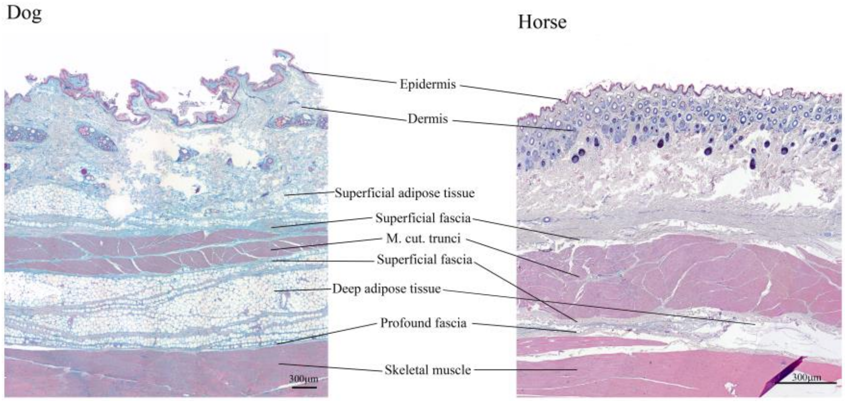

Fig. 1: Alcian blue stained sections from just caudal to the axillary region in a dog and horse. The fascia layers are marked showing the differences in the superficial adipose tissue layer and the superficial fascia. The blue color indicates the presence of hyaluronan.

S01-5

DOES THE CHOICE OF LOWER BODY STRENGTH TEST MATTER WHEN CALCULATING DYUNAMIC STRENGTH INDEX?

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INTRODUCTION

The testing and evaluation of an athlete's lower body strength is a key element, for physicians and coaches alike, in guiding athletes exercise protocols (1). The dynamic strength index (DSI) has been proposed as a reliable and valid method to describe and evaluate the relation between explosive strength and maximal strength (2). However, as different methods of calculating the DSI have been used interchangeably, the aim of this study was to investigate whether DSI computed using either isometric squat (IS) or isometric mid-thigh pull (IMTP) results in a different DSI.

METHODS

Eighteen moderately active people (female; n=5, male; n=13, age of 23.6±2.3 years, height of 173.7±8.6 cm, body mass of 74.9±17.5 kg) were recruited for participation in the current study. All participants were physically active 1-4 times per week and had no injuries in the three months leading up to the study. The participants performed three maximal attempts in IS, IMTP and CMJ. After each attempt participants were given a one-minute rest to minimize fatigue development. The IS was measured by fixing an immovable barbell in a squat rack. Participants were placed under the barbell with a hip angle between 140-150° and a knee angle of 130-140° (3) and their feet on top of a force plate. Participants were instructed to push "as hard and fast as possible." IMTP was measured by having the participants grab an immovable barbell, using straps, and placing their heels on markings on the force plate. This resulted in similar angles as with the IS. The participants were given the same instructions as with the IS. The attempts in both IS and IMTP had a duration of five seconds. CMJ was measured by having the participants stand on the force plate and jump with their hands held akimbo and a knee angle of 130-140°. Participants were instructed to jump "as hard and fast as possible." CMJ was always the first test followed by either the IS or IMTP selected at random. The attempt with the highest ground reaction force was used for analysis. The two DSI were calculated as CMJ peak force divided with IS force and CMJ force divided by IMTP force, respectively. Prior to the test the participants attended a familiarization protocol to ensure the validity of the test.

RESULTS AND DISCUSSION

The DSI computed with IS resulted in a DSI of 0.8±0.14 and the DSI computed with IMTP resulted in a DSI of 0.8±0.15. The statistical analysis showed no significant difference between DSI calculated with IS and DSI calculated with IMTP.

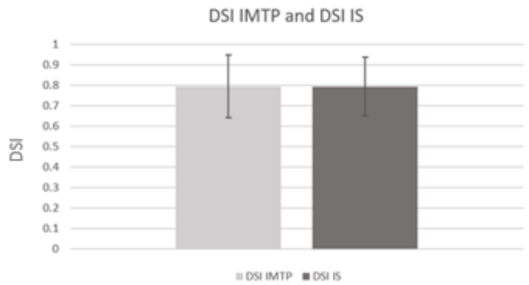

Fig. 1 *shows the mean DSI score calculated with IMTP and the mean DSI score calculated with IS*

Former studies have shown that both IS and IMTP can be used as a reliable measure of lower body strength, however previous literature has also shown that a larger peak force is usually measured in IS, suggesting that IS and IMTP cannot be used interchangeably (4). However, the current study found no significant difference in peak force between IS and IMTP, which could in part be explained by the participants experiencing some discomfort around the upper back area when performing the IS, thus resulting in a peak force lower than what they are capable of. This would suggest that the peak force measured in IS would not be a valid measure of the participants lower body strength.

CONCLUSION

In the current study the peak force measured was equal between IS and IMTP and thus resulted in a similar DSI. However, the IS may not be a suitable measurement of lower body maximal strength in a group inexperienced in resistance training due to the discomfort it may entail on the upper back area.

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THE ASSOCIATION BETWEEN DYNAMIC STRENGTH INDEX AND MEASURES OF SPRINT, CHANGE OF DIRECTION AND JUMPING ABILITY

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INTRODUCTION

Former studies have shown that sprinting speed (SS), change of direction (COD) and vertical jump performance are all valid tests for estimating performance (5). However, the association between these parameters and the dynamic strength index (DSI) has yet to be investigated. The aim of this study was to investigate if a correlation exists between either DSI, isometric squat (IS) or isometric midthigh pull (IMTP) and SS, COD or jump and reach (JaR) tests.

METHOD:

Eighteen healthy moderately physically active individuals (female; n=5, male; n=13, age = 23.6±2.3 years, height = 173.7±8.6 cm, body mass = 74.9±17.5 kg) participated in the present study. The participants were physically active 1-4 times per week and injury free. The participants were instructed to perform the counter movement jump (CMJ) "as fast and hard as possible" as they could while keeping their arms akimbo with a one-minute rest period between each attempt. The DSI IMTP and IS was conducted according to recent literature on the subject (1,2,4). The performance tests were performed with three attempts and one minute rest between attempts and two minutes between exercises. 1) In JaR a yardstick (Swift, Australia) was used. 2) The 20-meter sprint test and 3) 505 change of direction test was performed according to recent literature (5). The trial with the highest peak force of the three trials for both IMTP, IS and CMJ was used for further analysis, as it was seen as the participant's peak performance (2). To test for correlation between DSI, peak force and performance parameters, a Pearson correlation analysis was conducted with a significant level of $p \leq 0.05$.

RESULT AND DISCUSSION.

Significant correlation was found between the DSI IMTP and SS (r= 0.52; p = 0.04), as well as DSI IMTP and JaR (r = -0.55; p = 0.03) (figure 1b). Against the hypothesis of the present study, no correlations were found between any of the performance parameters and DSI IS (figure1a and b). This might be due to the high compressive forces on the spine which lead to discomfort for some of the participants (3). This might support the literature on the subject in using IMTP when calculating DSI instead of IS even though recent literature claims that a higher peak force are found in IS compared to IMTP (1,2). Significant correlations were also found between IMTP peak force (N/kg) and SS (r=-0.75; p=0.001), COD (r=-0.54; p=0.006) and JaR (r=0.65; p=0,006), respectively. Correlations were also found between IS peak force (N/kg) and SS (r-=0.66; p=0.005), COD (r=-075; p=0.001) and JaR (r=0.55; p=0.026), respectively.

