CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

Validity of Inertial Measurement Units for Tracking Human Motion: A Systematic Review

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By

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ABSTRACT

Validity of Inertial Sensor Systems for Tracking Human Motion: A Systematic Review

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Master of Science in Kinesiology

Tracking and interpreting human motion is an invaluable skill used by researches and practitioners to illuminate methods of subject improvement ranging from athletic performance to injury recovery or disability analysis. In today's current field, human motion is often tracked through the application of inverse kinematics in tandem with 3D motion tracking. This method of motion analysis has been shown to provide high levels of reliability and validity for respective applications such as gait analysis, or knee valgus displacement during a landing task.

More recently, some motion variables have been tracked through the use of accelerometers organized in a way to create an inertial measurement unit (IMU). These IMUs are measuring the rate of change in velocity of specific segments on the subject. The values are then overlaid and triangulated with different algorithms to output information such as: gate speed, joint angles or change in gate patterns. A major advantage of using such a system is the ease of access and application. These devices are often times much more affordable and accessible as well as far less intrusive than some of the 3D motion tracking methods previously discussed. This could provide researchers with a tool that could greatly improve their research collection speed and lessen subject discomfort. The purpose of this study is to evaluate the validity of these

inertial sensor systems when being used to track human motion. If these inertial sensor systems show a high level concurrent validity for their specific applications, they could greatly improve the ease and rate of research production as well as patient analysis or performance testing.

Four electronic databases were used to search for primary research pertaining to validity inertial sensor systems. Two reviewers independently assessed the literature to determine its methodological rigor. Of 524 studies initially found amongst the 4 databases, 11 fit the criteria of this systematic review and were ultimately included in the final research. It was found that IMUs have a high level of agreement with the motion capture systems (MOCAP) in the frontal and sagittal planes, measured with root mean square error (RMSE), intraclass correlation coefficient (ICC), and Pearson's correlation (r). The transverse or rotational planes began to show large discrepancies in joint angles between the two systems, though. Furthermore, as the intensity of the task being measured increased, RMSE values for joint angles and ROM began to get much larger.

In conclusion, this review found that some IMUs showed high levels of concurrent validity when compared to currently established MOCAP devices in the field, specifically during low intensity single plane movements. As the movements increased in intensity and became more dynamic, the levels of ICC and Pearson's correlation began to fall, providing insight that the IMU device was no longer a valid measuring tool. Close interpretation is required when assessing these devices due to some RMSE values being classified as having a high level of agreement but still showing 2-3° of difference in a single joint angle. These values suggest that the IMU is not precise enough to use in a research setting at this point. Currently the use of accelerometers and inertial sensor systems has limited application in the assessment of human motion, but if refined further could provide for a great improvement in the field.