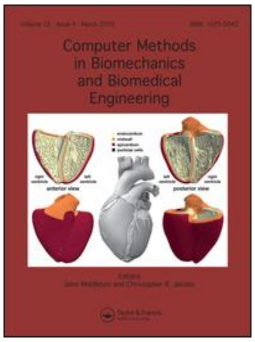

Computer Methods in Biomechanics and Biomedical Engineering

ISSN: 1025-5842 (Print) 1476-8259 (Online) Journal homepage: https://www.tandfonline.com/loi/gcmb20

Design and implementation of an electronic goniometer for gait analysis

C. Adel, Y. Benabid & M. A. Louar

To cite this article: C. Adel, Y. Benabid & M. A. Louar (2017) Design and implementation of an electronic goniometer for gait analysis, Computer Methods in Biomechanics and Biomedical Engineering, 20:sup1, S3-S4, DOI: 10.1080/10255842.2017.1382832

To link to this article: https://doi.org/10.1080/10255842.2017.1382832

Published online: 27 Oct 2017.

COMPUTER METHODS IN BIOMECHANICS AND BIOMEDICAL ENGINEERING, 2017
VOL. 20, NO. S1, S3–S4
https://doi.org/10.1080/10255842.2017.1382832

Taylor & Francis
Taylor & Francis Group

Design and implementation of an electronic goniometer for gait analysis

C. Adel, Y. Benabid and M. A. Louar

LCSM, Ecole Militaire Polytechnique, Alger, Algérie

KEYWORDS Gait analysis; joints angles; electronic goniometers; ergo-design; implementation

1. Introduction

Walking is the main mean of movement for Man, therefore in the last century many studies have been carried out to reach a better understanding the human walk. The study of this latter is multidisciplinary and, from a biomechanical point of view, it is based on records of the kinematics and dynamics of the different body segments set in motion (Neelesh et al. 2009). Motion capture devices are used in medical application to help practitioners in the clinical interventions and to improve performance of athletes, and in the analysis of the subject gait to evaluate the condition of the joints and bones (Yazdifar et al. 2013). Gait analysis aims to measure the angular variations of the body joints, mainly those of the lower limbs :the hip, the knee and the ankle (Neelesh et al. 2009). A functional implant or prosthesis requires an understanding of the basic mechanics of motion and load transfer which should be reflected in the implant design (Link and Keller 2003). Traditional goniometers are clinically used to measure joint angles, for example the maximum knee angle flexion/extension achieved by a patient under treatment (Yazdifar et al. 2013). This paper describes the design and realization of a system for recording real-time angles measurements (hip, knee and ankle) obtained on the basis of electronic goniometers for the lower limbs for the sagittal plane, intended for the North African population (Anthropometric measures: segment length, weight, height … etc.) by following and developing an appropriate and methodological design process. The identification and adaptation of appropriate tools and environments for the process design is proposed in order to improve the gait evaluation as a first step, and the design of medical devices as a second step.

2. Methods

The design of a gait evaluation system requires a good comprehension of the lower limbs structure. The analysis of the lower limbs anatomy reveals the presence of four (04) principal parts (the core, the thigh, the leg and the foot) linked by three joints (hip, knee and ankle).

The kinematic test of the walk passes necessarily through the measurement of their joint movements (sagittal plane). The implementation of this goniometric system using potentiometer sensors (non-telemetric) is divided into two main parts.

2.1. Ergo-design and realization of the structure

The structure must be adaptable for all the adult subjects, with a height between 150 and 190 cm (which cover the majority of the North African population adults).

An ergonomic design needs a choice of the accessible and appropriate technological solutions (see Table 1).

This solution must include a number of functionalities (Figure 1).

A prototype, which was used in the primary tests for the validation of the system, has been developed to fulfill the demands of interchangeability (between left and right legs), size, height and functionality.

Then a second one that overcomes the disadvantages found in the first (the weight, the comfort of use, the precision of angle measurement …).The latter is made from carbon fiber reinforced epoxy which has a total weight of 1100 g (straps, sensors and acquisition card included), double hinges (Figure 2) on the sides of each joint were used to give a better comfort for the subject and more mobility in the facial plane, leather adaptable straps was also used to insure a better fixation for different sizes.

2.2. Acquisition software

A computer software was developed allowing real-time monitoring of joints angles, and storage in customized disk files. It includes a data-base that manages: name, age, sex, pathology, date and time for each acquisition.

CONTACT C. Adel chiboubadel5@gmail.com

Table 1. Information about evaluated subjects.

Subject	Nbr	Sex	Age	*H* (cm)	*W* (kg)
Healthy	4	M	22–24	178–187	70–85
Hemiparesic	1	F	46	152	70
Hemiplegic	1	M	44	160	65

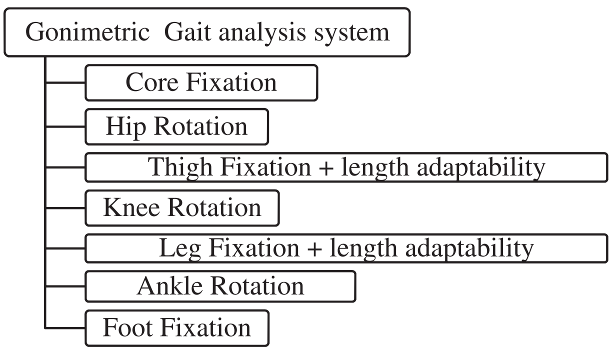

Figure 1. Needed functions in the structure.