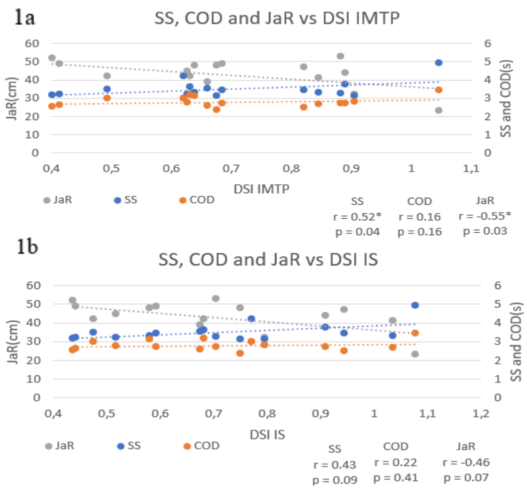

Fig. 1 1a Shows no correlation between SS and DSI measured with IS, COD and DSI IS, JaR and DSI IS. 1b: shows a correlation between SS and DSI measured with IMTP, JaR and DSI IMTP and no correlation between COD and DSI IMTP.

Since there is a strong association between absolute strength and performance in the JaR, SS and COD and since DSI is a ratio it may not be a reliable predictor of performance in the physical test. This suggests that IS PF N/kg can be a better predicter compared to DSI IS based on the findings in the present study.

CONCLUSION.

IMTP peak force and IS peak force exhibited a significant strong correlation with all the performance parameters, while DSI IMTP displayed a significant moderate correlation with SS and JaR. Peak force obtained in IMTP and IS therefore seemed to be a better predictor of the performance tests than DSI

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P01-1

Custom-made foot orthoses for rheumatoid arthritis: Looking at responders and no responders

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INTRODUCTION

Rheumatoid arthritis (RA) is a chronic inflammatory disease affecting synovial tissue in multiple joints, especially in the smaller joints of the hands and feet are affected [1]. Foot orthoses (FO) are the first-line treatment for foot pain and impairments in patients with RA. However, the pain-relieving effects of FO are still controversial. Our previous studies have shown that patients have different pain-relieving effects [2,3]. This study aimed to investigate potential biomechanical differences between patients with RA responding well to a custom-made FO with patients not responding in pain relief.

METHODS

Twenty-five participants with RA completed this quasi-experimental study using a control insole for four weeks and then a custom-made FO in the following four weeks. A visual analog scale was used to monitor changes in foot pain. 3D gait analysis was measured during walking with a control insole and a custom-made FO, respectively. Responders were participants with a foot pain intensity relief greater than 20mm on a VAS scale. No responders were participants with a foot pain intensity relief smaller than 20mm.

RESULTS

The responder group (n=8) had a pain relief of -40.1 (±13.1) mm and reduced ankle plantarflexion moment with the FO compared to the control (Fig. 1). The no-responders (n=15) had a pain relief of -4.3 (±4.3) mm and no difference in gait mechanics between the control and the FO.

CONCLUSIONS

The present study demonstrates a paradox. Although the FO was customized to each participant's foot, it did not cause similar motion control changes for all participants. Participants without altered gait mechanics did not achieve a clinically significant pain reduction.

ACKNOWLEDGEMENTS

Trygfonden (124714) and Gigtforeningen (R161-A5276) support the study.

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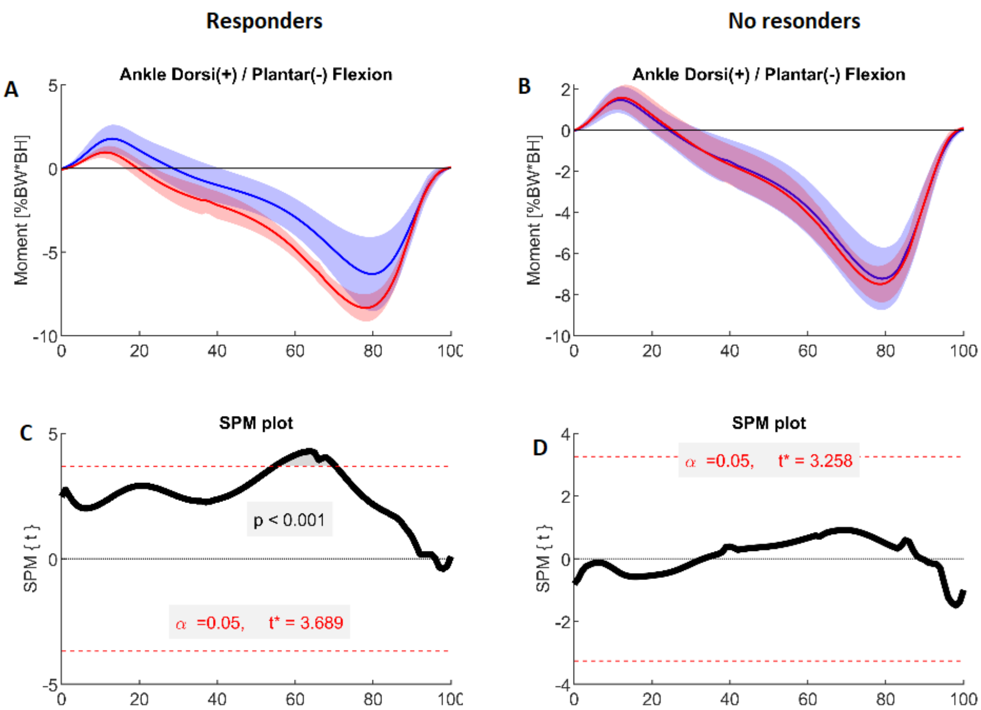

Fig. 1 A: Mean and standard deviation of the ankle moment for the responders walking with custom-made FO (red line) and responders walking with the control insole (blue line). B Mean and standard deviation of the ankle moment for the nonresponders walking with custom-made FO (red line) and responders walking with the control insole (blue line). C and D are the corresponding SPM plot to the figure above. The dotted red line is the critical threshold. If the black line crosses the critical threshold, the two variables are statistically different, during which the red dotted line is broken.

P01-2

Non-invasive measurements of the mechanical properties of muscle tissue in canine and equine athletes using the Myoton Pro device.

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INTRODUCTION

The Myoton Pro device is a validated tool that has been used successfully to measure muscle stiffness and elasticity in humans [1]. However, whether the Myoton Pro device is useful for the investigation of muscle tissue of canine and equine athletes is unclear.

METHODS

Methods: n=15 well trained equine athletes (dressage horses) and n=15 well trained canine athletes (Lour cursing whippets) were included.

Myotonometry was applied and age, gender, training status and clinical history was recorded for each athlete.

Figure 1) Myotonometry measurements on a horse.

RESULTS AND DISCUSSION

The primary result of the present study was that the Myoton Pro device could be applied successfully to both canine and equine athletes.

For equine measurements, the best results were achieved when the horse stood well balanced on all 4 legs in order to ensure measurements on relaxed muscles.

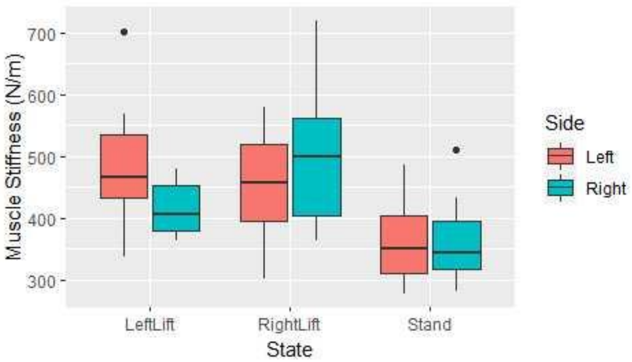

Figure 2) Myotonometry during standing and lifting

In canine athletes, the best measurements were achieved when the dog was lying on its side in a relaxed state.

