Computer Methods in Biomechanics and Biomedical Engineering: Supplement for the Society of Biomechanics 2015 Conference

Papers must not be more than two pages long in total, including title, authors, author affiliations, keywords, acknowledgements and reference list, **in Letter US, not A4**. There is no abstract.

Please write your text in Times New Roman 10 point and use a 2-column layout: see template on the next page.
Text should cover the subject, methods of investigation and results.
Two figures and one table can be included to illustrate results and methods.

Text should be arranged under the following headings:
1. Introduction
2. Methods
3. Results and discussion
4. Conclusions
Acknowledgements
References

Deadlines and process

- Papers must be submitted by Friday, April 10th, 2015
- The scientific committee will notify authors by Monday, May 11, 2015
- You should correct your article according to the recommendations of the scientific committee and submit the new version before Friday, Mai 22nd, 2015**.**

If your paper is accepted for publication, it will be copyedited and typeset by the publishers Taylor & Francis. You will be sent a proof copy; please answer any author queries which have been raised by return, as the publication schedule is very tight.

Quantify osteoarthritis gait at the doctor's office: A simple pelvis accelerometer based method independent from footwear and aging.

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1. Introduction

The gold standard to evaluate the severity of osteoarthritis in the doctor's office remain clinical scores [1], [2]. The Western Ontario and MACmaster universities (WOMAC) osteoarthritis index is the most largely used score in rheumatology for lower limb osteoarthritis. It is valid, reliable and sensitive to evaluate osteoarthritis and adapted to doctor's office [3].

However, clinical scores are inherently subjective and they depend from the patient's impression and from the clinician's interpretation. Gait analysis in modern gait laboratories with force plates and photogrammetry is a good tool to have an objective, quantified and precise insight in osteoarthritis [4]. Compared to matched controls, knee osteoarthritis patients have reductions in walking speed [4] and cadence [5], [6], longer double support time [5], [7], a smaller stride length [8]. But for clinical measurements in consultation, simpler methods are needed.

For practical reasons, skin mounted inertial sensors are well suited for investigating gait kinematics [9]. In accelerometer based gait analysis, aging is also known to affect gait parameters [10]–[12]. To have a clinical measure of osteoarthritis, it is essential to find a technique that is independent from aging. Footwear can also affect walking parameters [13], [14]. Since it is too time consuming to ask the patient to take off his shoe for the measurement, it is essential to find a method independent from the shoe type.

Walking ten meters go and ten meters back on a level surface at comfortable walking speed is a well suited protocol for clinical situations that afford 20 meters of walking on a 10 meter walk way.

This study propose to test a 3-D pelvis accelerometer based measurement method on a group of 49 patients suffering from lower limb osteoarthritis and 12 asymptomatic subjects. The aim is to see if the accelerometer based method is correlated with the severity of the lower limb osteoarthritis evaluated with the WOMAC index. This method also needs to be independent from aging and footwear.

2. Methods

2.1 Subjects

Forty seven osteoarthritis patients had hip or knee osteoarthritis diagnosed and graded with the WOMAC index (0 to 96 43 to 90 years, mean 70.9 years) by the same surgeon. Twelve asymptomatic age matched subjects were included in the study (40 to 87 years, mean 60.8). Participants were divided in 4 severity groups. The repartition was based on the WOMAC index. Score ranges were fixed in order to obtain three groups of same score amplitude.

- Severity group 0: asymptomatic subjects.
- Severity group 1: WOMAC from 1 to 32 (slightly impaired subjects).
- Severity group 2: WOMAC from 33 to 64.
- Severity group 3: WOMAC from 65 to 96 (severely impaired subjects).

To assess aging as a confounding factor, seventy five additional asymptomatic subjects were included in the study (18 to 40 years, 27.3). Thus, asymptomatic participants were divided into 4 age groups.

- Age group 0: age from 18 to 39.
- Age group 1: age from 40 to 59.
- Age group 2: age from 60 to 79.
- Age group 3: age more than 80.

Both patients and asymptomatic subjects gave their written consent to participate in this study.

