ESTIMATION OF INTERSEGMENTAL LOAD AT L5-S1 DURING LIFTING/LOWERING TASK WITH MARKERLESS MOTION CAPTURE

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Introduction

In an industrial environment, workers are often required to repeat specific gestures in the workstation, which can cause musculoskeletal disorders (MSDs). Intersegmental load estimation plays an important role in MSDs risk evaluation [1, 2]. It can be calculated using marker-based motion capture and force platforms based on information such as human posture, external forces applied to the body, and anthropometric measurements. However, it is difficult to apply for evaluating the MSDs risk of workers in the factory without obstructing their activities. Therefore, in this study, we present a solution to estimate the intersegmental load at L5/S1 for the lifting/lowering task using a multiview markerless motion capture system.

Methods

Twelve individuals (24.2±2.3 years, 172.4±10.1cm, 65.9±14.7kg) took part in the study (CPP 06036, Paris VI). A surgeon attached 57 markers to each participant. The participants were instructed to lift a cardboard box onto a table and then move it back down. Two different systems were used to record the movement: a marker-based system (Vicon, UK) (synchronized with a force platform) and a markerless system with four digital cameras[3]. The dataset collected included over 180K multi-view face-blurred RGB frames and the corresponding 3D coordinates of 17 key points.
A neural network [4] was trained for 3D human pose estimation (HPE) from multi-view RGB images. Three-fold cross-validation was performed during the training where the dataset was split into three parts with each being used as the test set in turn. Based on the HPE results, the human body was modeled as 10 body segments where the inertial properties of each were calculated through the method in [5]. The methods top-down and bottom-up [1] were applied to calculate L5/S1 loads. The top-down method was used for estimation with the RGB images, whereas the bottom-up reference was calculated with the data from Vicon and force platform. The RMSE was calculated between the load estimate and the reference value on the whole dataset.

Results

The load estimates were in good agreement with the reference (Figure 1). The RMSE for the force estimation in the three directions were approximately or less than 21N, regarding the moment, they were around or less than 11Nm (Table 1).

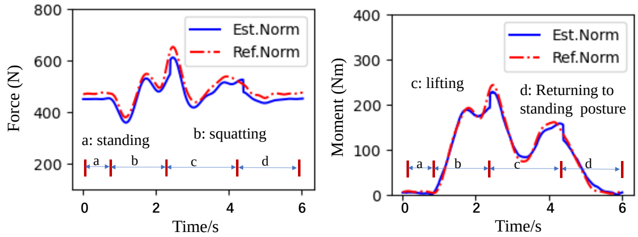

Figure 1: L5-S1 load estimate versus reference during an example lifting task. Est.=estimate, Ref.=reference, Norm= Euclidean norm

Force	Ant.-Post	Vert.	Medi.-Lat.
RMSE(N)	17.31	21.62	20.52
SD(N)	14.62	18.31	20.51
Moment	**Front.**	**Trans.**	**Sag.**
RMSE(Nm)	10.24	5.22	11.16
SD(Nm)	9.99	5.04	10.90

Table 1: The RMSE ±SD of the L5/S1 load between estimate and reference.

Discussion

The calculation of the load estimate with markerless system and with the reference adopted independent calculation strategies to compute body segments and the external forces. Therefore, the good agreement validated the consistency of the load estimation. Besides, the estimated load and the RMSE were in line with the results in the literature [1, 6]. In [6], the RMSE between the top-down and bottom-up with markerless method was below 28 Nm. However, in our study, the L5-S1 load based on markerless capture was evaluated against a more accurate bottom-up reference, based on marker-based capture and force platforms. While further validation in industrial setting should be performed, this study establishes the feasibility of estimating L5-S1 load thanks to a multiview markerless motion capture system.

References

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