The webcast will begin shortly…

Effect of mental demand on leg loading in highly dynamic motion

September 29th, 2020

Outline

- General introduction to the AnyBody Modeling System
- Presentation by Simon Auer
  - *Effect of mental demand on leg loading in highly dynamic motion*
  - Question and answer session

Presenter:
Simon Auer
PhD student and research assistant at the Laboratory for Biomechanics at the OTH Regensburg.

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG

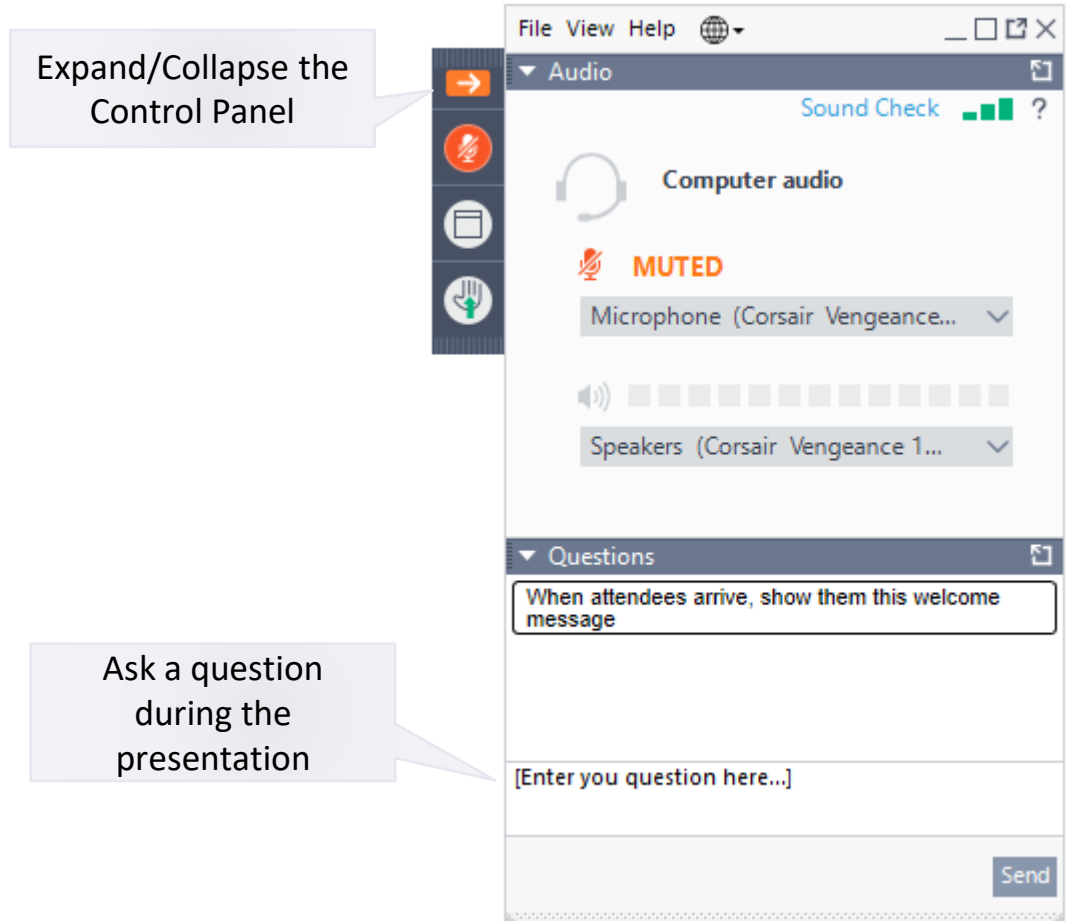
Host:
Kristoffer Iversen
R&D Engineer
AnyBody Technology

Control Panel

The Control Panel appears on the right side of your screen.

Submit questions and comments via the Questions panel.

Questions will be addressed at the end of the presentation. If your question is not addressed, we will do so by email.



