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# Measurement of Human Gait Impact with Tibial Accelerometry

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**Background, Motivation and Objective.** During the human gait, the longitudinal axis' acceleration peak at the tibia results in terms of the impact of the foot to the ground (calcaneous bone), producing a mechanical shock wave that propagates through the musculoskeletal system, e.g., as from the foot and dissipates as it comes closer to the head. This vibration can be harmful to the human body depending of its' amplitude, frequency and time of exposition. Nowadays, the impact is measured through the Weight Acceptance Ratio (WAR), which is one of the parameters analysed by the footwear comfort standards. Force plates can be used to WAR measurement (force *versus* time curve first derivate – linear region in the first 50ms), providing information about the ground reaction force. The use of force plates does not aloud us to measure other forces, for example at the corporal segments, like the ankle and the knee, which is being exerted. The aim of this study is finding a way to measure the initials gait contact impacts, so it has been developed a study using an accelerometer attached to the medial tibial region.

**Methods.** The uniaxial accelerometer was attached to the tibial medial point with a belt. Subjects (female, size between 35 to 37, in the Brazilian grade) walked on a treadmill, initially barefoot and then with sport footwear, at the speed of 1.11 m/s, for 10 minutes each modality. The accelerometry data acquisition system was developed for analysis of vibration absorption during the human gait (developed at the Brazilian Institute of Technology Leather, Footwear and Devices, at the biomechanics lab). The accelerometer was connected to a signal conditioner then to an A/D converter. The LabView software was used to capture signals and an algorithm, on MatLab, was written for mathematical and statistical analysis. Besides, a software written in PHP was used to data base. A test methodology was developed, which included a study about the most qualified data acquisition index, time of acquisition (10 minutes shod and 10 minutes barefoot – necessary time for the sampling behaves itself as Gaussian), statistical analysis (t Student test, which is the average peak value and calculation of the VAI%), minimum number of trials (made on different days), subjects' evaluation, among others. Thereby, a Vibration Absorption Index (VAI%) was created to compare barefoot and with shoes acceleration peaks, which can be calculated according to the equation 1, evaluating the relative shoes' influence.

$$VAI = \frac{Barefoot - Footwear}{Barefoot} * 100$$

**Equation 1**

**Results.** Studies findings (sport shoes, safety shoes and sandals) showed a data acquisition index of 2kHz, that is necessary only 3 subjects to get an acceptable statistics result, with maximum standard deviation of 7%, the data acquisition is not affected by 10 minutes uninterrupted or interrupted (minute by minute) trials and that is possible to separate shoes, in qualitative terms, using VAI%. After approximately 150 experiments, corresponding to 100 hours of human gait, performed by this study, it was possible to conclude that there is correlation between results

obtained in different days, due to the methodology, for example, it was possible to admit that the same shoe obtained a 7% standard deviation. It means that this methodology can turn the human being variable into a minimum controlled one, with a standard deviation so low that approved and unapproved shoes can be distinguished.

**Discussion and Conclusions.** Ahead of the results, it could be noticed that using a sampling rate inferior to 2 kHz, sampling does not show essential characteristics to determine parameters of tibial vibration. On what refers about time of acquisition, in this study it was possible to verify that inferior trials' time of 10 minutes does not present Gaussian distribution. However, it could be noticed that is also possible to realize trials intermittently, but only if the trials' duration is 10 minutes minimum. The tested shoes showed values of VAI between 24% to 52%, with higher peaks corresponding to barefoot and the lowers corresponding to shod, on behalf of sole and midsole (shoes) properties to absolve vibration. On a preliminary analysis, it was possible to establish VAI levels of approvals, corresponding to values higher than 40%.

**Figures and Tables**

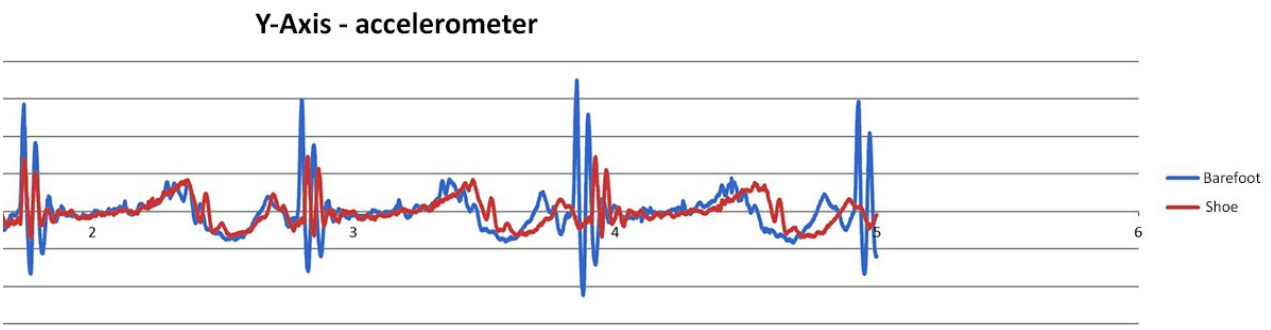


**Figure 1** – Aceleration peaks: barefoot and shoed comparision.

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**Keywords.** Health; Vibration Absorption; Loading Accepting Rate; Signal Conditioner; Musculoskeletal System;