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THE EFFICACY OF VIDEO-BASED MARKER-LESS TRACKING SYSTEM IN GAIT ANALYSIS

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An alternative to the 3D motion capture is the marker-less 3D video tracking system. Though not rigorously tested yet, the 3D marker less video tracker would break new grounds if it is possible of extracting similar kinematic parameters as the gold standard 3D marker based motion capturers. The aim of our study is to explore the feasibility of a video based marker-less system which is as accurate and precise as its marker based counterpart. A series of gait analysis tests were carried out on ten subjects with a marker and marker-less system simultaneously. The study suggests potential applications in gait analysis in the academic classrooms and clinical settings where observations of anatomical motions provide meaningful feedback.

KEY WORDS: Markerless, motion-capture, gait, three-dimension, biomechanics

INTRODUCTION: Gait analysis is an effective tool in the clinical decision making process for improving treatment outcome in an individual particularly with respect to lower limb injuries (Engsberg et al., 2007).
Such analyses typically require relevant information such as foot pronation, tibia rotation and multiple-joints coordination to be augmented to the user simultaneously with real scenes captured by imaging equipment. Existing motion capture equipment is arguable expensive and bulky, requiring practically at least 6 precision proprietary cameras and these are mainly installed in specialised institutions. Consequently, a large proportion of the population seeking medical consultations for such injuries at polyclinics and neighbourhood doctors will not have immediate direct access to the equipment. The quality of general health care can be significantly increased if such systems are made available to mainstream healthcare locations. This is achieved through the innovation of a more mobile and significantly cheaper system without compromising accuracy and reliability. By integration of innovative technologies, this system provides intuitive and accurate results for doctors and also allows remote diagnosis for the convenience of mainstream patients.
The aim of this study is to investigate the efficacy of the marker-less video based system, Star Tracker 3D. The hypothesis is that Star Tracker 3D is as reliable and accurate as the existing industry's marker based gold standard motion capturing systems.

METHODS: 2.1 Subjects: Ten healthy male subjects with ages ranging from nineteen to twenty six, volunteered in this gait analysis test. They had no significant lower body injuries for the past six months prior to the day of testing. All participants gave written informed consent prior to participation in the research. This study received approval from the university human research ethics committee.
2.2 Equipment: The experimental set-up consisted of a Gaitway motorized treadmill (H/P Cosmos Gaitway II S, Germany) that was surrounded by an eight camera Motion Analysis System (Motion Analysis Corp., Santa Rosa, CA) and Two Point Grey (GS2-FW-14S5C, Canada) cameras. The processing pipeline of the Star Tracker 3D system (markerless system) is adapted from (Zhang et al., 2011). To decrease the processing time, the area for tracking for each segment at the first frame only is confirmed and the rest is automated.
Data sampling was accomplished at 100 Hz and 25 Hz respectively. The participants then had retro-reflective markers placed on the right lower extremity in accordance with Dierks & Davis (2007). The marker set consisted of 6 individual markers and two clusters of four (leg) and three markers (rearfoot) respectively. The subjects walked on the treadmill at self-selected speed (3.5-4km/hr) conditions. Subjects walked on the treadmill for

approximately seven minutes (Lavcanska et al., 2005) and kinematic data were measured for 30 seconds during the 8th minute.
The first three consecutive complete strides that were recorded on the 8th minute were used for analysis. The kinematic data were filtered with a Butterworth low-pass filter with a cut-off of 6Hz. The time histories were normalized to 100% of the gait cycle. Three-dimensional leg and ankle angles were calculated using the Visual3D software (C-motion Inc, USA). Segment coordination coupling between the rearfoot (inversion/eversion) and tibial (internal/external) rotation angles were calculated based on the Chang et al. (2008) approach. The kinematic data from the two systems were analysed using paired-T-test and correlation.