Musculoskeletal Simulation

Motion Data

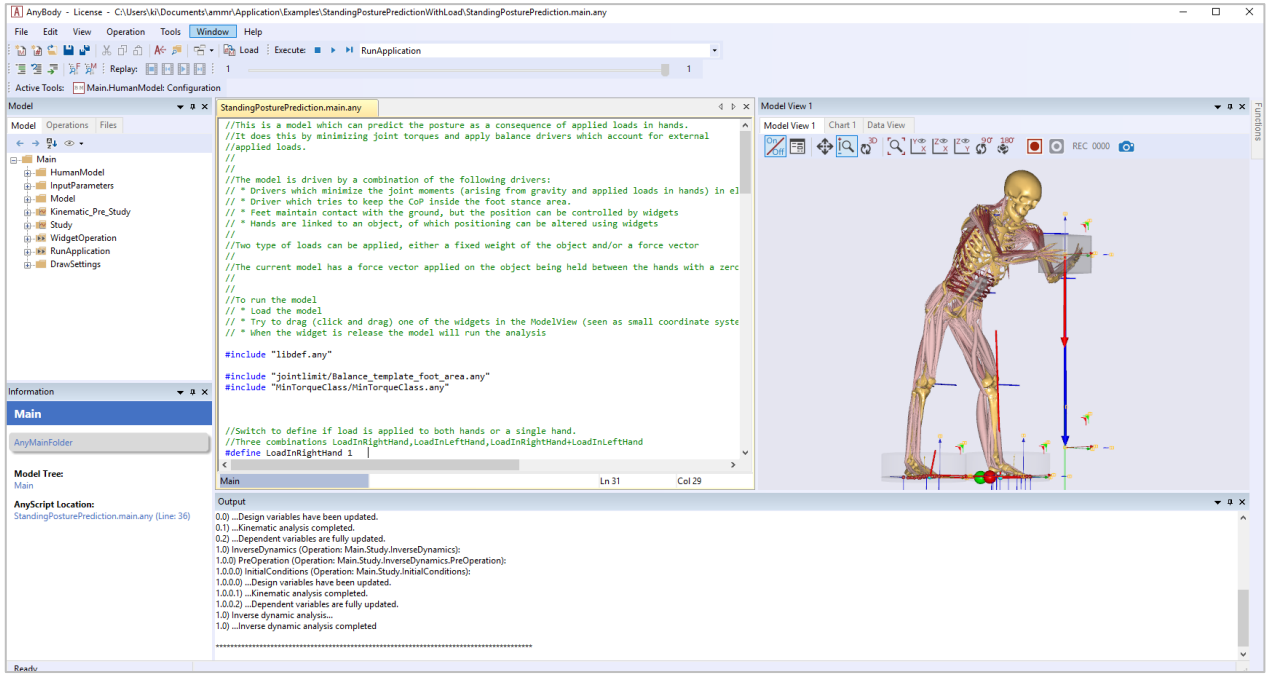
Kinematics and Forces

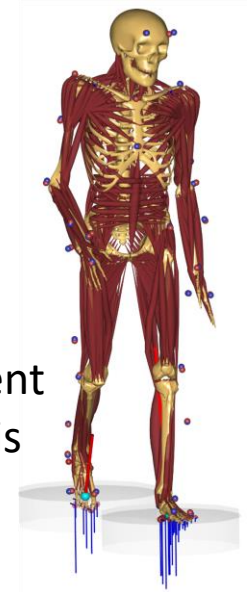
ANYBODY

Modeling System

Body Loads

- Joint moments
- Muscle forces
- Joint reaction forces

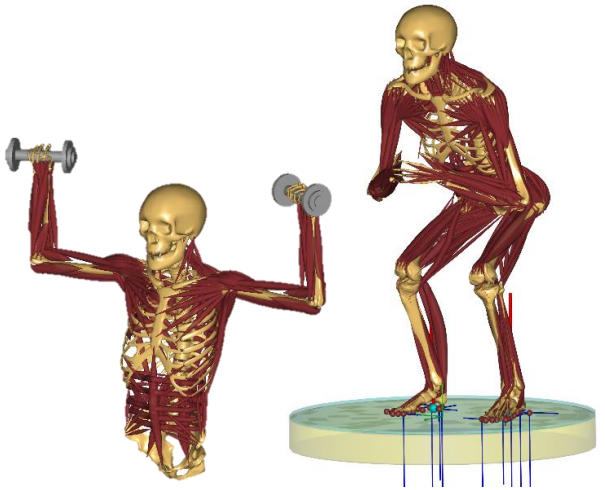




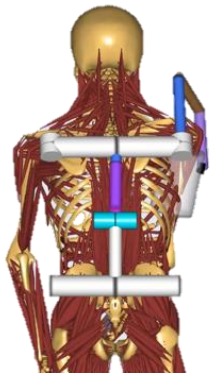
Movement Analysis

Product optimization design

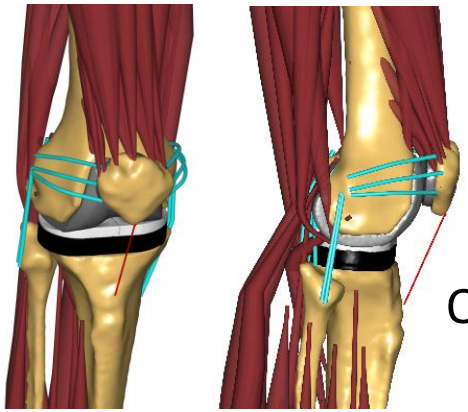
ANYBODY Modeling System



Sports

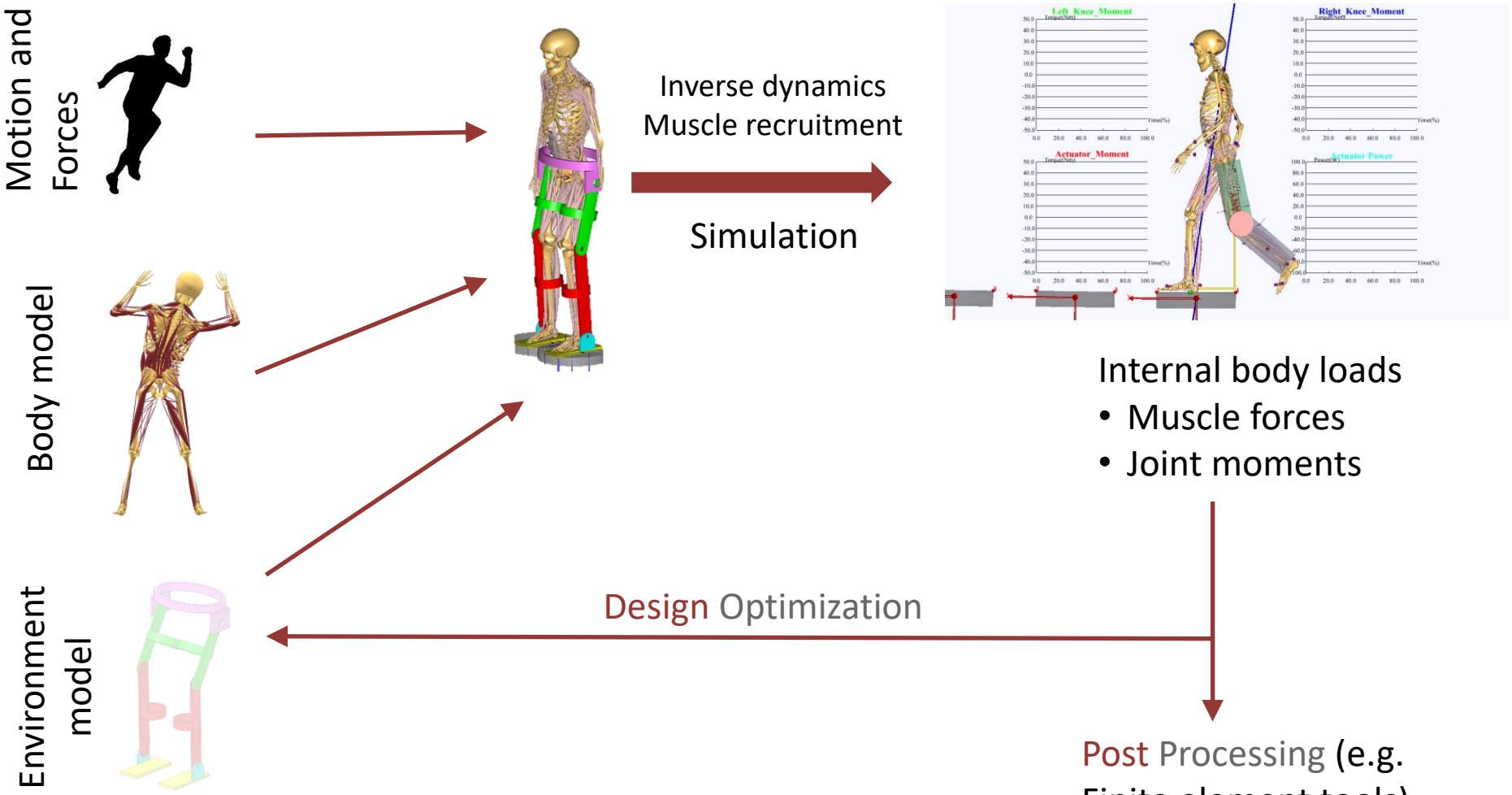


Assistive Devices



Orthopedics and rehab

AnyBody Modelling System



38th International Society of Biomechanics in Sport Conference, Physical conference cancelled, Online Activities: July 20-24, 2020

EFFECT OF MENTAL DEMAND ON KNEE FORCES IN PROFESSIONAL YOUTH SOCCER PLAYERS

Simon Auer[1], Simone Kubowitsch[1], Werner Krutsch[2], Tobias Renkawitz[3], Franz Süß[1], Sebastian Dendorfer[1,4]

Laboratory for Biomechanics, Ostbayerische Technische Hochschule (OTH) Regensburg, Germany[1]
Department of Trauma Surgery, University Medical Centre Regensburg, Germany[2]
University Medical Centre Regensburg, Asklepios Klinikum Bad Abbach, Germany[3]
Regensburg Center for Biomedical Engineering, OTH and University Regensburg, Germany[4]

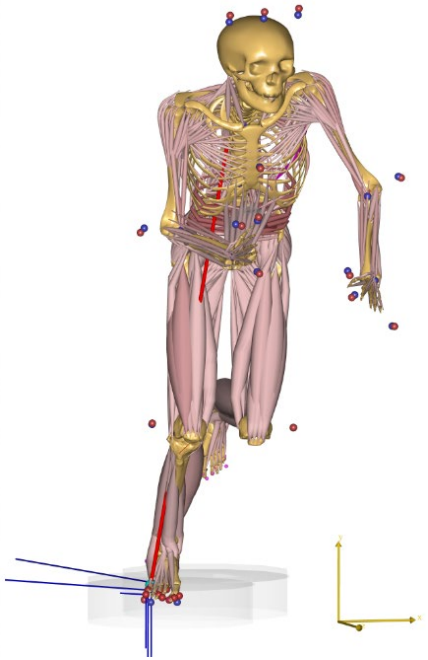
Soccer is one of the most popular sports all around the world. It is an injurious type of sport with a focus on lower extremities and high psychological pressure during matches. The stressor is linked with injuries and an increased musculoskeletal loading. This study investigates the influence of cognitive stress on the load profile of the knee joint. Twelve professional youth soccer players performed highly dynamic runs with and without additional cognitive stress. The runs were analysed with a musculoskeletal simulation software. The data analysis shows no difference in knee joint reaction loading under additional mental stress compared to the baseline. Yet running times are significantly lower in the baseline. While there is no increase in the joint loads, the running times indicate an altered movement behaviour when the subjects are exposed to additional mental demand.

