# IMPACT FORCES IN SPORT SURFACES MEASURED BY ACCELEROMETRIC METHOD

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## INTRODUCTION

It has been documented that repeated impact forces can lead to injury (e.g. Voloshin 1981 and 1982, Wosk 1981). Although there are different mechanical methods in literature to measure shock absorption in areaelastic sport surfaces, even in standards (DIN 18032), there are few studies with subjects and accelerometry about the influence of sport surfaces on impact forces. Kim (1992) find differences during runnig on various surfaces. Gross (1988) did not find differences during landing from a vertical jump on various surfaces. The great within-subject variability may be a reason for the scarcity of results.

The aim of this study is to validate the accelerometric method and to find out the influence of impact forces of two different prototypes of indoor surfaces: a wooden surface and a cork surface. We established a concrete surface like reference.

## METHODOLOGY

Accelerometers have been widely used to evaluate the impact waves suffered by the musculoskeletal system. In order to measuring the shock wave that travel through the bones, the ideal method would be an accelerometer directly attached to the bone (e.g. Light 1980).

This implies the method to be invasive, and under most of the situations clearly impractical. Saha and Lakes (1977) reported two main conclusions: First, a preload force is necessary on the skin-mounted accelerometers in order to compress the soft tissue. Second, the properties of the soft tissue separating bone and transducer must be taken in account when attempting to measure bone vibration.

The prototypes of wooden surface and cork surface were of 3,5x3,5 meters. These dimensions were selected by analogy of DIN 18032.

Six healthy young persons were selected and the maximal jump height was determined for every subject. Two accelerometers were attached on the subjects: One in the lower limb and other in the forehead. The lower limb placement was chosen to be the proximal anterior part of the tibia, 3-4 cm under the tibial tuberosity in the internal part. The accelerometer specifications are: Range 20 g, resonance frequency 1200 Hz, sensitivity 2.1 mv/g, weight 0.3 grams. One accelerometer was attached to the skin by a double sided adhesive tape and an aluminium support. The weight of the system was less than 2.5 grams. An elastic bandage wrapped tightly around the shank was used to fasten the accelerometer and to preload the skin. Before the measurements the subject did five minutes of warming up in a static bicycle. Then the subject did forty-five jumps over the three surfaces: Fifteen over concrete, fifteen over wood and fifteen over cork. The jumps were the 95% of the maximal jump and the sequence of jumping was randomized to avoid adaptation to the pavement. Every subject wore his normal sport shoes to avoid changes in the normal pattern of movements. Every group of three jumps the subject did two minutes of rest to complete most of the ATP-PC reserves, principal metabolic way used in this kind of exercise. In this manner we try to avoid the fatigue effects that could be caused by a lactate production (McArdle 1990).

The signal of two accelerometers was amplified and digitized in a personal computer at 1 KHz sampled frequency.

Different parameters were extracted from the acceleration-time curve. We extracted the forefoot contact **(AT1)**, the heel contact **(AT2)** and the maximal of AT1 and AT2 (ATMAX) from the signal of the accelerometer attached at the tibia. We extracted the maximal acceleration (AF) from the signal of the accelerometer attached at the forehead. The acceleration was measured in g (gravity).