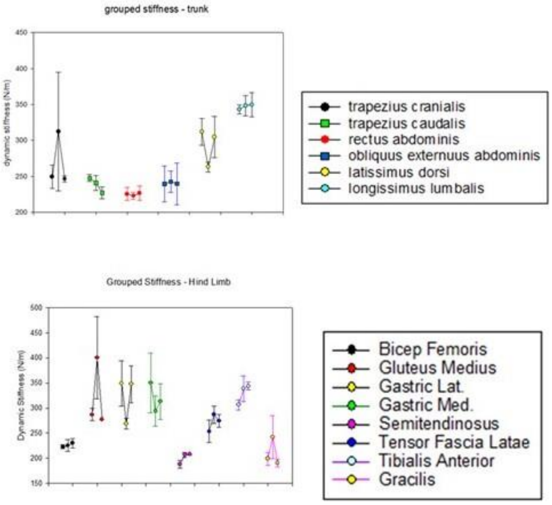

Figure 3) Muscle stiffness in young, middle aged and old canine individuals

In both Canine and Equine athletes a Myoton setting with 3 Tap repetitions gave the best results, while 5 Taps are preferable in humans

Muscle stiffness [N/m]	Mean	SEM
Trapezius	458.90	25.29
Flexor carpi ulnaris	371.10	10.04
Extensor carpi radialis	438.95	16.66
Gluteus medialis	461.05	10.82
Semitendinosus	357.29	9.64
Biceps Femoris	361.62	8.89

Muscle frequency [Hz]	Mean	SEM
Trapezius	20.63	0.59
Flexor carpi ulnaris	19.40	0.41
Extensor carpi radialis	20.98	0.45
Gluteus medialis	23.41	0.68
Semitendinosus	19.85	0.41
Biceps Femoris	19.28	0.59

Muscle decrement	Mean	SEM
Trapezius	0.94	0.03
Flexor carpi ulnaris	1.33	0.05
Extensor carpi radialis	0.87	0.03
Gluteus medialis	2.59	0.17
Semitendinosus	1.27	0.05
Biceps Femoris	1.79	0.07

Muscle relaxation [ms]	Mean	SEM
Trapezius	11.93	0.48
Flexor carpi ulnaris	14.69	0.43
Extensor carpi radialis	12.07	0.47
Gluteus medialis	12.40	0.43
Semitendinosus	14.40	0.45
Biceps Femoris	15.71	0.54

Table 1. Muscle siffness in equine athletes

CONCLUSIONS

The present study showed that the Myoton Pro device is a useful tool for the evaluation of the mechanical properties of muscle tissue in veterinary athletes when applied with care in a relaxed state. Future studies should focus on whether the Myoton Pro device can be used for injury prevention and rehabilitation monitoring in veterinary athletes.

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THE FREELY CHOSEN CADENCE IS INCREASED DURING REPEATED BOUTS OF SUBMAXIMAL CYCLING

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INTRODUCTION

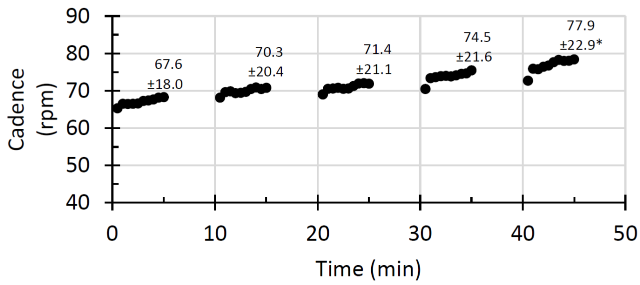
The purpose of the present study was to test whether the motor behavioural phenomenon of repeated bout rate enhancement (as previously reported for index finger tapping [1, 2]) also occurs during submaximal ergometer cycling. In the present context, repeated bout rate enhancement is defined as an increase of the freely, or spontaneously, chosen cadence applied during repeated bouts of pedalling. This is for example relevant to study since cadence, and thus the described phenomenon, can affect biomechanical and physiological responses and, thus, data collected from cycling tests.

METHODS

Recreationally active individuals (n = 27) performed five consecutive 5-min bouts of submaximal ergometer cycling at 100 W. Cycling was performed on an SRM cycle ergometer (Schoberer Rad Messtechnik, Jülich, Germany). Cadence was freely chosen during all cycling. The bouts were separated by 10-min rest periods. Cadence was noted every 30 s. Subsequently, a single value of the freely chosen cadence was calculated as a mean across the noted values during the last 3 min, for further analysis. Heart rate was recorded with a Garmin Forerunner 245 (Garmin International Inc., Olathe, KS, USA) and noted every 30 s. Subsequently, a single value of the heart rate was calculated as a mean across the noted values during the last 3 min, for further analysis. $p \leq 0.05$ was considered statistically significant.

RESULTS

The primary result was that cadence at the end of the 5. bout (78 ± 23 rpm) was statistically significantly higher than at the end of all other bouts (p-values from paired t-tests were between less than 0.001 and 0.003). This is illustrated in the figure. Overall, the cadence at the end of the 5. bout was 15.6% ± 20.4% higher than at the end of the 1. bout. The altered rhythmic motor behaviour was accompanied by a statistically significant effect of bout on heart rate (p = 0.050, determined by a repeated measures ANOVA), which amounted to 125 ± 17 and 131 ± 26 beats per min at the end of the 1. and 5. bout, respectively.



*Cadence as a function of time during the five consecutive cycling bouts. *Different from the values during the other bouts (p < 0.003).*

DISCUSSION AND CONCLUSION

It is possible that the observed alteration of cadence occurred because of a nonconscious rhythmogenesis process. Thus, a neuromodulation in form of a net excitation of relevant parts of the nervous system might explain the increased cadence [3].

The results might have implications for key data obtained during testing and research. Pedal force, and consequently generated muscle force, is reduced with increased cadence [4]. At the same time, oxygen uptake, and energy turnover, is increased with increased cadence [5]. Thus, it is suggested that the current findings are of relevance for the protocol design of cycling tests.

In conclusion, the motor behavioural phenomenon of repeated bout rate enhancement during submaximal ergometer cycling was observed in the present study. Thus, the freely chosen cadence showed an increase of on average about 15%, corresponding to 10 rpm, as accumulated values across the five consecutive bouts of ergometer cycling.

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AGE-RELATED DECLINE IN POWER OUTPUT REFLECTING AEROBIC POTENTIAL IN TRAINED CYCLISTS

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INTRODUCTION

It is generally considered that an age-related decline in aerobic capacity occurs as we get older. The decline has been estimated to be about 1% per year in adult men and women, starting from the age of about 25 years. It may, however, be influenced by the activity level of the individual [1]. The aim of the present study was, therefore, to examine the effect of aging on power output reflecting aerobic potential in trained cyclists, in a cross-sectional study.

METHODS

Sixteen male cyclists, classified as either trained or well-trained [2], were recruited and divided into two groups depending on their age. Group 1 (G1, n=8) and group 2 (G2, n=8) were characterized by a mean age of 27.9±5.9 and 53.8±5.2 years, respectively ($p<0.001$). Body mass was 75.7±10.7 and 78.9±9.6 kg in G1 and G2, respectively (NS). G1 trained 4.5±1.4 times and 10.3±4.9 h per week while G2 trained 4.6±2.5 times and 8.6±5.4 h per week at the time just before the start of the study (NS). Training background was 6.3±2.9 and 24.8±9.5 years of cycling training for G1 and G2, respectively ($p<0.001$). Anaerobic threshold (AT) power output was determined using a continuous incremental test starting at 140 W and increasing by 40 W every 5th min, until a blood lactate concentration of 4 mmol per L was reached. Subsequently, maximal watt (W_{max}) was measured in a continuous incremental test starting at 200 W and increasing by 25 W every min, until exhaustion.