2.2 Instrumentation

Pelvis linear acceleration was collected using one triaxial accelerometers (XSens® MTw Measurement Units 100 Hz). The sensors was fixed on the pelvis (L4-L5 vertebra) using manufacturer designed adhesive Velcro® tape.

2.3 Experimental design and data acquisition

First, WOMAC index was evaluated and recorded by the same experimented orthopedic surgeon. After the sensor fixation, the participant was instructed to execute following sequence: stand quiet 6 s, walk 10 m at preferred walking speed on a level surface, make a U turn, walk back at preferred walking speed on a level surface, stand quiet 2 s.
Participants could keep their clothes and their shoes on. Participants wearing high heels (>2 cm) were asked to do the exercise without their shoes. Each participant made two runs of this exercise to improve the reliability of the measure.
To assess footwear as a confounding factor, one single subject walked 5 trials with five different footwear (25 trials). The shoe types were. Type 1: boots; Type 2: running; Type 3: classical; Type 4: socks; Type 5: sneakers.

2.4 Experimental design and data acquisition

The phases of the exercise (quiet standing, walking and U turn) were manually annotated. Main frequency given by the major peak of the Fast Fourier Transform was computed on the manually annotated walking phases of the exercise including initiation of gait and gait termination. The mean value of the result on the two runs was taken. For the influence of shoe experiment, the mean value on the five runs was taken.

2.5 Statistical analysis

ANOVA analysis with Turkey test pair comparison was performed.

3. Results and discussion

Figure 1 presents the main frequency as a function of severity groups (**A**), the main frequency as a function of age groups (**B**), the main frequency as a function of footwear (**C**).
We observed a decrease of the walking main frequency with the severity of osteoarthritis. Differences were significant for the following pairs: 0-3; 0-4; 2-4. No clear correlation was found between main walking frequency and aging. No significant variation of the walking frequency was found with the footwear.
The objective of our method was to set up a pelvis acceleration method adapted to the doctor's office that have the potential to be correlated with the clinical WOMAC index assessed osteoarthritis severity in 49 patients and 12 asymptomatic subjects walking go and back ten meters in clinical consultation conditions. This method should be independent from footwear and aging.
Gait frequency is known to decrease with aging [11]. This is not clear in our study. It can be explained by the fact that walking frequency is more sensible to osteoarthritis severity than to aging. In fact, our study detects differences with severity but not with aging. This makes main walking frequency a good parameter to assess osteoarthritis severity with accelerometers.

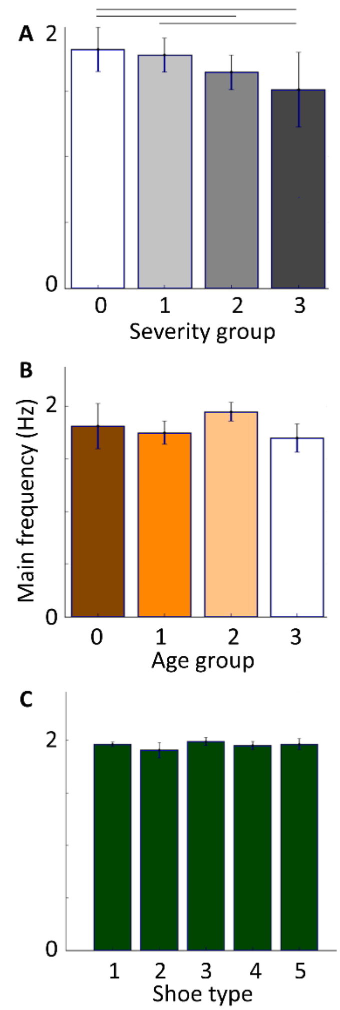

Figure 1: **A** – Main frequency as a function of severity groups. ANOVA analysis with Turkey test pair comparison was performed. **B**- Main frequency as a function of age groups. **C**- Main frequency as a function of footwear.

4. Conclusions

This pelvis accelerometer based method shows a trend correlation with the WOMAC index. This method seems independent from aging and footwear and is well suited for daily use at the doctor's office.

Acknowledgements

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