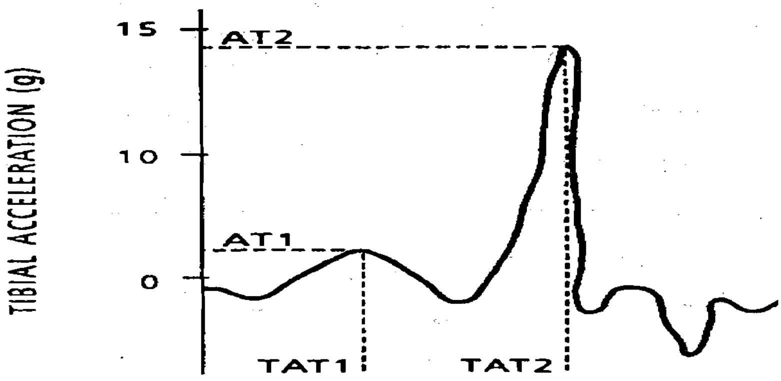


Figure 1: Tibia acceleration

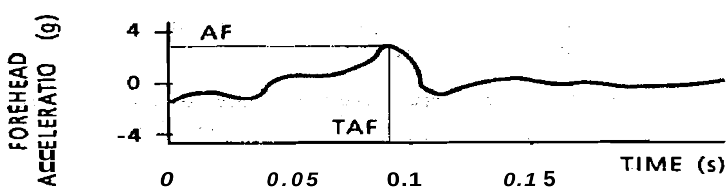


Figure 2: Forehead acceleration

Which each of these variables a multifactor analysis of variance of repeated measures was performed with an alpha value of 0.05. Subject and surface was considered as factors. A multiple range test of Least Squared Differences (LSD) at 95% was used for post **hoc** analysis to determine in which surfaces the differences were significant.

RESULTS AND DISCUSSION

**Table 1: Significative Level(p), Means and Standard Errors for all variables**

| | | AT1 p=0.5 | AT2 p=0.057 | ATMAX p=0.0004 | AF p=0.0001 |
|---|---|---|---|---|---|
| CONCRETE | ME | 6.1 | 10.8 | 12.4 | 2.4 |
| | SE | 0.3 | 0.6 | 0.5 | 0.1 |
| CORK | ME | 5.8 | 9.8 | 10.6 | 2.1 |
| | SE | 0.2 | 0.5 | 0.4 | 0.1 |
| WOOD | ME | 5.9 | 9.9 | 11.2 | 2.0 |
| | SE | 0.2 | 0.5 | 0.4 | 0.1 |

Table 1: Significative Level (p), Means and Standard Errors for all variables

In Table 1 means, standard errors of different parameters are showed. We show the significative level of the surface's factor too. The results of AF and ATMAX are clearly significative. There is not significative level for AT1 and AT2.

A subsequent revision of the measures showed that sometimes the FOREFOOT CONTACT **(AT1)** was higher than HEEL CONTACT **(AT2).** This means that there were two different patterns of movements in the measures. Then we repeated the multifactor analysis of variance without the measures where AT1 was higher than AT2. In this case AT2 has a good significative level (Table 2).

| | | AT1<br>$p=0.26$ | AT2<br>$p=0.025$ |
|---|---|---|---|
| CONCRETE | ME<br>SE | 5.2<br>0.3 | 13.2<br>0.6 |
| CORK | ME<br>SE | 4.7<br>0.2 | 11.6<br>0.6 |
| WOOD | ME<br>SE | 4.9<br>0.2 | 11.9<br>0.6 |

Table 2: Significative Level@), Means and Standard Errors for **AT1** and AT2 when **AT1** is higher than AT2

The multiple range test show that the cork surface is similar to the wooden surface and the two sport surfaces are clearly different of concrete (Table 3). This result is consistent with the manufacturer intentions of developing a cork surface that has characteristics similar to wood surfaces.

| | AT1 | AT2 | ATMAX | AF |
|---|---|---|---|---|
| CONCRETE | * | * | * | * |
| CORK | * | * | * | * |
| WOOD | * | * | * | * |

Table 3: Multiple Kange Test when **AT1<AT2**

The differences that it is possible find with this methodology if we consider a F-test power of 0.8 and alpha 0.05 are showed in Table 4.

Table 4: Differences in **units** of **gravity**

| AT1 | AT2 | ATMAX | AF |
|---|---|---|---|
| 0.4g | 0.7g | 0.6g | 0.2g |

So **we** could deduce that the differences between cork surface and wooden surface are lower of **0.6g** for ATMAX and **0.2g** for AF

CONCLUSIONS

With this accelerometric methodology is possible to study the shock absorption in sport surfaces and find significative levels if the differences are higher than **0.6g** in tibia and **0.2g** in forehead.

**Even if there are two different patterns of movement it is possible find significative levels in tibia acceleration if we consider the maximal of forefoot and heel contact.**

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ACKNOWLEDGMENTS


This work was supported by the Spanish Interministry Commission for Science and Technolgy (Reference Number SAF94-0518) and the enterprise SUBERA S.L.