RESULTS AND DISCUSSION

The primary result of the present study was that G2 showed a significantly lower W_{max} of 333±40 W as compared to 380±32 W for G1 ($p=0.019$) as well as lower AT power output of 259±34 W as compared to 300±21 W for G1 ($p=0.013$). These differences correspond to on average 12% and 14% lower values for G2, respectively. Taking the average difference of 26 years between G2 and G1 into account, the average differences in W_{max} and AT power output between the groups correspond to declines of 0.5% per year (Fig. 1).

An age-dependent decline in aerobic capacity should be expected, regardless of activity level. However, the present results indicate that the older participants in the study managed to halve the textbook-based expected age-related decline of 1% per year when considering the experimentally determined aerobic potential estimates of W_{max} and AT power output.

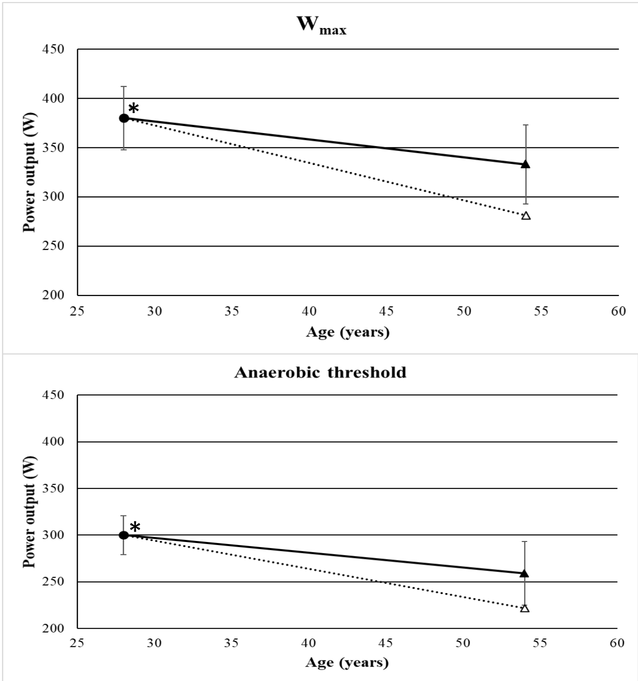

Fig. 1 W_{max} and AT power output. Circles represent G1. Triangles represent G2. Filled symbols and unbroken lines represent experimentally determined values from the present study. Open triangles and broken lines reflect textbook-based age-related estimates of 1% decline per year. *significant difference in experimentally determined values between G1 and G2.

CONCLUSIONS

In conclusion, differences in W_{max} and AT power output were observed between younger and older trained cyclists, in favor of the younger. Of note, the two groups were similar regarding performed training at the time just before the start of the study as well as regarding body mass. The age-related difference in aerobic potential indicators was on average about 13%, which corresponds to a decline of 0.5% per year lived.

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CALCULATING SAMPLE ENTROPY FROM ISOMETRIC TORQUE SIGNALS: METHODOLOGICAL CONSIDERATIONS AND RECOMMENDATIONS

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INTRODUCTION

There has been an increasing interest for the nature of isometric force or joint torque fluctuations over time during a continuous isometric contraction, as it has been theoretically linked to a deeper insight of the underlying motor control [1]. Specifically, measures like sample entropy (SaEn) for the quantification of regularity in isometric force or torque signals has been used. However, several critical methodological choices are made during the implementation of SaEn to biological signals [2]. Therefore, the purpose of the present study was to determine the appropriate use of SaEn on isometric torque signals. This was achieved by investigating 1) the effect of different sampling frequencies, 2) the effect of different input parameters, and 3) the effect of different observation times.

METHODS

Forty-six participants performed sustained isometric knee flexion at 20 % of their maximal contraction level and torque data was sampled at 1000 Hz for 180 seconds. Power spectral analysis was used to determine the appropriate sampling frequency. The time series were downsampled to 750, 500, 250, 100, 50 and 25 Hz to investigate the effect of different sampling frequency with either a fixed observation time or fixed number of data points. Relative parameter consistency was investigated using combinations of vector lengths of 2 and 3 and tolerance limits of 0.1, 0.15, 0.2, 0.25, 0.3, 0.35 and 0.4, and data lengths between 500 and 18000 data points. The effect of different observations times was evaluated using Bland-Altman plot for observations times between 5 and 90 seconds.

RESULTS AND DISCUSSION

The group mean of the highest frequency was observed to be 11.4 Hz with a maximal frequency across all participants at 21.9 Hz. Following recommendation of a sampling frequency of 4-6 times the maximal frequency, this would suggest an adequate sampling frequency of at least100 Hz. Furthermore, the SaEn increased at sampling frequencies below 100 Hz and was unaltered above 250 Hz (Fig. 1). In agreement with the power spectral analysis, this advocates for a sampling frequency between 100-250 Hz. Relative consistency was observed across the tested parameters and at least 30 seconds of observation time was required for a valid calculation of SaEn from torque data (Fig. 2).

CONCLUSIONS

Based on the present study, we can list three recommendations for future studies using SaEn to quantify regularity of low isometric force or torque signals: 1) the appropriate sampling frequency is between 100 and 250 Hz, 2) between-group and/or between-condition relative consistency of the input parameters *r*, *m*, and *N* should be tested and reported as SaEn changes with change in input parameter, and 3) the observation time should be at least 30 seconds to ensure the unfolding of the phenomenon in question.

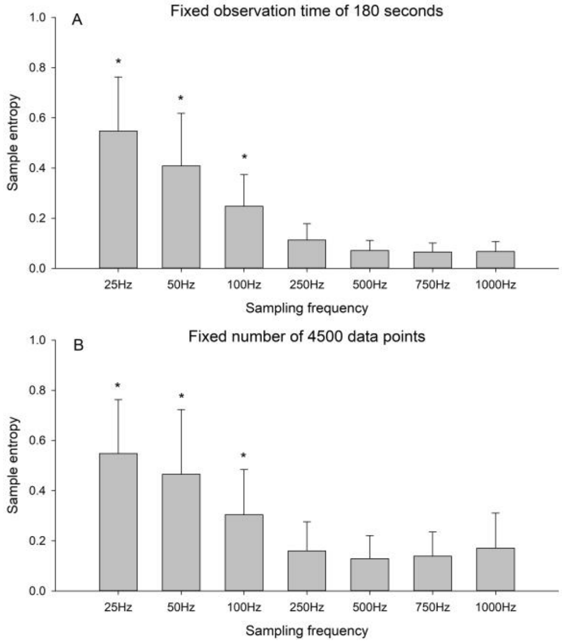

Fig. 1 SaEn at different sampling frequencies for a fixed observation time of 180 seconds (A) or a fixed number of 4500 data points (B). * indicates significant decrease in SaEn with increment in sampling frequency.

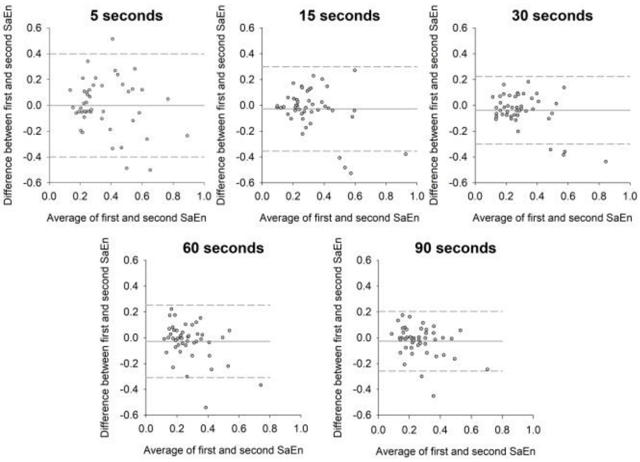

Fig. 2 Bland-Altman plot of the difference in SaEn between the first and second window of the time series against the average of the SaEn from the two time series for the five different observation times. Solid horizontal line indicates SaEn bias and dashed lines indicate upper and lower limits of agreement.

