A low-cost Kinect™ for Windows® v2-based gait analysis system

A feasibility study with healthy subjects

Jorge Latorre[1], Roberto Llorens[1,2], Adrián Borrego[1], Mariano Alcañiz[1]

[1]Neurorehabilitation and Brain Research Group, Instituto Interuniversitario de Investigación en Bioingeniería. Universitat Politècnica de València. Valencia, Spain.
jlatorre@i3b.upv.es

Carolina Colomer[2], Enrique Noé[2]

[2]Servicio de Neurorrehabilitación y Daño Cerebral de los Hospitales NISA. Fundación Hospitales NISA. Valencia, Spain

***Abstract*— The high cost and required space of current gait analysis and instrumented walkway systems could explain their limited use in the clinical setting. We hypothesized that a Kinect v2-based system would overcome these limitations and enable reliable estimation of gait characteristics. To test this, we have evaluated the most widespread used spatiotemporal (stride time, length, and velocity) and kinematic variables (hip and knee flexion) of 257 healthy individuals divided in different decades of age (from 10 to 80 years old) with a low-cost Kinect-v2 gait analysis system. The experimental system was able to evidence age-related differences in spatiotemporal and kinematic parameters (previously described using laboratory-grade systems), which support the use of the Kinect v2-based system as a promising low-cost alternative for gait analysis.**

Keywords—gait; kinematics; Kinect v2; low-cost; stroke; Parkinson's desease; multiple sclerosis

I. Introduction

Alterations in balance and gait are a common sequelae of a wide variety of physical and neurological disorders as stroke, Parkinson's disease, and multiple sclerosis [1], [2]. In the daily practice gait is commonly assessed through clinical scales and tests, which are usually rapid and easy to administrate but may lack accuracy and add subjectivity. Gait analysis labs or instrumented walkway systems can overcome these limitations but their price and dimension could prevent their use in most of the clinics.

Kinect™ for Windows® v2 (Microsoft, Redmond, WA), also known as Kinect v2, is a low-cost infrared camera which enables human motion tracking by estimating the 3D position of the main human joints, which has shown comparable results to motion capture systems [3].

We hypothesized that a Kinect v2-based system would be able to characterize the spatiotemporal and kinematic variables of a sample of healthy volunteers and evidence age-related differences among them. The objective of this study was to register and analyze the gait parameters of a sample of healthy individuals on a Kinect v2-based gait analysis system.

II. Methods

A. Participants

Two hundred and fifty-seven participants (129 men and 128 women) with a mean age of 43.9±21.3 years old, ranging from 10 to 80 years old, without musculoskeletal or cognitive disorders were included in the study (Table I).

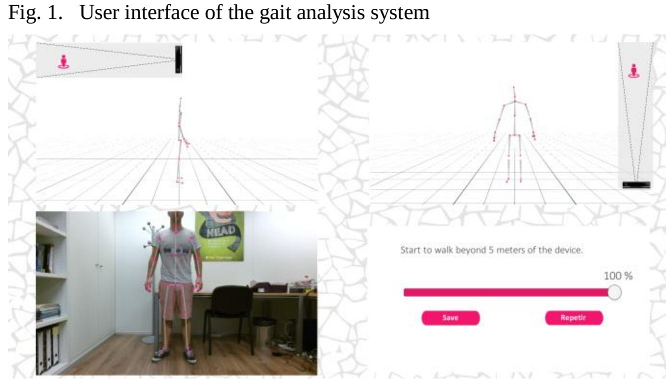
TABLE I. Distribution of participants in age decades

Age decades	*Females*	*Males*	*Total*
10-19	15	22	37
20-29	19	28	47
30-39	14	23	37
40-49	21	10	31
50-59	19	15	34
60-69	18	15	33
70-79	22	16	38
Total	**128**	**129**	**257**

B. Instrumentation

The user interface showed the participants' skeleton with a sagittal (Fig. 1.a) and frontal perspective (Fig. 1.b), a frontal view of the real video stream of the participants with their skeleton superimposed (Fig. 1.c), and a control panel (Fig. 1.d).

