EVALUATION OF MARKERLESS MOTION CAPTURE USING MUSKULOSKELETAL MODELS

Simon Auer (1), Lukas Gschoßmann (1), Sebastian Dendorfer (1,2)

1. Laboratory for Biomechanics, OTH Regensburg, Germany; 2. Regensburg Center of Health Sciences and Technology, Germany

Introduction

Motion capture is a valuable tool in biomechanical research and especially in musculoskeletal modelling for quite some time. It enables to recreate real human movements in models and consequently to calculate body-internal and external reaction forces. Marker-based motion capture (MMC) has long been the state of the art for this purpose [1]. Nevertheless, a good and reliable MMC setup is laborious in preparation and post-processing. Thus, there have also been innovations in recent years that have simplified kinematic recording. Inertial motion capture (IMC) is already widely used for musculoskeletal models and has been verified for its accuracy with them [2]. Recently, there are also systems based on simple optical video recordings (VMC) that often do not require instrumentation of the subjects. However, a broad database is lacking for these systems, especially in their use with musculoskeletal models. This work aims to compare MMC and VMC data for musculoskeletal models. Specifically, joint kinematics from range of motion (ROM) exercises are analyzed.

Materials and Methods

For this study, 18 subjects (12 male, 6 female) with a mean age of 23.8±2.7 y, mean weight of 71.3±11.7 kg and a mean height of 1.77±0.11 m were recruited. The kinematics 17 of motion (ROM) exercises, were simultaneously recorded with 12 MMC cameras (Vicon Vero v2.2, Oxford, UK) and 8 VMC cameras (CapturyLive, v. 250, Saarbrücken, DE) at 60 Hz. Every motion for each degree of freedom (DOF) was performed three times in a row by all subjects at a self-selected speed. The movements started in neutral joint position (0°) and were conducted in both directions to the individual's maximum ROM. Recorded kinematic data was used to perform an inverse dynamics analysis with the AnyBody Modeling System (AMS, v.7.4). Joint angles of the head (flexion, rotation, lateral bending), shoulder (flexion, abduction), elbow (flexion, pronation), hand (flexion, abduction), thorax-pelvis (flexion, rotation, lateral bending), hip (flexion, abduction), knee (flexion), and ankle (flexion, inversion) joint were analyzed, omitting those DOF where the model (AMMR v. 2.3.4) had kinematic restrictions (e.g., knee abduction). The median root mean square error (RMSE) of the VMC driven musculoskeletal model compared to the MMC driven model as well as the mean Pearson correlation coefficient *r* were determined for each DOF.

Results

In total 612 calculations were performed and presented in Figure 1 combined for each investigated joint. The major joints' median RMSE ranges from 2.8° for hip abduction over 4.1° for knee flexion, 6.5° for shoulder flexion and 6.7° for elbow flexion to 7.9° for shoulder abduction and hip flexion. The thorax-pelvis joint

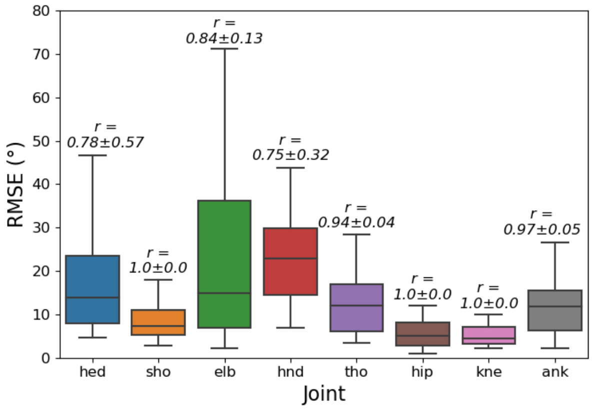

Figure 1: Boxplots of the RMSE for each investigated joint including mean r values on the whiskers. The individual DOF are combined for clarity.

showed small errors for lateral bending (5.0°) but deviated more in flexion (15.8°) and rotation (13.4°). The highest RMSE are found for hand abduction (24.8°) and elbow pronation (36.1°).

Discussion

This investigation aimed to evaluate VMC against MMC using musculoskeletal models. The analysis of the 17 DOF showed that VMC grasps many joints well. Overall, the proximal extremity joints perform better than the distal ones except for elbow pronation. IMC driven models feature similar RMSE and *r* values for the lower extremities during gait [2]. Others compared VMC and MMC without musculoskeletal models for treadmill walking and found slightly lower RMSE values for the lower extremities [3]. During hand flexion, tracking quality varied greatly, resulting in either relatively small or large deviation (median RMSE=14.8°). Otherwise, the lower tracking quality of the palm results in a high RMSE for elbow pronation and hand abduction. The differences in the thorax joints are caused because for VMC models, some motion is transferred to the pelvis and consequently the hip joint. Regarding the ankle, the flexion was tracked reliably (RMSE=6.3°) but inversion shows an error of 12.4°, probably due to VMC movement being transferred to the hip rotation. The rather larger deviations in the head are presumably due to the marker headband used for MMC, which was often worn differently by the test subjects and can thus lead to a joint offset in the musculoskeletal model. In summary, VMC driven models can represent human motion well. Even though some joints still need improvement, especially the lower extremities and the shoulder joint show a high accuracy and agreement with the literature.

References

1. Windolf et al, J Biomech, 41, 2776-2780, 2008.
2. Karatsidis et al, Med Eng Phys, 65:68-77, 2019.
3. Kanko et al, J Biomech, 127, 110665, 2021.