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Footwear Traction Device with Biomechanical Loading Conditions

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INTRODUCTION

Falling is one of the most frequent causes of work related and occupational accidents in the Denmark [1] with slipping being a significant cause. Slipping occurs when friction between footwear outsoles and surfaces is inadequate [2]. Therefore, optimizing friction properties between footwear and surface have great potential for reducing the numbers of fall accidents. The purpose of this study was to design and present a tribosystem with the ability to replicate biomechanically relevant testing conditions and conduct slip resistance measurement on a whole shoe.

METHODS

We designed a large-scale pin-on-disc tribometer (Figure 1A), which consisted of a "pin": a strain gauge-instrumented beam with a shoe last attached, and a "disc" 8000 mm steel plate. The steel plate was powered by a servo motor that was mounted on a steel frame below the attached plate. The tangential velocity in the contact point between the shoe and steel disc was adjustable between 0-2.5 m/s. 400 N normal force was applied with weight plates on top of the beam. Five measurements were performed with a rubber shoe (Figure 1B) for each testing conditions and averaged.

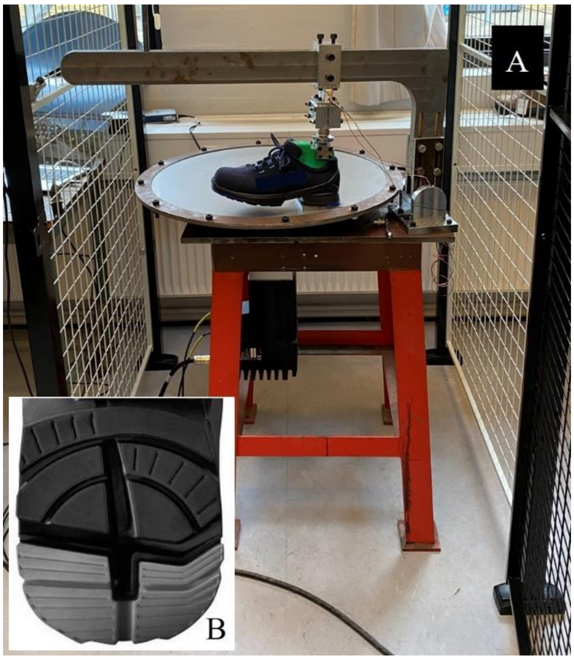

Fig. 1: (A) Picture of the large-scale pin-on-disc tribosystem for footwear ACOF measurements. (B) Picture of the shoe heel part.

The shoe was tested on the heel part with a 7° contact angle, which is in accordance to the ISO 13287 (test method for slip resistance). The different test conditions comprised of sliding velocities at 0.3, 1.0 and 2.5 m/s, and with glycerin and canola oil as contaminants. The shoe was washed with soap and water, abraded with 400 grit sand paper, wiped with isopropyl alcohol and dried at room temperature, and the steel surface was thoroughly cleaned with toluene and wiped with isopropyl alcohol, when the contaminant was changed. Available coefficient of friction ACOF (μ) was calculated between 0.3 s and 1.0 s after initial contact.

RESULTS AND DISCUSSION

The ACOF measurements for the six testing conditions are presented in Table 1.

Table 1. ACOF results

	0.3 m/s	1 m/s	2.5 m/s
Canola oil	μ = 0.147 (±0.007)	μ = 0.151 (±0.008)	μ = 0.201 (±0.019)
Glycerine	μ = 0.210 (±0.016)	μ = 0.194 (±0.014)	μ = 0.202 (±0.024)

In the present study, we observed an increased friction coefficient with increasing sliding velocity with canola oil as contaminant. Even though the contact time is only 1 s, we assume an increased rubber temperature, which may cause the observed increase in friction coefficient as function of increased sliding velocities. The ACOF results found in this study is low and the probability of slipping is high, since the slip probability on level walking is high with ACOF measurements of ~0.2 [3]. Aside from the rubber properties discussed above, the outsole patterns plays an important role for fluid drainage, which in particular is important when contaminants are present. The outsole pattern used in this study has relatively large outsole patterns and may entrap fluids causing a hydro- or boundary lubrication regime. Previous research has indicated that small outsole patterns with many ducts have good drainage abilities, which results in higher ACOF measurements in contaminated environments [4].

CONCLUSIONS

The results from this large scale tribometer demonstrate that sliding velocity affects the ACOF between footwear and surface by up to 25% between 0.3 and 2.5 m/s under contaminated testing conditions. This supports the notion that sliding speed is not irrelevant and, that footwear slip resistance measurements should be performed under biomechanically reasonable testing conditions.

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P01-7

UNIVERSITY OF COPENHAGEN
FACULTY OF HEALTH & MEDICAL SCIENCES

BIOMECHANICS RESEARCH GROUP
(PUBLISHED IN JEVS: 68: 73-80, 2018)

The efficacy of intermittent long-term bell boot application for the correction of muscle asymmetry in equine subjects

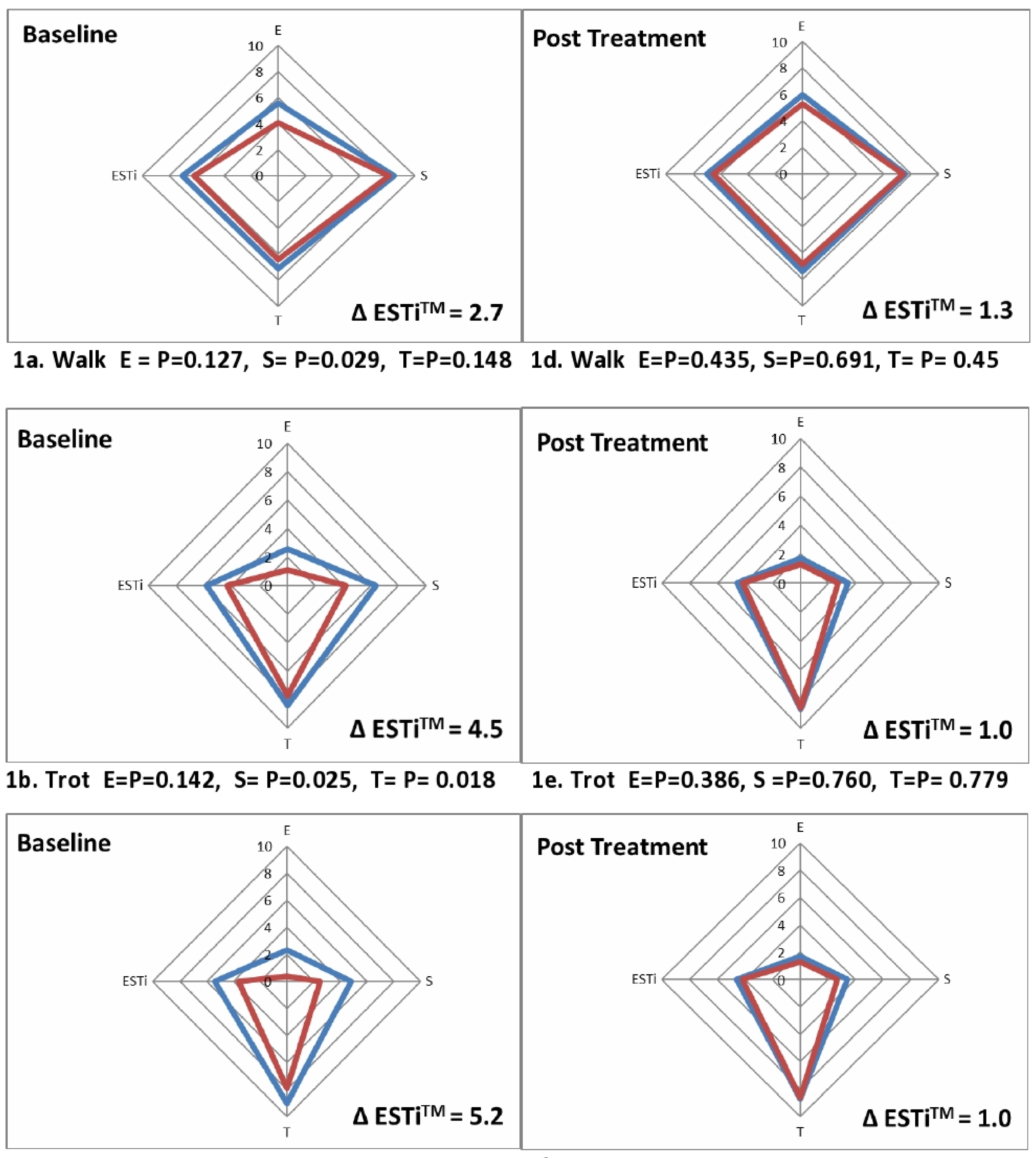
Anne-Mette Jensen,Waqas Ahmed, Vibeke S. Elbrønd & Adrian P. Harrison