Fig. 1. User interface of the gait analysis system



The gait analysis system required participants to walk towards the Kinect v2 from a distance of 5 m. The gait cycle was detected from the changes of ankle velocity [4]. Most common spatiotemporal and kinematic parameters of the gait (with the exception of those that involved the toe) were computed bilaterally [1].

The design of the user interface and the computation of the gait parameters were done using Unity 3D (Unity Technologies, San Francisco, CA). The position of the main joints of the participants and the video stream were provided by the Kinect v2 at 30 Hz. An 8-core Intel® Core™ i7-3632QM @ 3.60 GHz with 8 GB of RAM was used.

C. Procedure

All the sessions were guided and supervised by an experimenter. Participants stood still at a distance of 5 m from the Kinect v2 and were required to walk towards the device. This process was done at least five times for each participant. After each repetition, the experimenter evaluated the data online and discarded the results if any technical or physical complication occurred. A refined search for abnormal results was performed offline.

For this study, velocity, stride distance and stride time for spatiotemporal and hip flexion/extension and knee flexion/extension for kinematics.

III. Results

Average velocity, stride distance, and stride time obtained from each age decade are shown in Fig. 2. Average left hip and knee kinematics are shown in Fig. 3 and 0, respectively.

Fig. 2. Velocity, stride distance, and stride time

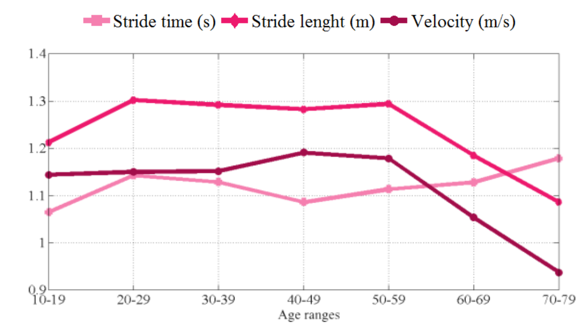


Fig. 3. Left hip kinematics

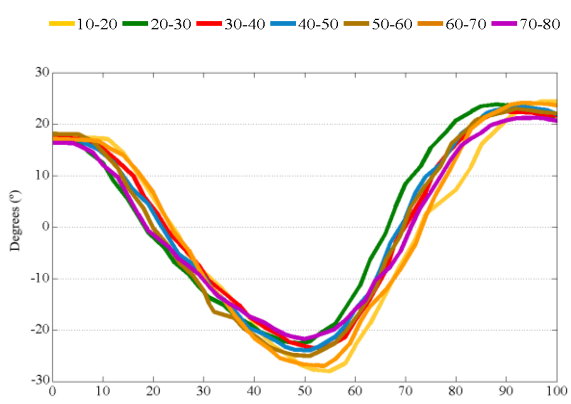
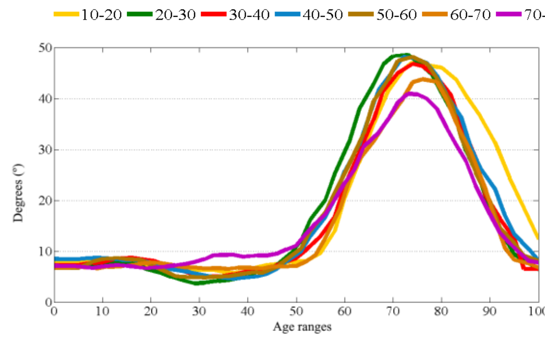


Fig. 4. Left knee kinematics



IV. Discussion

The decrease in the gait speed with age, motivated by a decrease in the stride length, detected in our study has been reported as a natural pattern to achieve safer and stable gait [5]. Although all participants showed similar hip and knee degree kinematics, knee flexion decreased with age, which is also supported by previous studies [5].

Kinematic parameters detected in our study showed shapes and variations similar to those reported by previous reports [6][7]. However, the peak values of the curves and the spatiotemporal parameters presented lower values. The limited working range of the Kinect v2, from 0.5 m to 4.5 m, prevented participants to reach and maintain their comfortable gait speed [6], thus explaining these differences. It is important to highlight therefore than this test could reflect the acceleration and deceleration phases rather than the gait itself. However, preliminary testing with healthy subjects showed promising results and support the use of the Kinect v2 as a low-cost alternative for gait analysis.

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