Ambulatory quality evaluation of the gait

Fonseca, Ligia Cristiane Santos[1]; Koch, Kathrin[1]; Gooding, Jorge[1]; Claus, Thomas[2], Disselhorst-Klug, Catherine[1]

[1]Department of Rehabilitation & Prevention Engineering, Institute of Applied Medical Engineering

RWTH Aachen University, Germany

[2]Dr. Becker Rhein-Sieg-Klinik, Nümbrecht, Germany

E-mail: fonseca@hia.rwth-aachen.de

Introduction

A good structure of knee's articulation conduct to a normal mobility life while the degenerative cartilage loss results in increased stiffness and joint deformity, problem called osteoarthosis (OA). The OA's patients report significant limitations in daily life activities and reduction in quality of life. The conventional therapy can be positive for many young patients, but with increasing age, cartilage repair becomes more complex and the outcome is less predictable, been necessary an arthroplasty and intensive rehabilitation after the surgery to minimize pain and postoperative limping severity. Although patients are able to walk in a normal pattern after this intensive rehabilitation, they fall back into their limping patterns unintentionally. However, walking in a pathological movement pattern means additional stress to the already damaged tissues. Based in this context, the aim of this paper is to present a portable, wearable assistance system which can be used autonomously and provides a direct feedback about the quality of the gait and occurrence of limping to the patient.

Methods

Triaxial-accelerometer based sensor units were integrated into commercially patellar tendon straps. The units measured the acceleration of the knee and transmitted the digital data wireless through an integrated ANT sender module. On the receiver's end, an iOS device equipped with an ANT dongle receives and processes the data for being able to evaluate the quality of the gait. Therefore several parameters were calculated for each step from the measured signals. The gait is divided into two different phases: swing and stance. To detect that gait phases, the extraction of the characteristics events toe-off, heel-strike and toe-strike is necessary. These events were represented by extrema in the acceleration signals and could be extracted. There were seven parameters calculated that describe the quality of the gait. To calculate the gait events, the signals of the three channels of the sensors were used for both legs and for the parameters the signal with the highest energy in the affected leg was used. From the seven parameters, six described the signal shape for each gait cycle and one compared the whole signal between the affected and non-affected leg. Then, a scale within 0-7 points was developed, used to classify the gait in four different categories: normal gait (NG≤2), light limping (LL= 3 to 4), strong limping (SL=5) and very strong limping (VSL≥6). However, in order to minimize the effect of single outliers, as may be the case with a sudden change of direction while walking, the features of single steps were averaged every 5 seconds during gait.

Results

Measurements were performed on a group of 10 patients in rehabilitation after knee or hip replacement surgery. They were asked to walk over a straight, 10 m-long path, four times, in a comfortable speed. The system classified seven patients in the same category as a physical therapist expertise evaluation. The three other patients that the professionals

classified as a normal gait, the system could detect a light limping. The mean score of the patients was 3,6 points at the system and 3,2 points evaluated by the physical therapist.

Conclusion

The developed system demonstrated ability to quantify the quality of gait providing a valuable, easy to use tool for the objective assessment of gait during the rehabilitation. Additional tests series are being carried out to later quantify more precisely the gait quality, allowing not only the detection of pathological gait, but also providing valuable information regarding the severity of the abnormality, which should give insights into the effect of the rehabilitation phase in the clinic, as well in the residential setting, where the system can be used to provide a direct feedback to the patient regarding the quality of the gait in daily living situations.