

Three-dimensional biomechanical assessment of treadmill gait using Microsoft Xbox Kinect

Assessment of walking patterns, known as gait analysis, is an effective clinical tool widely used in various applications such as rehabilitation, diagnosis of neurological diseases, and assessment of fall risk. While a two-dimensional movement analysis approach, using video cameras, is affordable and easy-to-use, it lacks the necessary detail to provide clinicians with the information they need to help them in the decision making process when prescribing interventions based on neuromuscular performance.

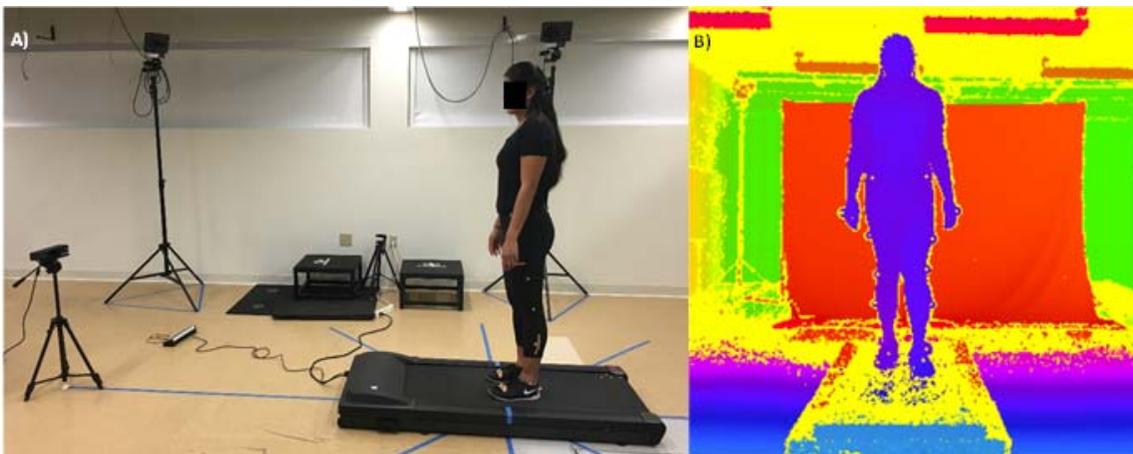


Fig. 1. A) The experimental setup including the 3DMA and Kinect, B) The Kinect depth map.

Optoelectronic, marker-based three-dimensional motion capture (3DMA) systems are the gold standard for dynamic movement assessment used to perform 3D biomechanical assessment of gait and can provide the required detail. Data collected include, spatiotemporal gait parameters such as step length, gait speed, and cadence; and 3D kinematics such as 3D joint angles. However these systems have significant limitations including: cost, the need for technical expertise, lack of portability, substantial space requirements, and comprehensive setup time. Therefore, a cost-effective and clinician-friendly motion capture solution, allowing valid and reliable assessments of kinematic and spatiotemporal variables during functional movements, such as gait, is a logical step toward improved patient care.

In this study the validity of a commercially-available videogame accessory, the Microsoft Xbox One Kinect, was investigated when performing a 3D biomechanical assessment of treadmill gait. Variables included spatiotemporal parameters and kinematics. The Kinect is a depth sensor, which light pulses' time of flight from the sensor to the tracked object to determine accurate distance estimations for the objects being tracked.

Ten healthy subjects (5 males, 5 females, age: 26.7 ± 5.4 years, height: 174.4 ± 7.9 cm, mass: 71.8 ± 11.4 kg) participated in this study. A single Kinect sensor (Microsoft Corp. Redmond, WA), placed

2.5 meters from the subject at a height of 0.75 meters, and a 3DMA system (SMART-DX 7000, BTS Bioengineering, Milano, Italy) composed of eight infra-red cameras, were used to concurrently collect movement data (Fig. 1).

Our findings when assessing lower extremity sagittal plane joint angles during treadmill walking indicated that, although there are several potential limitations with the Kinect, the hip (1.3 m/s: Kinect = $46.44 \pm 3.38^\circ$, 3DMA = $44.39 \pm 3.29^\circ$; 1.6 m/s: Kinect = $49.69 \pm 3.71^\circ$, 3DMA = $47.42 \pm 4.06^\circ$) and knee (1.3 m/s: Kinect = $64.57 \pm 1.94^\circ$, 3DMA = $64.53 \pm 3.46^\circ$; 1.6 m/s: Kinect = $64.49 \pm 3.24^\circ$, 3DMA = $66.08 \pm 4.89^\circ$) supported the system's utility for assessing joint angles (See ensemble curves in Figure 2). In contrast to our hip and knee findings, ankle joint angles (1.3m/s: Kinect = $10.92 \pm 2.31^\circ$, 3DMA = $30.68 \pm 5.56^\circ$; 1.6 m/s: Kinect = $10.58 \pm 2.44^\circ$, 3DMA = $31.22 \pm 5.33^\circ$) did not display favorable measurement consistency, agreement, or concordance compared to the 3DMA system, and poor ankle joint tracking accuracy was evident.

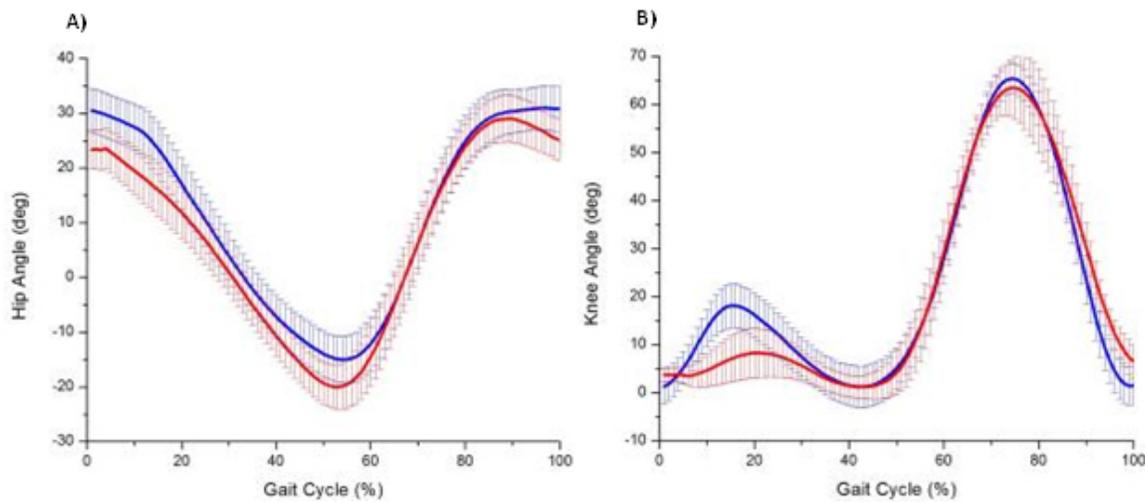


Fig. 2. A) Hip sagittal-plane joint angle during 100% of the stance phase, B) Knee sagittal-plane joint angle during 100% of the stance phase. Blue lines: 3DMA and red lines: Kinect.

In conclusion, the Kinect sensor can potentially be an effective clinical tool for evaluating sagittal plane knee and hip joint kinematics and some spatiotemporal variables during treadmill gait. Given the advances in depth sensor technology and ease of data acquisition and processing, the Kinect can be a feasible and cost-effective alternative to the expensive marker-based 3DMA systems for use in clinic and at-home applications.

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