KEYWORDS: psychological stress, injury prevention, musculoskeletal simulation

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG
LABORATORY FOR BIOMECHANICS

Effect of mental demand on leg loading in highly dynamic motion



Simon Auer[1], Lukas Reinker[1], Franz Süß[1], Simone Kubowitsch[1], Werner Krutsch[2], Markus Weber[3], Tobias Renkawitz[4], Sebastian Dendorfer[1]

1. Laboratory for Biomechanics, Ostbayerische Technische Hochschule Regensburg
2. Department of Trauma Surgery, University Medical Centre Regensburg, Germany
3. Department of Orthopaedics, University Medical Centre Regensburg, Asklepios Klinikum Bad Abbach
4. Department of Orthopaedics and Trauma Surgery, Heidelberg University Hospital

Cooperation

OSTBAYERISCHE TECHNISCHE HOCHSCHULE REGENSBURG
LABORATORY FOR BIOMECHANICS

Universitätsklinikum Regensburg

HEIDELBERG UNIVERSITY HOSPITAL

ASKLEPIOS Klinikum Bad Abbach

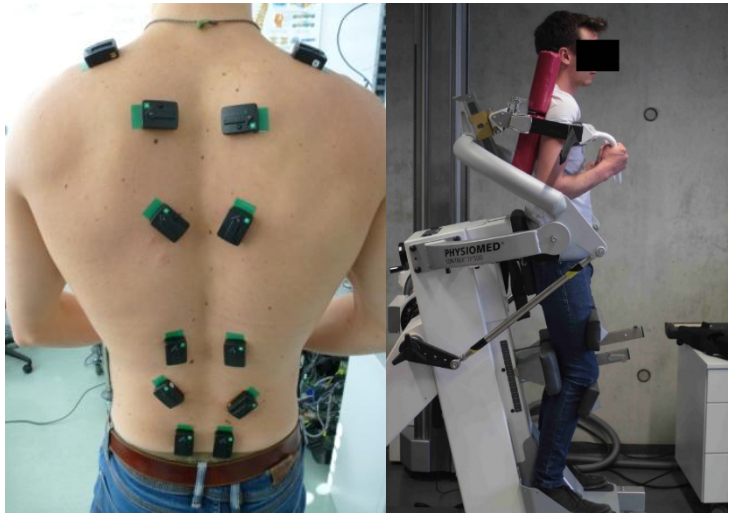
FIFA MEDICAL CENTRE OF EXCELLENCE
Football Medicine Centre Regensburg

Introduction

What do we mean with (psychological) stress?

Mental stress in occupational research[1-3]:

- Stressors:
  - Arithmetical tasks
  - Short-term memory tasks
  - negative/discouraging language

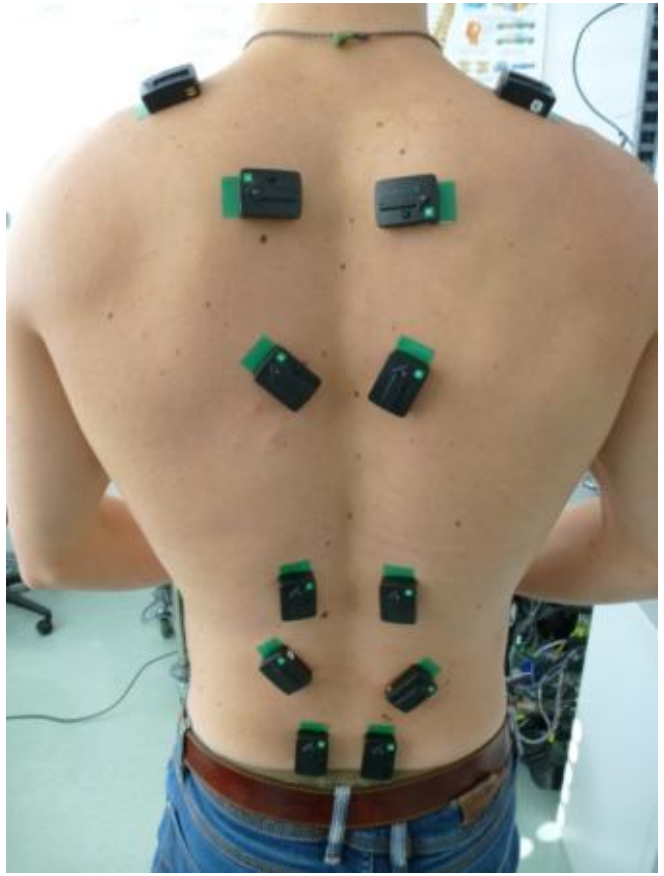


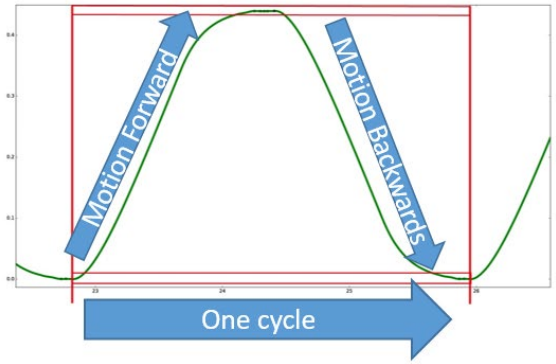
- Findings:
  - Increased muscle activity
  - Increased compression and shear forces in the spine
  - No information on muscle or joint reaction forces

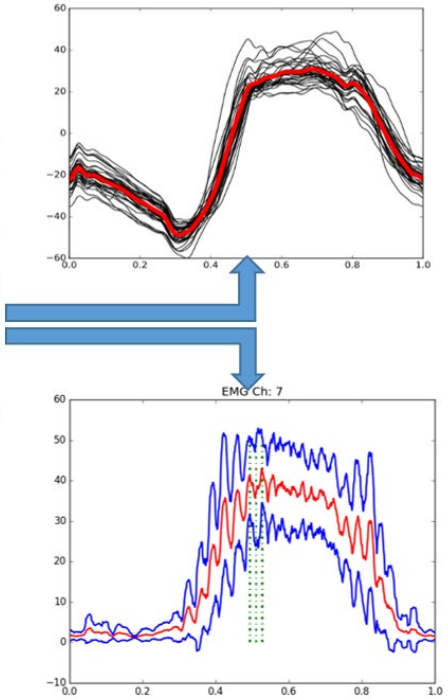
1. Nimbarte et al. (2012) Influence of psychosocial stress and personality type on the biomechanical loading of neck and shoulder muscles. Int J Ind Ergon 42(5):397–405.
2. Wijsman et al. (2013) Trapezius muscle EMG as predictor of mental stress. ACM Trans. Embed. Comput. Syst. 12(4):1–20.
3. Srinivasan et al. (2016) Effects of concurrent physical and cognitive demands on muscle activity and heart rate variability in a repetitive upper-extremity precision task. Eur J Appl Physiol 116(1):227–239.

Introduction

Previous study on the effects of mental stress in our lab.