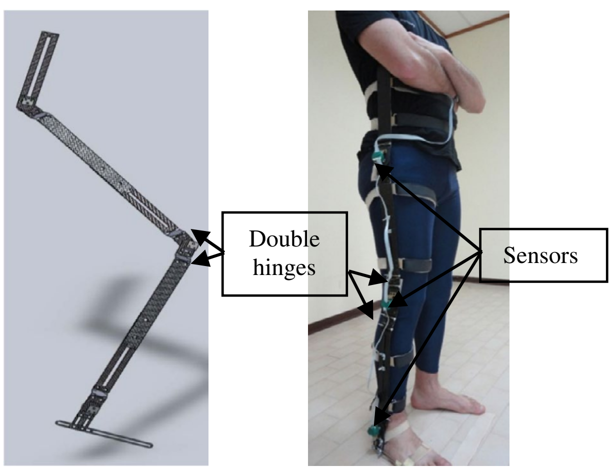

Figure 2. 3D Model and realised structure.

3. Results and discussion

The tests were performed on valid subjects on a distance of 17 m long, barefoot. The gait cycle is auto-detected by the software and displayed in real time (Figure 3) for a single gait cycle and for the three joints simultaneously.

The recording is practically not limited since it is done directly on a computer. The acquisition card only performs the analog-to-digital conversion and sends the signal to the computer. The gait cycle is between two successive maximums of the hip curve, it is easily selected manually or automatically (with an algorithm).

We can observe that the results in red are in concordance with the references (Schmitt 2007) in black. The maximum flexion/ extension angles of the joints are very close to those references. A slight difference is observed at the knee in the first peak, probably due to the fixation.

The results are within a tolerance of ±5°, a value proposed by practitioners which is sufficient to detect an abnormality in walking in case of invalid gait according to them. The electronic goniometer was also used on a number of subjects presenting different kinds of disabilities such as: hemiplegia and hemiparesis.

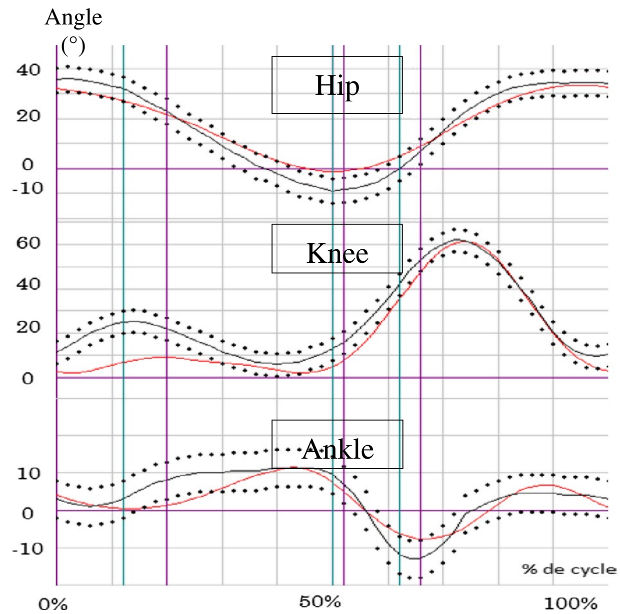

Figure 3. Example of measurement with the developed goniometer for a healthy subject.

4. Conclusions

In this paper, an approach to choose the process design is presented. For this process many tools and methods were identified in order to use them in different stages to generate an innovative gait evaluation system.

Through this paper, we have presented the steps of development of an electro-goniometric gait analysis system. The use of an instrumented exoskeleton would allow to the practitioner precision and objectivity during the walk examination; and to the subjects a gain of time and less inconvenience during the installation and the setting of prosthesis or an orthotic. This system is an inexpensive solution for gait analysis with an acceptable precision.

References

Campiglio G, Mazzeo J, Rodriguez S. 2013. A wireless goniometry system. J Phys: Conf Series. 477:012008.

Link HD, Keller A. 2003. Biomechanics of total disc replacement. Springer-Verlag Berlin Heidelberg.

Neelesh K, Dienesh P, Ankit M. 2009. Evaluation of normal Gait using electro-goniometer. J Sci Ind Res. 68:696–698.

Schmitt C. 2007. Orthèses fonctionnelles à cinématique parallèle et sérielle pour la rééducation des membres inférieurs. Lausanne: École Polytechnique Fédérale de Lausanne.

Yazdifar MR, Mahmud J, Esat I, Chizari M. 2013. Evaluating the hip range of motion using the goniometer and video tracking methods. Procedia Eng. 68:77–82.