RESULTS

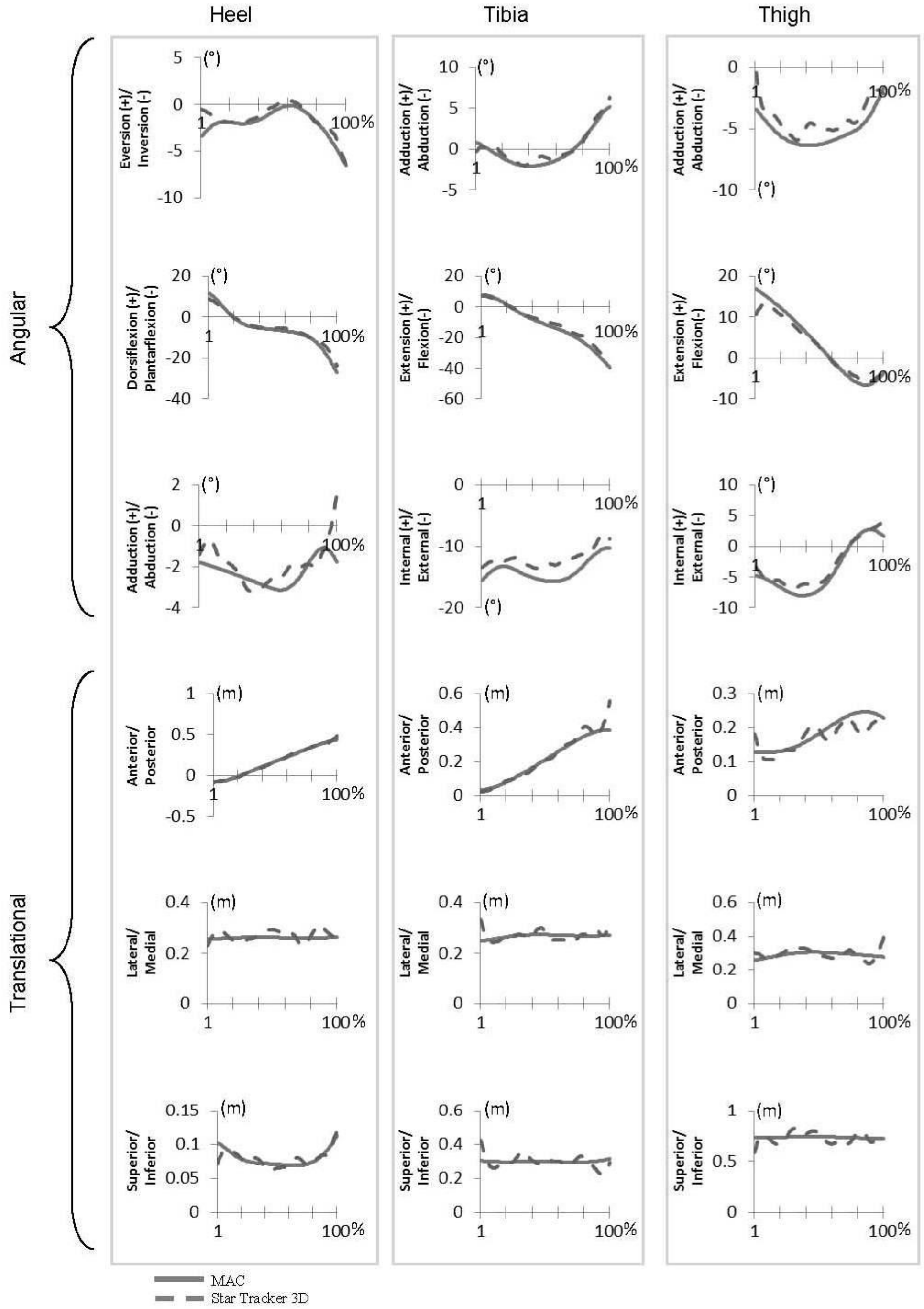

Figure 1. The comparison of angular and translational movements observed in the heel, tibia and thigh from data computed between the Star Tracker 3D and the MAC

DISCUSSION/CONCLUSION: The aim of this study is to investigate the efficacy of the marker-less video based system, Star Tracker 3D. The study suggests that the translational information correlates well between the two systems and no significant differences was observed. The angular information showed moderate correlation for the anterior-posterior axes and the medial-lateral axes but significant differences were observed. We reject the hypothesis that Star Tracker 3D is as reliable and accurate as the existing industry's marker based gold standard motion capturing systems.

The translational data showed feasible agreement for all the three segments. These are used to compute segmental angular movements where significant differences are observed ($p > 0.05$). This may be due to motion blur (Ting & Peng, 2010) and possible areas to improve accuracy are to increase the number of cameras, use higher resolution sensors and faster rate of captures amongst others.

The study suggests potential applications in gait analysis in the academic classrooms and clinical settings where observations of anatomical motions provide meaningful feedback. More detailed and accurate measurements can be done using optical cameras.

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