ASSESSING MARKERLESS SYSTEMS FOR PELVIS AND TRUNK KINEMATICS IN PATIENT HANDLING TASKS

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Summary

This study assesses the accuracy of markerless systems (Smartphones and IMUs) for pelvis and trunk kinematics in healthcare workers during patient handling, using Vicon as a reference. Results show accurate pelvic angles, except for the pelvic list from IMUs, but poor trunk kinematics reconstruction.

Introduction

Low Back Pain (LBP) is a prevalent occupational disease, emphasizing the need for preventive measures to reduce biomechanical overload risks in workers [1]. Caregivers are among the professionals most affected by LBP, having to perform heavy maneuvers on patients lying in bed. This research arose from a collaboration with the "National Institute for Insurance Against workplace Injuries" (INAIL). The present study assesses the accuracy of markerless motion capture systems in evaluating pelvic and trunk kinematics during such maneuvers, comparing their performance with the gold-standard Vicon system.

Methods

The study involved a healthcare worker (HW) (male 52 years old, 83 kg, 178 cm) from Pisa University Hospital, who performed patient-handling movements. A 28-year-old male (96 kg, 188 cm) simulated the patient, lying passively on a bed. Several maneuvers were examined, but the focus here is limited to the Lateral Translation (LT), shown in Fig. 1: the HW places one hand under the patient's sacrum and the other on his pelvis, then laterally pulls toward themselves while ensuring the patient remains completely still. Three motion capture systems were used: a standard marker- based Vicon system with 8-infrared cameras, IMUs and videos. Two BlueTrident IMUs, one on the sacrum and one on the C7 vertebra, were used, and acquired data was processed in OpenSim through OpenSense workflow [2]. The iPhone acquisitions were integrated into the OpenCap platform [3].

Figure 1: The HW performing the Lateral Translation maneuver.

Results and Discussion

Figure 2 shows angles estimated by the three systems, revealing significant discrepancies in trunk rotation when comparing Vicon to OpenCap. OpenCap relies on a musculoskeletal model to infer joint angles, which may not fully account for subject-specific anatomy and movement variability. Additionally, depth perception and occlusion issues can introduce inaccuracies, particularly in complex movements such as patient-handling tasks. Similarly, notable differences were observed between Vicon and IMUs data, especially in trunk rotation and pelvic list, likely due to soft tissue artifacts that affect angular displacement calculations. Furthermore, inconsistencies in anatomical reference system definitions in musculoskeletal models, compared to the Vicon system, may explain the differences in pelvic and trunk kinematics reconstructed from IMU and smartphone data. Table 1 illustrates R^2 values computed by the linear fit model (LFM) [4]. OpenCap underestimates (R^2<50%) trunk kinematics during the handling task; IMUs underestimates trunk lateral bending and rotation and pelvic list.

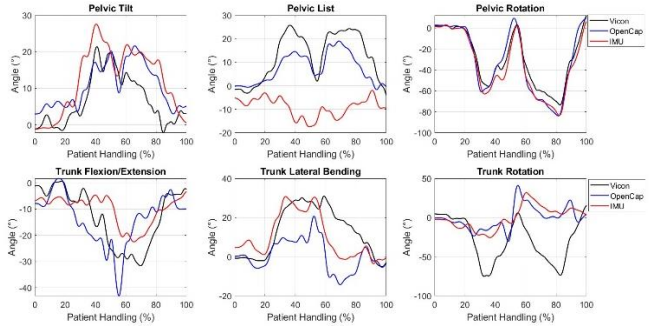

Figure 2: Pelvic and trunk angles from Vicon, IMUs and videos.

Table 1: R^2 values comparing Vicon vs. smartphones (OpenCap) and Vicon vs IMUs (IMU).

Joint angles	OpenCap	IMU
Pelvis tilt	0.658	0.640
Pelvis list	0.826	0.122
Pelvis Rotation	0.959	0.994
Trunk Flex-Extension	0.410	0.664
Trunk lateral banding	0.181	0.485
Trunk Rotation	0.062	0.027

Conclusions

Smartphones accurately capture pelvic movement, but IMUs struggle with the list angle. Three out of six joint angles showed good agreement (R^2>60%) with marker-based estimation. Differences may stem from inconsistent anatomical reference definitions.

References

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