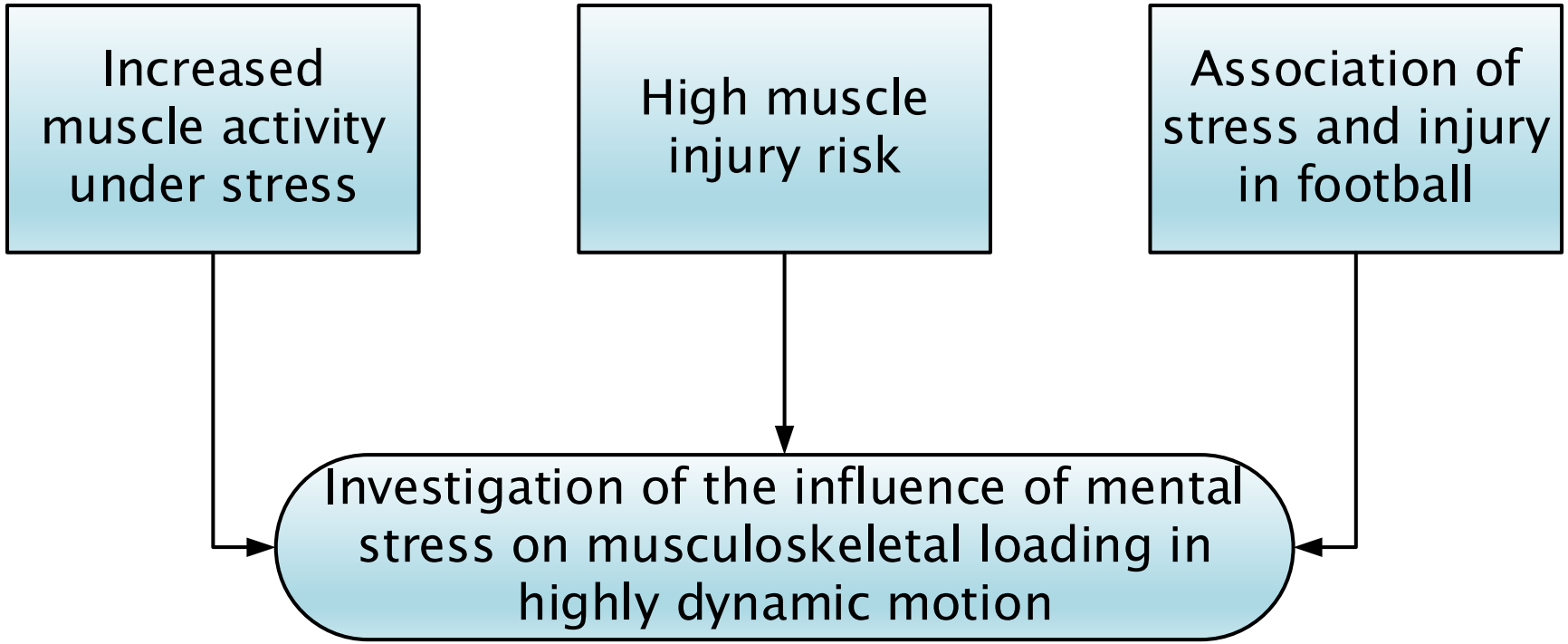


Introduction

- Muscle injury is a big problem in football[4]
- Psychological stress associated with injuries[5]
- Stress often occurs in elite junior football[6]

4. Ekstrand et al. (2011) Injury incidence and injury patterns in professional football: the UEFA injury study. Br J Sports Med 45(7):553–558.
5. Ivarsson et al. (2017) Psychosocial Factors and Sport Injuries: Meta-analyses for Prediction and Prevention. Sports Med 47(2):353–365.
6. Mendez-Villanueva et al. (2013) Match play intensity distribution in youth soccer. Int J Sports Med 34(2):101–110.

Introduction



Methodology

Study 1: SpeedCourt

- 12 male youth football players from a German 2nd Bundesliga U17 team
- Change of direction manoeuvres[7]
- Two runs in a SpeedCourt
- Mental stressor and baseline
- Optical motion capture

Study 2: Sprints

- 5 male amateur football players
- 2x 50 m sprint
- Mental stressor and baseline
- Inertial motion capture

7. Achenbach et al. (2019) Contact times of change-of-direction manoeuvres are influenced by age and the type of sports: a novel protocol using the SpeedCourt system. Knee Surg Sports Traumatol Arthrosc 27:991–999.

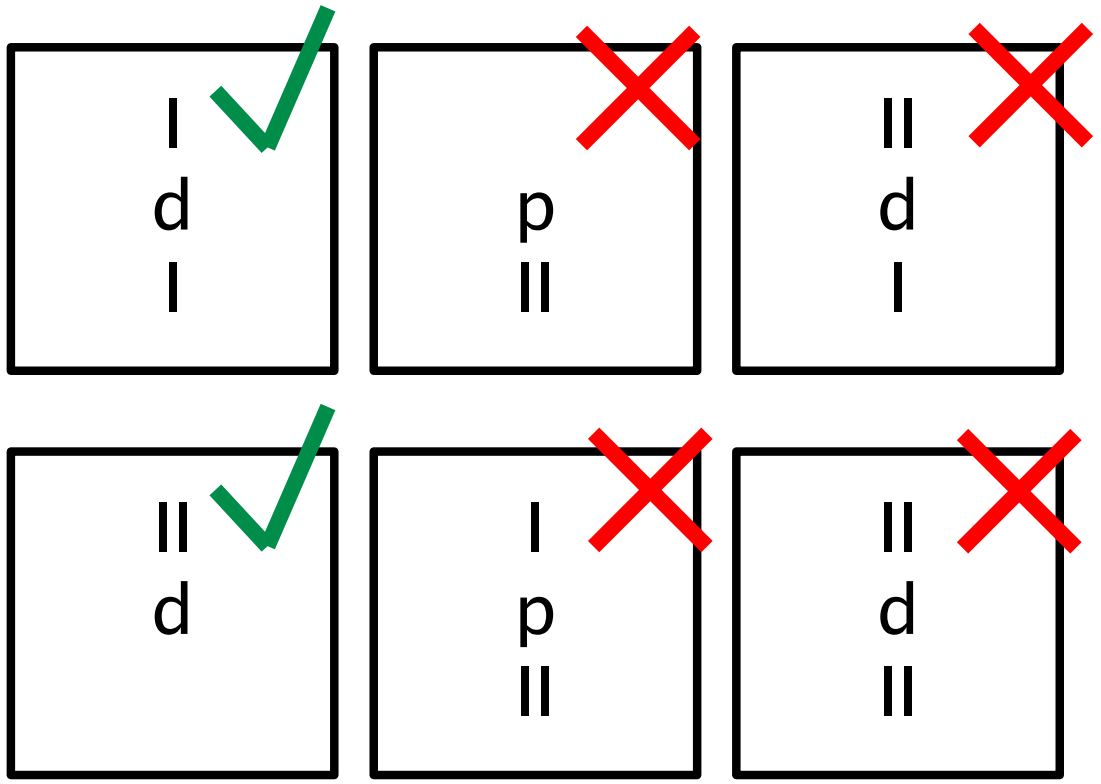
Methodology

Stressor:

- Modified d2 attention test[8]
- Displayed in a sequence on a screen

Stressor evaluation:

- NASA-TLX[9]
- Rating of physical demand, mental demand, performance, effort and frustration



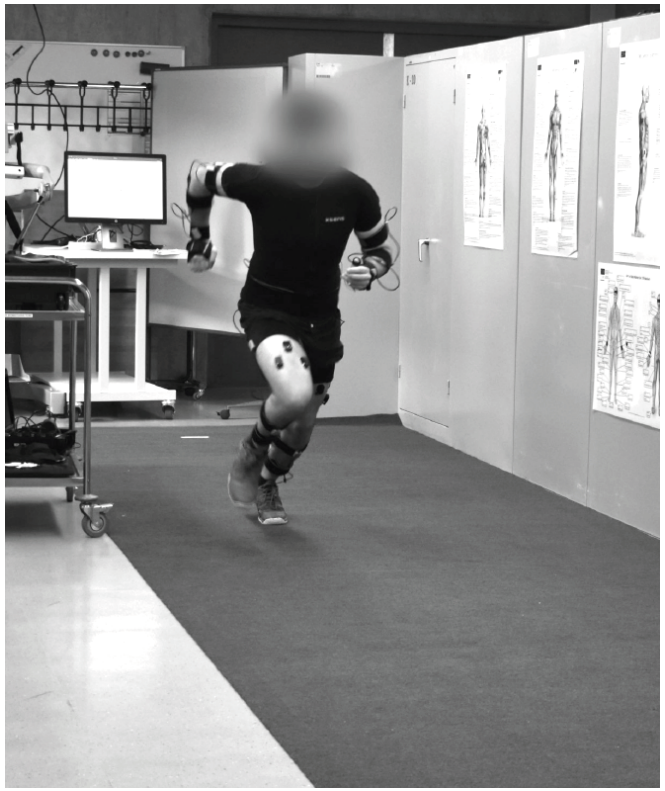
8. Brickenkamp et al. (2016) d2-R. d2 Test of Attention - Revised, 1. Aufl. Hogrefe Ltd, Oxford
9. Hart and Staveland (1988) Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In: Human Mental Workload, Band 52. Elsevier, S 139–183

Methodology (Study 1, SpeedCourt)

Investigated parameters:

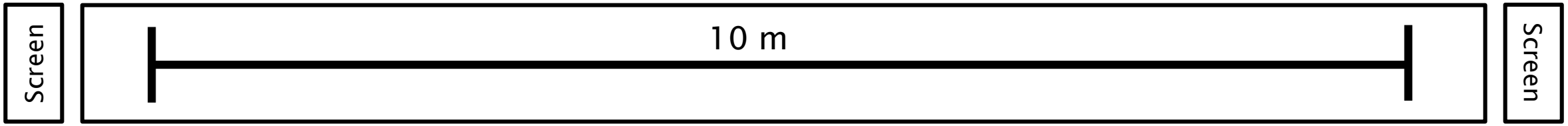
- Kinematics: running time
- Contact phases of outer fields (±0.6 s)
- Muscle forces of
  - M. rectus femoris
  - M. vastus medialis
  - M. biceps femoris
  - M. semitendinosus