Introduction

It has been proposed that manipulating proprioceptive signals of the equine distal limb as part of a rehabilitation process in cases of musculoskeletal pain or neurologic deficits can be used to correct postural control and restore normal motor programs.
This trial has examined the effect of treatment with a light-weight and loose-fitting bell boot (82 g) on an imbalance of muscle gluteus superficialis function in horses as measured using acoustic myography (AMG).
Hypothesis: This study has tested the following hypotheses: (1) functional asymmetry in m. gluteus superficialis of exercised horses can be measured using AMG and (2) the use of a light-weight and loose bell boot over a period of weeks can rectify an imbalance in the hind limbs, as assessed by m. gluteus superficialis function measured using AMG.

Materials & Methods

Eight horses were trained over a 60-minute period every 3 days for 6 weeks, a protocol based on preliminary findings.
Acoustic myography measurements, recording the coordination, spatial and temporal summation of muscle contractions, were made at the start (baseline) and at the finish (week 6) after a warmup period and following a set procedure of physical activity.



1a. Walk E = P=0.127, S= P=0.029, T=P=0.148 1d. Walk E=P=0.435, S=P=0.691, T= P= 0.45

1b. Trot E=P=0.142, S= P=0.025, T= P= 0.018 1e. Trot E=P=0.386, S =P=0.760, T=P= 0.779

1c. Canter E=P=0.023, S=P=0.004, T=P=0.032 1f. Canter E=P=0.514, S=P=0.425, T=P=0.921

Radar plots for the E-, S-, and T-scores as well as the combined ESTi score for *m. gluteus superficialis* measured during walking (A and D), trotting (B and E), and cantering (C and F) on a left-hand circle. Values are the mean of n = 8 horses. Note that the blue radar plot is for the left-hand side and the red radar plot is for the

Acknowledgement
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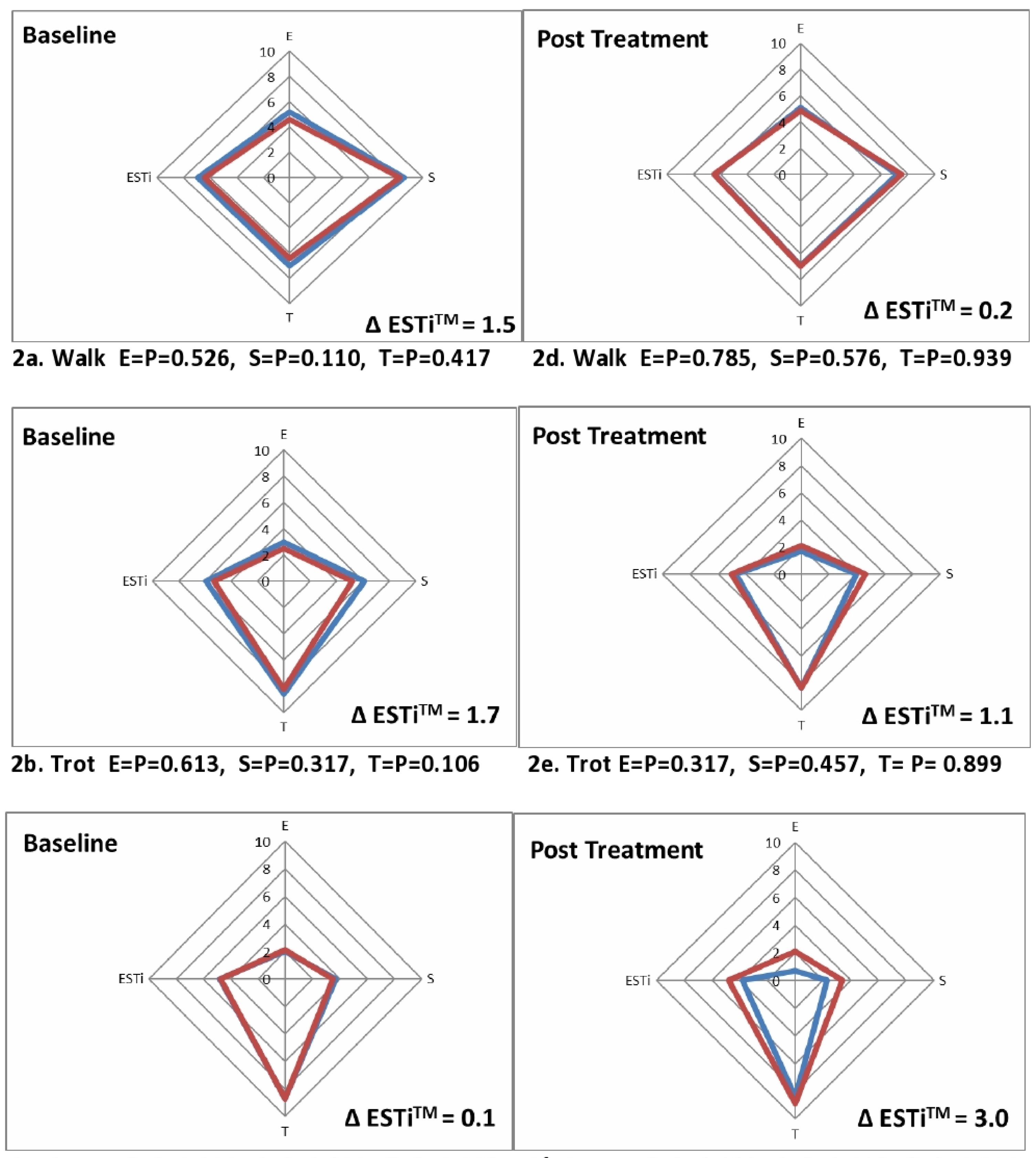
Results

Walking, trotting, and cantering during a left-hand circle at the start of the trial revealed a slight but significant asymmetry between the left and right hind limb muscle, which improved suc- cessfully after 6 weeks of proprioception training.

Data for the right-hand circle, which revealed no significant asymmetry, during walk, trot, and canter at the start, showed no change after 6 weeks of training at the walk and trot but developed an imbalance during cantering, the result of over- compensation.