Methodology (Study 2, Sprinting)



Investigated parameters:

- Kinematics:
  - running time
  - step length
- Electromyography of
  - M. rectus femoris
  - M. vastus medialis
  - M. vastus lateralis
  - M. biceps femoris
  - M. semitendinosus



Methodology

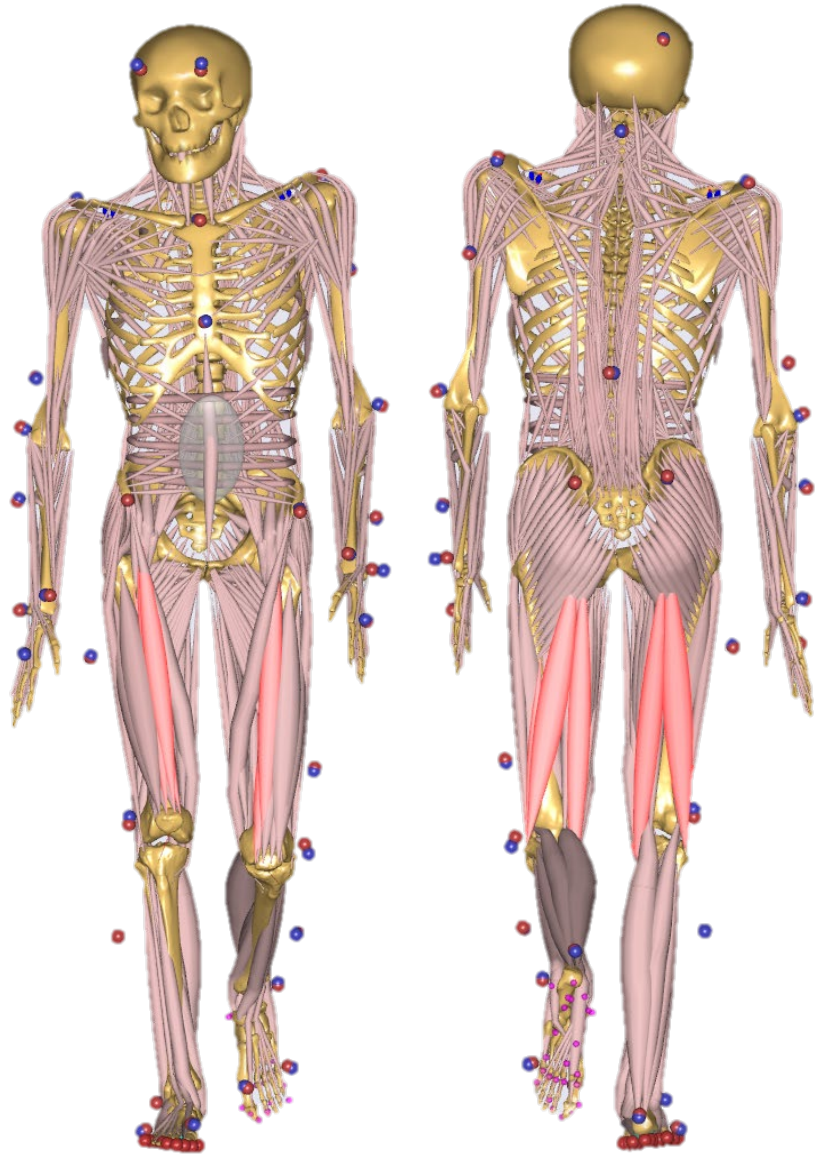
Musculoskeletal Model

Study 1 (SpeedCourt):

- AMS v. 7.2
- AMMR v. 2.2.0
- Model based on Plug-in-Gait example with custom marker set
- Quadratic muscle recruitment criterion
- Ground reaction force prediction

Study 2 (Sprinting):

- AMS v. 7.2
- AMMR v. 2.2.3
- Model based on the BVH example



Results (Study 1)

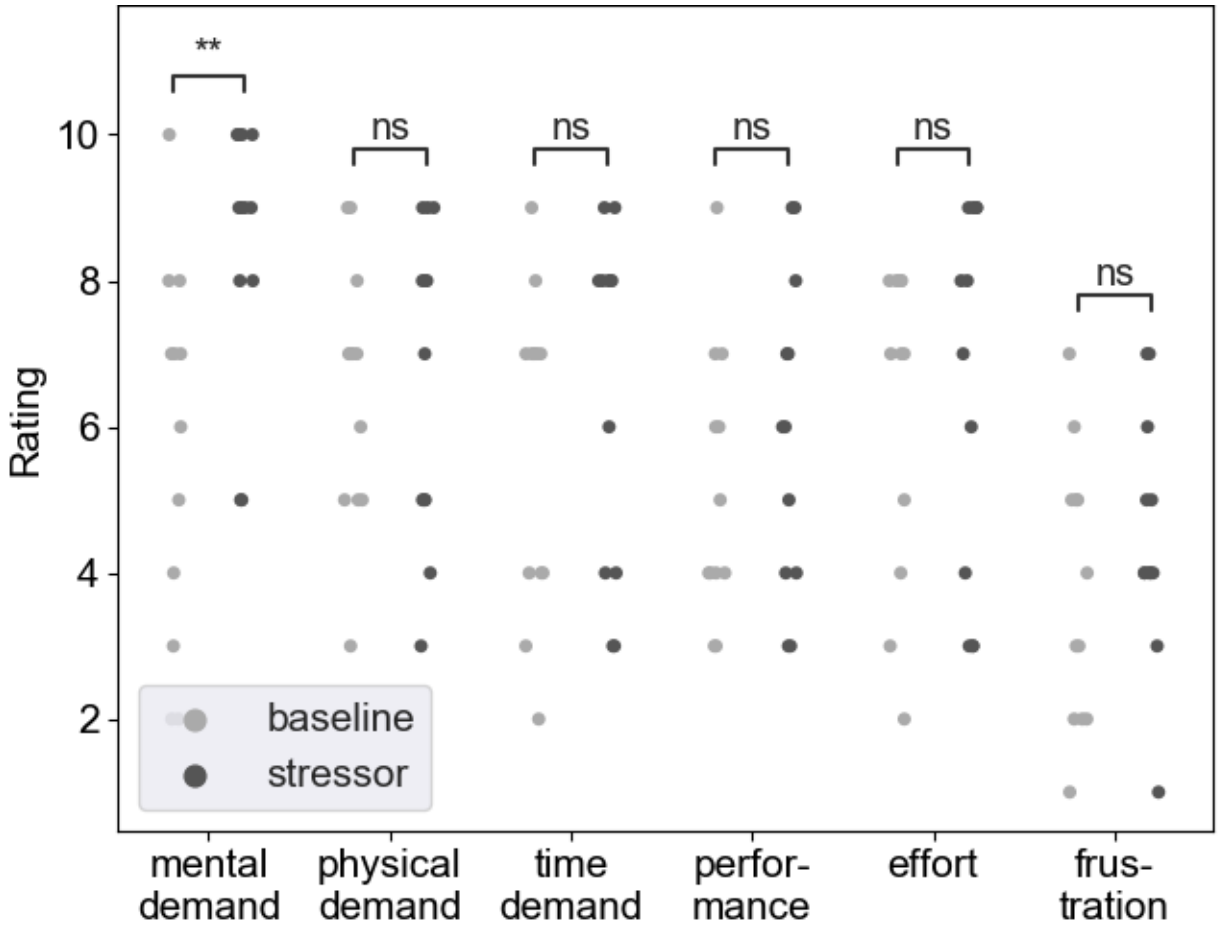


Fig.: Results of the NASA-TLX

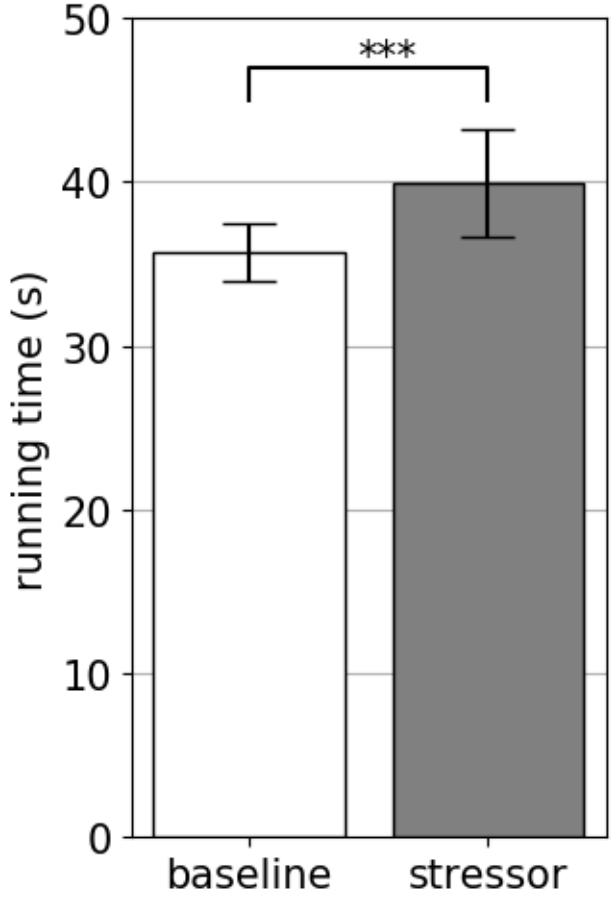
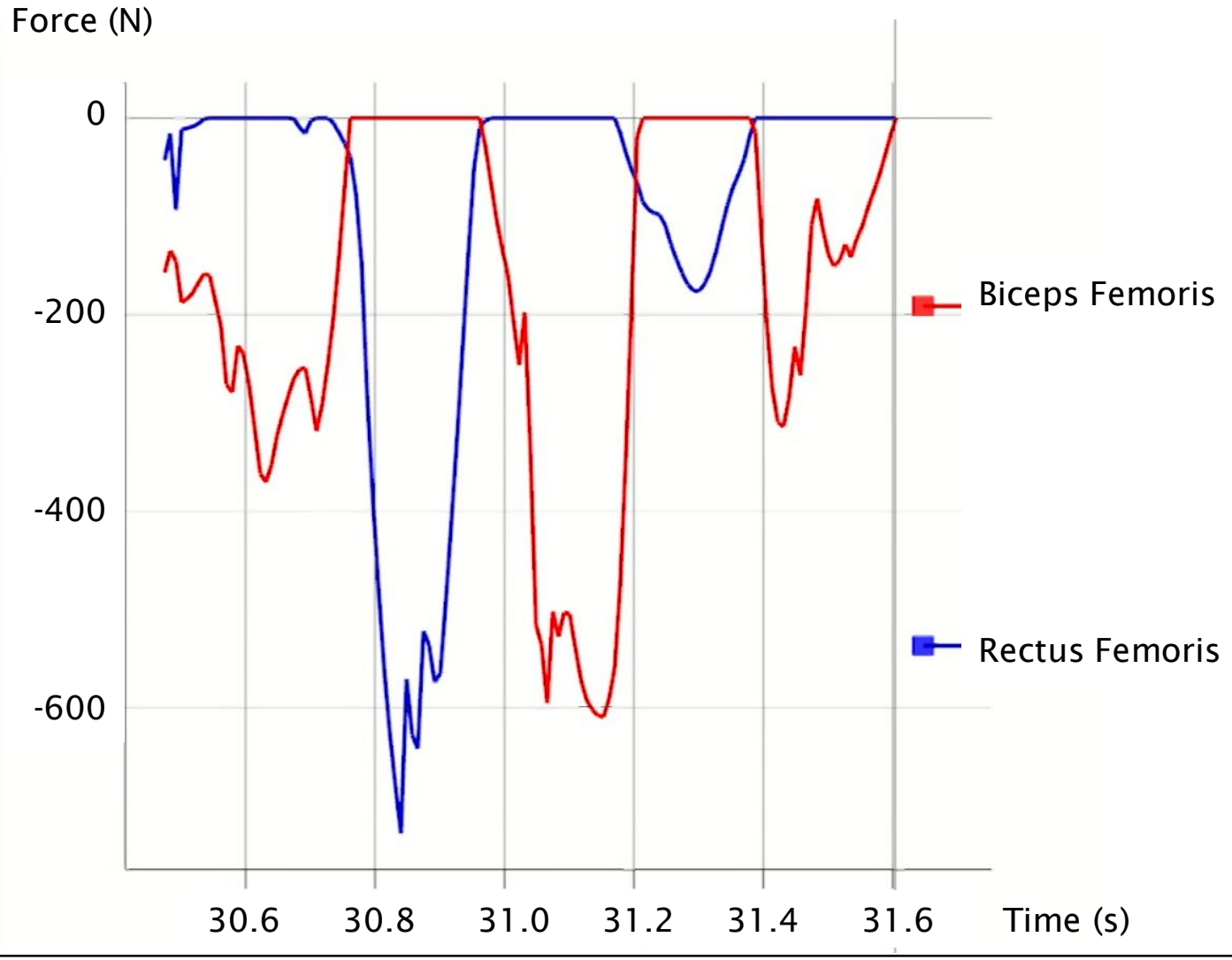


Fig.: Mean running time in the SpeedCourt

Results (Study 1)



Results (Study 1)

Tab.: Results of the musculoskeletal simulation for the participants. The table presents the mean difference between stressor muscle force and baseline and the mean peak loading in the baseline runs in %BW and the relative change. The negative values have been shaded grey for better a distinction.

		Parameter / Player	01	02	03	04	05	06	07	08	09	10	11	12	$\bar{x}$
RF	right	Delta (%BW)	-35	16	23	-12	-36	-32	-20	-13	-48	14	9	-21	-11
		Mean (%BW)	171	172	126	204	175	166	280	163	177	153	169	209	181
		rel. change	-20%	9%	18%	-6%	-21%	-19%	-7%	-8%	-27%	9%	5%	-10%	-5%
	left	Delta (%BW)	-8	71	5	-3	-146	8	-11	-18	65	27	-14	-9	-2
		Mean (%BW)	117	140	185	182	290	168	239	200	178	153	221	148	191
		rel. change	-7%	51%	3%	-2%	-50%	5%	-5%	-9%	37%	18%	-6%	-6%	-3%
VM	right	Delta (%BW)	-24	24	-2	-14	-28	-31	-11	-5	-17	-53	-12	2	-13
		Mean (%BW)	148	162	141	135	134	129	166	131	143	199	179	156	152
		rel. change	-16%	15%	-1%	-10%	-21%	-24%	-7%	-4%	-12%	-27%	-7%	1%	-9%
	left	Delta (%BW)	-29	87	-7	-10	-40	23	25	-11	64	-6	44	-24	13
		Mean (%BW)	160	138	160	137	173	119	142	156	140	176	176	150	152
		rel. change	-18%	63%	-4%	-7%	-23%	19%	18%	-7%	46%	-3%	25%	-16%	10%
BF	right	Delta (%BW)	4	-11	-13	-9	-60	-10	-19	-8	-27	4	-55	-17	-20
		Mean (%BW)	73	76	89	118	165	107	107	127	183	82	119	71	113
		rel. change	5%	-14%	-15%	-8%	-36%	-9%	-18%	-6%	-15%	5%	-46%	-24%	-17%
	left	Delta (%BW)	-13	-14	20	33	-19	-11	43	10	-52	-11	-18	-2	-2
		Mean (%BW)	109	89	55	93	115	99	122	92	119	93	88	98	97
		rel. change	-12%	-16%	36%	35%	-17%	-11%	35%	11%	-44%	-12%	-20%	-2%	0%
ST	right	Delta (%BW)	-4	-5	-5	-4	-38	-12	-12	-7	-14	-6	-30	-11	-13
		Mean (%BW)	46	48	58	62	100	66	54	79	85	51	69	47	65
		rel. change	-9%	-10%	-9%	-6%	-38%	-18%	-22%	-9%	-16%	-12%	-43%	-23%	-19%
	left	Delta (%BW)	-4	-7	9	3	-16	-19	3	-2	-19	-17	-7	3	-6
		Mean (%BW)	63	48	37	58	69	69	75	61	61	63	49	55	59
		rel. change	-6%	-15%	24%	5%	-23%	-28%	4%	-3%	-31%	-27%	-14%	5%	-9%