2a. Walk E=P=0.526, S=P=0.110, T=P=0.417 2d. Walk E=P=0.785, S=P=0.576, T=P=0.939

2b. Trot E=P=0.613, S=P=0.317, T=P=0.106 2e. Trot E=P=0.317, S=P=0.457, T= P= 0.899

2c. Canter E=P=0.899, S=P=0.833, T=P=0.895 2f. Canter E=P=0.002, S=P=0.005, T=P=0.010

Radar plots for the E-, S-, and T- scores as well as the combined ESTi score for *m. gluteus superficialis* measured during walking (A and D), trotting (B and E), and cantering (C and F) on a right-hand circle. Values are the mean of n = 8 horses. Note that the blue radar plot is for the left-hand side and the red radar plot is for

Discussion & Conclusion

This study demonstrates that functional musculoskeletal asymmetry measured during periods of activity can not only be accurately detected using AMG but it also reveals an association between the program of proprioceptive training adopted and an improvement in muscular imbalance.
It is concluded that a slight musculoskeletal imbalance during periods of activity (walk, trot, canter), which is believed through altered stress to induce tissue strain and over time subsequent injury leading to lameness [2], can not only be accurately detected using AMG but can also be corrected through a program of pro- prioceptive training. The regimen of 60 minutes use a single light- weight bell boot every 3 days for a period of 6 weeks applied to the weakest limb, that is to say the one that is least engaged has a significant and positive effect on equine hind limb imbalance. Whether this corrective change induced through proprioceptive activation can be maintained permanently now remains to be established.

UNIVERSITY OF COPENHAGEN

FACULTY/DEPT. NAME

THE EFFECTS OF THREE STRENGTH TRAINING METHODS ON THE LOWER EXTREMITY BIOMECHANICS AND PERFORMANCE OF SPRINTERS DURING START ACCELERATION

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INTRODUCTION

Lower extremity explosive strength is a major factor in determining sprint performance. Traditional weight training can improve the lower extremity explosive strength, and eccentric weight training significantly increases the eccentric peak torque of muscles compared with concentric training. Combination of plyometric and weight training is termed as complex training, which stimulates the post-activation potentiation of performance, a phenomenon [1], that stimulates motor unit recruitment thus increasing the force producing potential of the utilized musculature within a given movement [2]. The purpose of this study was to compare the effects of 3 different training protocols (plyometric training with load, weight training, and complex training on selected biomechanical parameters of start acceleration performance.

METHODS

36 male sprinters (20.2±0.8yr, 1.72±0.05m, 61.8±9.3kg, 100-m times<11.74s) were randomly assigned to 1 of 3 groups: plyometric training with load (PT, n=12), weight training (WT, n=12), and complex training (CT, n=12).

Full-body kinematics of 36 sprinters were captured using an 8-camera motion capture system (Qualisys AB, 200 Hz) and force plates (Kistler, 1000 Hz). Subjects were instructed to perform a full-effort crouch start with a starting block and the first step was required to be on the force plate. The 30-m sprint performance was recorded. Data collections were measured before and after 8 weeks of training. Raw marker trajectories and force data were filtered with a cut-off frequency of 13.3Hz and 50Hz, respectively, and used to calculate lower extremity joint stiffness characteristics and peak vertical ground reaction forces (vGRF). Selected variables of at least 3 valid trials were averaged for each group.

For the PT group, subjects performed loaded counter movement jumps (4 sets, 8 reps, load 30% of 1RM), twice a week in all 8 weeks of training. For the WT group, subjects underwent 8 weeks of lower limb eccentric strength training, twice a week, using compensation eccentric strength training system (CC03). Eccentric squat was used and the load intensity of the subject was 120% of 1RM of half squat (5 sets, 6 reps). For the CT group, subjects performed half squat with load (5 sets, 6 reps, load 80% of 1RM) and continuous hurdle jump (4sets, 10reps, 0.76m/0.84m height). The rest period was 1.5-2 minutes between sets. Each subject filled out the s-RPE scale after each training class to assist in balancing the three groups of training loads.

Differences in all variables across time between groups were calculated using a 2-way (3×2, 3 treatments by 2 times of measurement) repeated-measures ANOVA ($\alpha = .05$). Post-hoc analysis was performed using Bonferroni-corrected alpha levels.

RESULTS AND DISCUSSION

The 30-m performance is significantly($p<0.05$) improved after training in all groups. The CT group exhibited significantly ($p<0.05$) better performance than the PT and WT groups in 30m performance and peak vGRF. For joint stiffness, the CPW group presented significantly ($p<0.05$) higher improvement compared with the PT and WT groups in ankle stiffness (**Table 1**).

CONCLUSIONS

The results suggest that the complex training is more conducive to improving the start acceleration performance of sprinters and ankle stability than plyometric training and weight training.

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Table 1 Means±SD between pre-training and post-training for all dependent variables for the 3 groups.

Group		0-30m (s)	Peak-vGRF (N)	Hip Stiffness ($N\cdot m\cdot kg^{-1}/°$)	Knee Stiffness ($N\cdot m\cdot kg^{-1}/°$)	Ankle Stiffness ($N\cdot m\cdot kg^{-1}/°$)
PT(n=12)	Pre	4.52±0.52	1320.85±160.66	0.087±0.015	0.053±0.016	0.068±0.010
	Post	4.26±0.48*	1300.88±168.21	0.088±0.011	0.050±0.008	0.061±0.008*
WT(n=12)	Pre	4.52±0.41	1355.15±326.49	0.102±0.015	0.059±0.021	0.064±0.011
	Post	4.32±0.31*	1310.65±293.68	0.095±0.010	0.063±0.014	0.052±0.005*
CT(n=12)	Pre	4.52±0.47	1291.36±139.92	0.083±0.018	0.050±0.011	0.057±0.007
	Post	4.19±0.32*	1385.80±143.46*^+	0.096±0.017*	0.053±0.007	0.064±0.008*^+

* $p<0.05$ vs. pretraining; ^ $p<0.05$ vs. PT group; + $p<0.05$ vs. WT group

P01-9

EFFECTS OF LEG FATIGUE ON PELVIS AND TRUNK KINEMATICS DURING STAIR ASCENT

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INTRODUCTION

Maintaining postural control and balance while climbing stairs is crucial to avoid falls, and these factors can be negatively influenced by lower extremity fatigue [1]. Postural control is largely influenced by the movement patterns of the pelvis and the trunk and therefore they play an important role in maintaining dynamic gait stability [2]. However, few studies have evaluated how the stability of the pelvis and the trunk is affected by fatigue. The aim of the current study was to analyze the effect of fatigue on pelvis and trunk tilt in a sample of healthy young males performing the stair ascent test.

METHODS

Twenty healthy young male adults (25.1±1.2yr, 1.75±0.04m, 71.2±7.0kg, right foot dominance) participated in the study to perform a staircase ascent tests before and after fatigue exercises. A 5-step cast iron simulating staircase (tread 17cm, riser 29cm) was used for the experiment. An 8-camera motion capture system (Qualisys AB, 200Hz) recorded full-body kinematics.

The subjects were instructed to begin walking from a standing position and entered the staircase with the same foot (right foot on the first step) and ascended in a step-over-step manner at a self-selected comfortable speed to the end of the top level. Each subject was given a few minutes to practice staircase ascent.

In the no fatigue session, stair ascent data collection was conducted right after practice. In the lower-limb muscular fatigue session, subjects performed a repeated squatting protocol at a frequency of 50 BPM while carrying 1/3 of their body weight. Fatigue was considered induced when (1) the subjects fell 4 squat cycles behind the set frequency or failed to complete 2 successive squat cycles, or (2) the heartrate went up to 85% maximum heart rate, and then stair descend data collection was started immediately. Each subject underwent 3 trails in each session.

Raw marker trajectories were low pass filtered with a cut-off frequency of 13.3Hz and used to calculate pelvis and trunk angles which referred to the orientation of the segment relative to the laboratory coordinate system. The angles in the sagittal plane during the stance phase were analyzed. The selected stance phase which was defined as that starting from the right foot on the third step and ending at the right foot off the third step.

Paired sample t-tests were conducted for each variable to determine the statistical significance of the differences between pre- and post-fatigue. Significance was set at $P \leqslant 0.05$.

RESULTS AND DISCUSSION

Pelvis and trunk angles at the selected events during stair ascent became significantly different between the pre- and post-fatigue. Larger pelvis anterior tilt and larger trunk anterior tilt were observed in the post-fatigue condition versus pre-fatigue condition (**Table 1**, **Figure 1**). However, fatigue did not affect the ROM of pelvis and trunk tilt.

Table 1 Means±SD of pelvis and trunk tilt angle.

		Pre-fatigue	Post-fatigue
Pelvis	RL	-9.01±7.82	-9.65±7.36
tilt angle	LT	-11.09±6.12	-12±5.71*
(°)	LL	-11.77±6.29	-12.56±6.22*
	RT	-12.57±5.21	-14±5.25*
	ROM	4.99±2.99	5.59±2.87
Trunk	RL	-17.18±5.49	-19.23±5.86*
tilt angle	LT	-16.99±5.07	-19.21±5.67*
(°)	LL	-17.65±5.23	-19.35±5.25*
	RT	-16.42±5.22	-18.11±5.53*
	ROM	2.94±0.97	3.22±1.21

* $p<0.05$ vs. pre-fatigue. RL = right-foot-landing; LT = left-foot-take-off; LL: left-foot-landing; RT = right-foot-take-off. ROM = range of motion. Positive signs indicate pelvis and trunk posterior tilt and negative signs indicate pelvis and trunk anterior tilt.

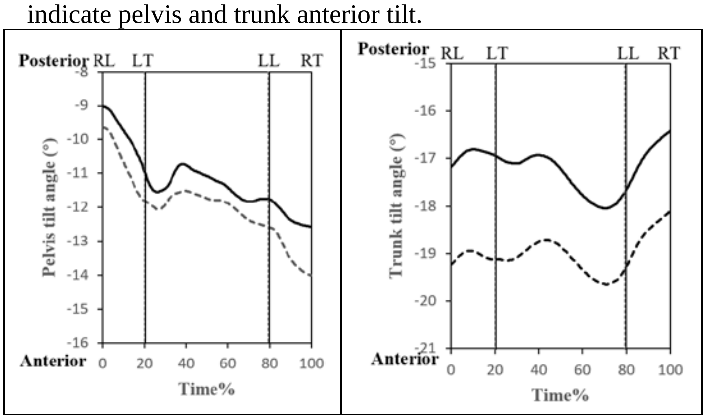

Figure 1 Variation of mean sagittal angle during stance phase of right leg under pre- (solid line) and post-fatigue (dashed line) conditions.

CONCLUSIONS

Lower extremity fatigue changes trunk and pelvis kinematics significantly during stair ascent. Higher pelvis and trunk anterior tilt due to fatigue could increase the risk of falling.

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P01-10

Equine myodural bridges An Anatomical and integrative and functional description of myodural bridges along the spine of horses: Special focus on the atlanto-occipital and atlanto-axial regions

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INTRODUCTION

Introduction: So called myodural bridges (MDB) linking the suboccipital muscles to the dura mater have been described in the human, canine, small ruminants, monkeys, rodents, porpoises, crocodiles, sperm whales, chickens and lately in equines. They are believed to have biomechanical functions and might also play a role in head/neck pathology and the pumping function of the cerebrospinal fluid. Up to now these bridges have only been described briefly in the horse in terms of their anatomy, and then only in relation to Ehlers-Danlos syndrome. The aim of this study was therefore to investigate and thoroughly describe the anatomy, biomechanics and integration of this complex throughout the equine spine, with special focus on the upper neck, the cervicothoracic- and the lumbosacral transitions. Pathology in these regions is well recognized in horses.

METHODS

For this study a total of twenty horses of different breeds, sex and age were used. The horses were euthanized for other reasons than this study by stunning and bleeding.
Dissections of the AO and AA myodural bridges in a total of fifteen horses were initiated by skinning the upper neck and head regions. The dorsal superficial muscles (m. splenius, m. semispinalis, mm. longissimus cervicis, atlantis and capitis) of the neck were removed and the suboccipital muscles in the AO and AA regions (m. obliquus capitis caudalis (OCCa) and cranialis (OCCr) and m. rectus capitis dorsalis major (RDMa)) were approached and exposed from a dorsal direction (fig.1).

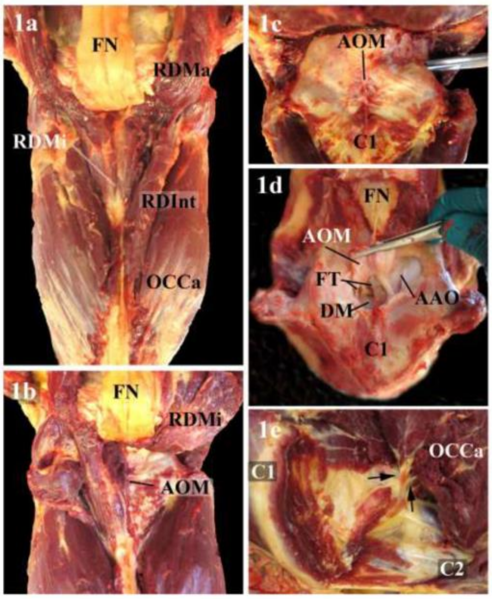

Fig 1. Dissection of the suboccipital region of the horse.

RESULTS AND DISCUSSION

Gross anatomical observations showed that muscle-membrane-spinal dura mater connections (MDB) were evident in the full equine columna vertebralis, and were specifically developed in the upper cervical, the cervicothoracic and the lumbosacral transitions. In the upper cervical region, the m. rectus capitis minor and major and the m. obl. cap caudalis attached tightly to the dorsal intervertebral AO and AA membranes. On the ventral membrane surface there were trabecular connections to dura mater. The two membranes differed markedly in the amount of elastic fibers giving them different biomechanical function. The structures of the AO MDB were evident on the MRI scans.

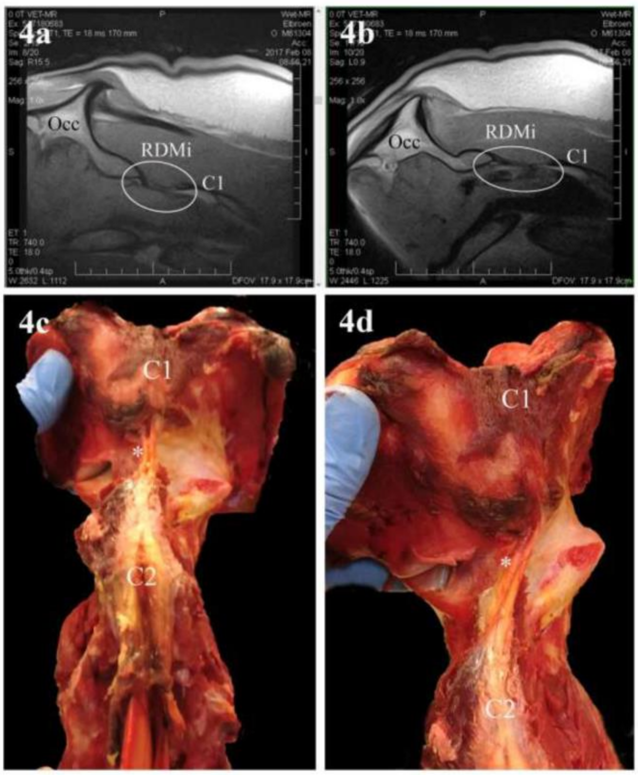

Fig 2. MRI scans of the MDB (white elipse) of the AO-region in an extended(a) and flexed (b) head posture

CONCLUSIONS

Horses, like humans, other mammals, a reptile and a bird to date, have myodural bridges, which are tightly integrated with surrounding structures as well as the biomechanics of the upper neck. In addition, similar structures are present throughout the whole spine.