Results (Study 2)

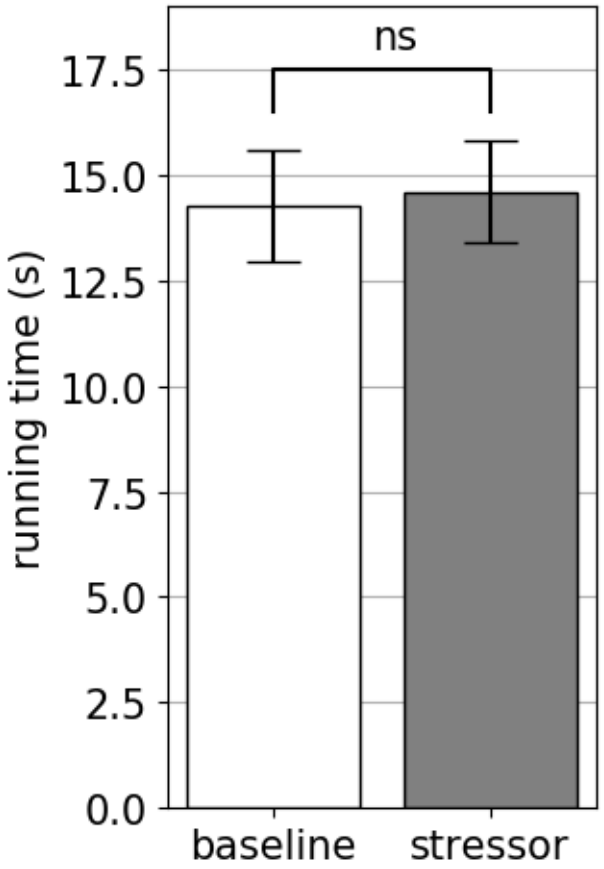


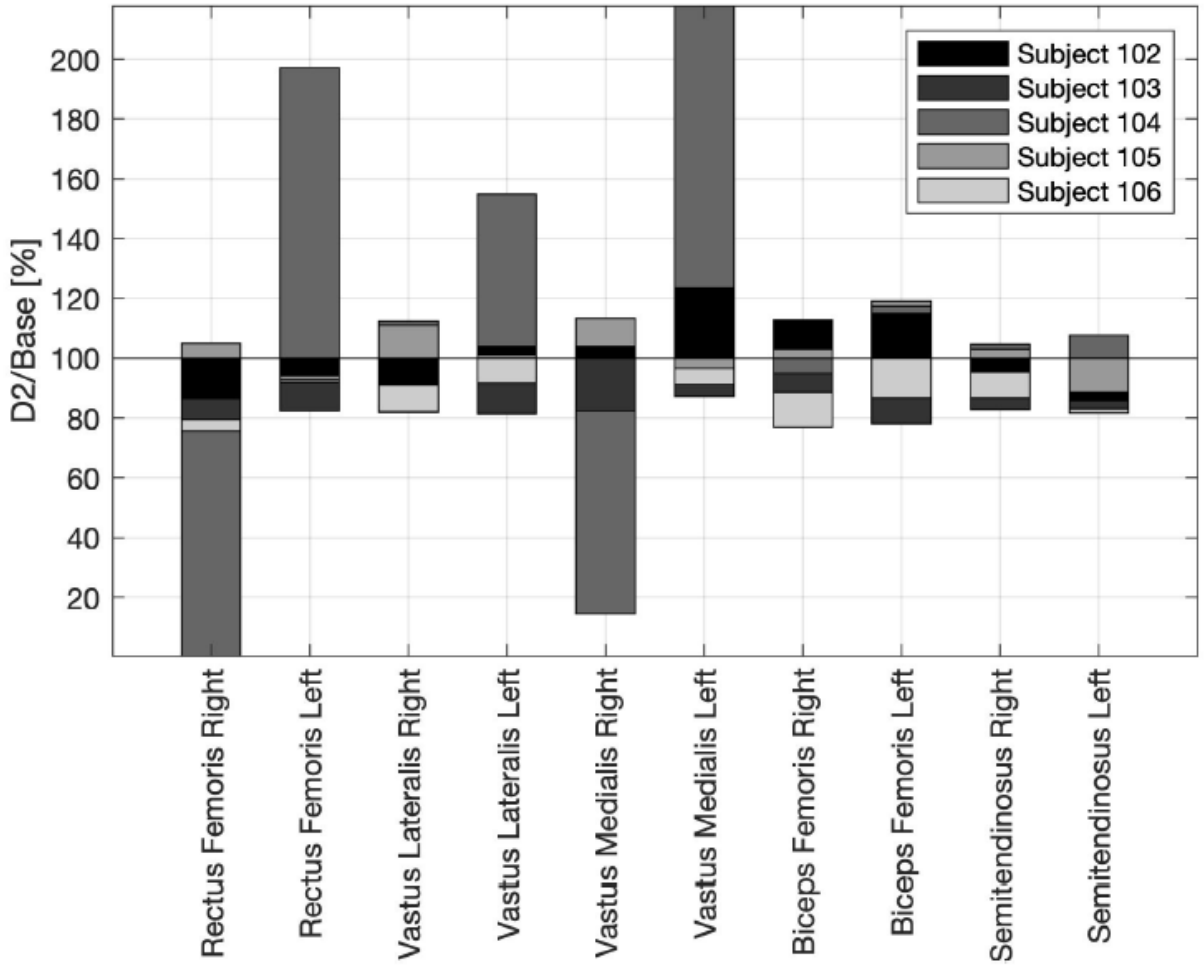
Fig.: Mean running time for 50 m

Subject Nr.	max step length [m]			
	Base		D2	
	Left	Right	Left	Right
Subject 102	2.87	3.01	2.72	2.73
Subject 103	2.88	2.74	2.86	2.74
Subject 104	2.49	2.63	2.45	2.64
Subject 105	2.63	2.56	2.82	2.65
Subject 106	3.02	2.84	2.90	2.96

Tab. 2: Averaged maximum step length for each foot and sprint per subject over 50 m

Results (Study 2)

Fig.: EMG analysis of sprints. Displayed as ratio between stressor and baseline in percent. Values >100% represent an increase in the stressor run.



Discussion

Aim of the study: Investigate influence of mental stress on musculoskeletal loads.

Study 1 (SpeedCourt)

- Lower running velocity under stress
- Higher perceived mental demand
- Changes in muscle forces

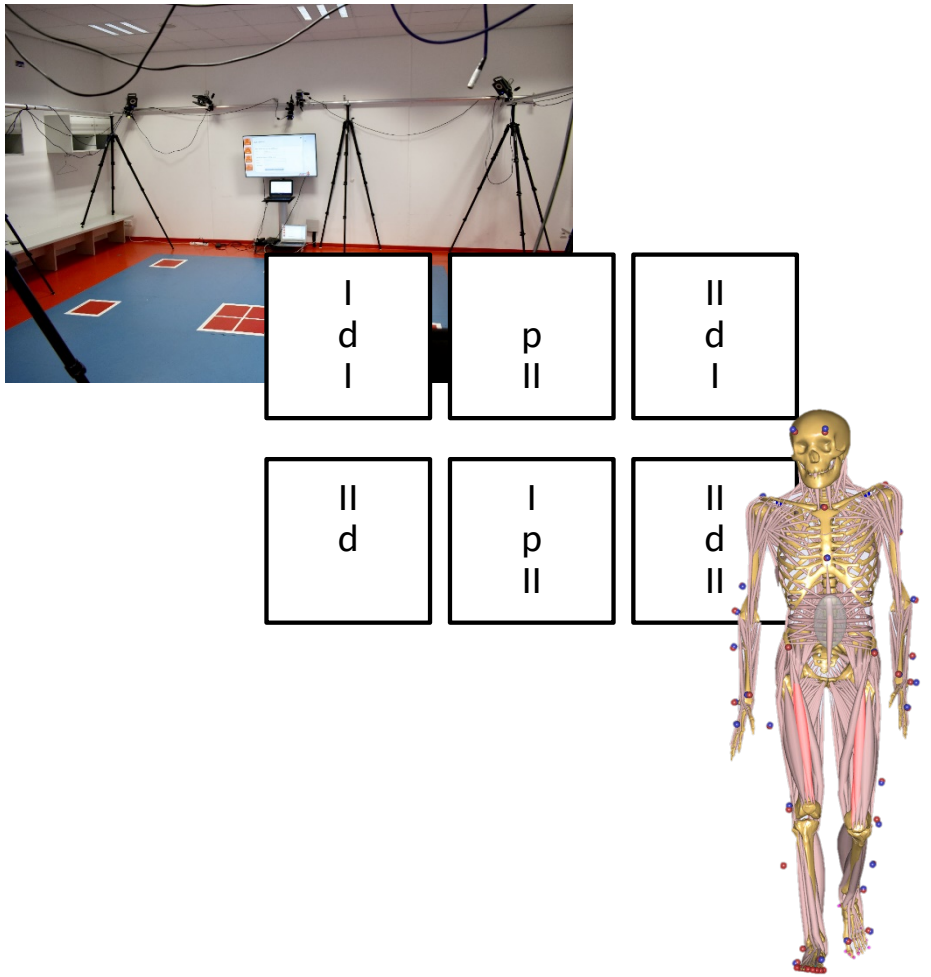
Study 2 (Sprinting)

- Equal running times
- Comparable step lengths
- Higher perceived mental demand
- Changes in muscle activity

Discussion

Limitations

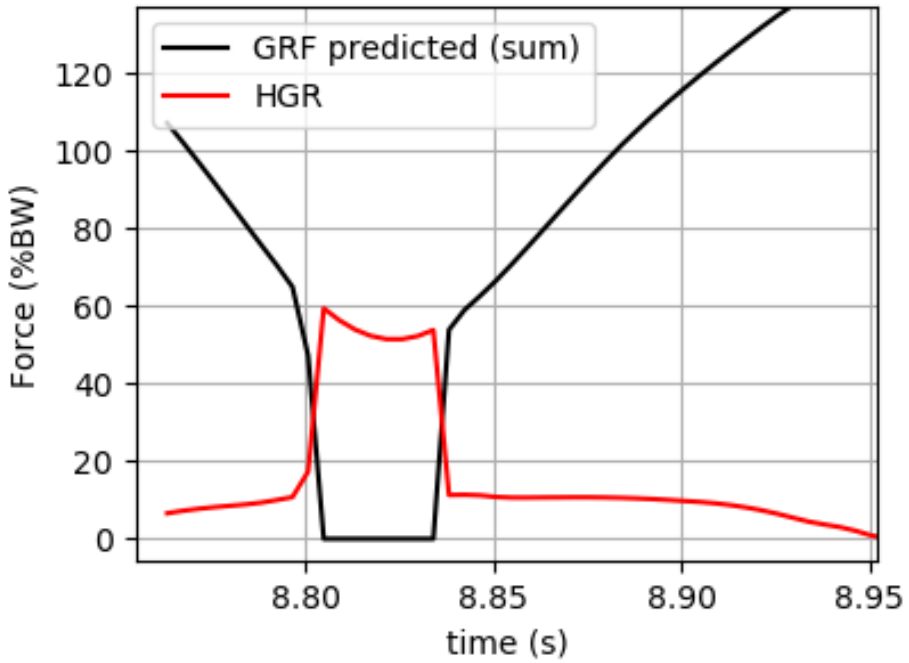
- Complex movements
- Stressor application/validation
- Simulation is solely based on kinematics



Discussion

Outlook and future work

- More participants
- Investigation with EMG
- More extensive psychologic investigation
- Investigation of Human Ground Residuals in AMS



Conclusion

- Investigation of mental stress and its effects on leg loading
- Mental stress is associated with lower running velocity
- Effects depend on the running task
- Individual reaction on stress
- Considerable changes in muscle force

www.anybodytech.com

- Events, Dates, Publication list, ...

www.anyscript.org

- Wiki, Repositories, Forum

Webcast:

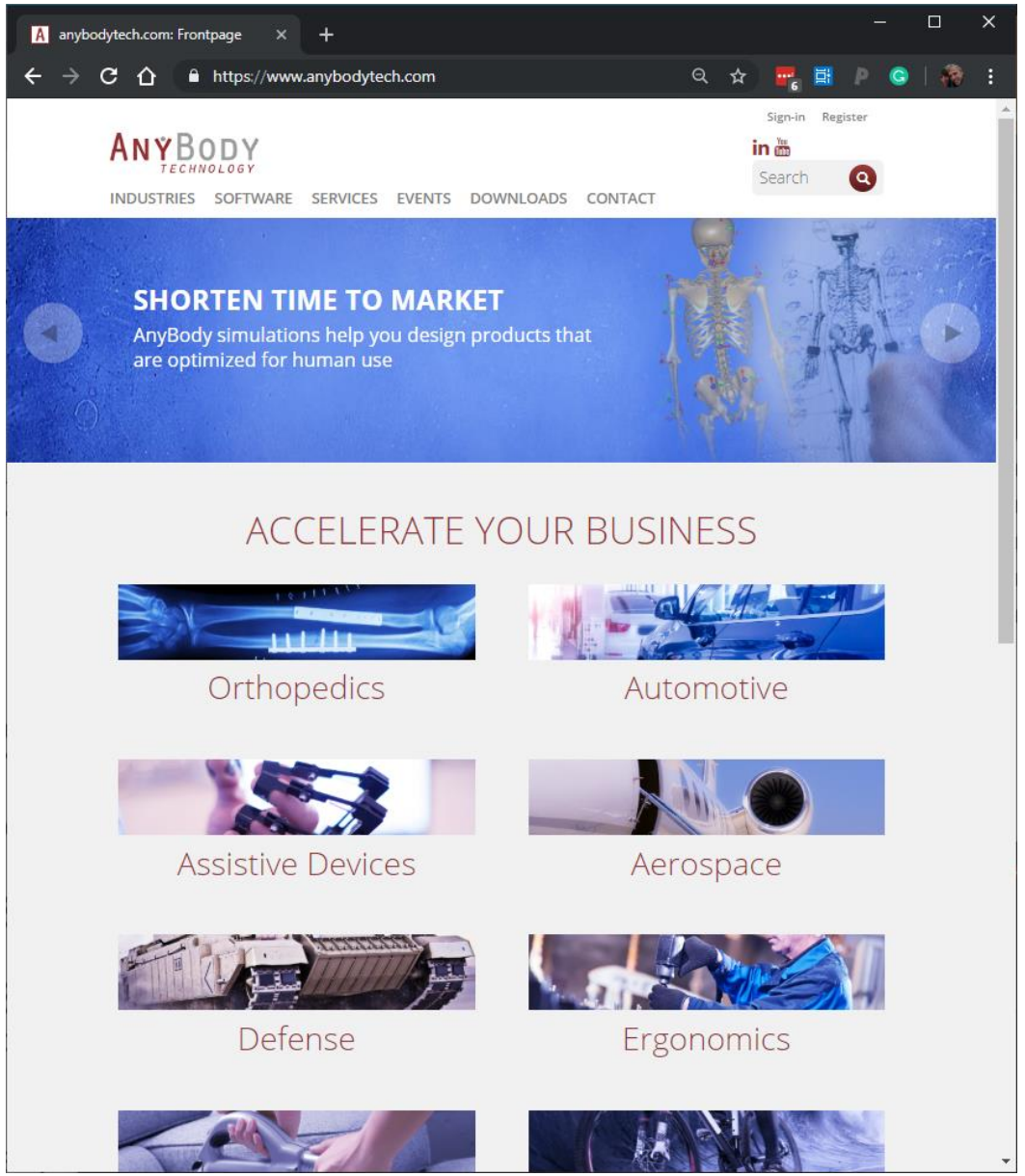
- New features in the AnyBody Modeling System

  Tuesday October 6th, 2020
- Registration link will be sent out on social media and by e-mail soon.

Meet us? Send email to sales@anybodytech.com

Want to present? Send email to ki@anybodytech.com

Find us:



Time for questions: