# INFLUENCE OF FOOTWEAR ON FOOT SENSITIVITY: A COMPARISON BETWEEN BAREFOOT AND SHOD SPORTS

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The purpose of this study was to compare the vibration thresholds of the sensor of the plantar foot between athletes that practice sport with shoes and athletes that practice sport without shoes. Fourty female subjects were divided in two groups: Shod group (SG) with 20 volleyball players and barefoot group (BG) with 20 gymnasts. Vibration thresholds were measured by the use of a vibration exciter at five points of the foot sole: Heel; Mid-foot; Metatarsal Head I; Metatarsal Head V and Hallux. The amplitude of the vibration stimulus was raised until it could be perceived by the subjects, which responded with a verbal sign. The amplitude read at the verbal sign was taken as the vibration threshold. The results show significantly lower vibration threshold values for the BG ($p< 0.001$) when calculating the mean values of the five foot points. The vibration thresholds measured at each of the five selected foot points were lower for the BG in comparison with the SG. However those differences were not statistically significant. The results indicate that the higher vibration sensitivity at the plantar foot for the BG may be explained by the sport practice without footwear as well as by the technical demands of the sport.

**KEY WORDS:** footwear, barefoot, plantar foot, vibration thresholds, sports.

## INTRODUCTION:

The research considering vibration sensitivity of the foot has gain importance over the years. Data from these investigations have been used mainly as an indicator for diseases of the neuronal system, like Diabetes Mellitus and Parkinson Syndrome (Halonen, Lang, Nyrke, 1998). It is also known that factors like age have an influence on the vibration thresholds. The increased age is related with a decline of the threshold values (Thornbury & Mistretta, 1981). However, there is still controversy in the literature on how the foot of healthy people reacts to vibration stimuli, since the thresholds are very individual and may also be dependent on anthropometrical parameters (Inglis et al., 2002, Bartlett et al., 1998). It's also not clear, how external factors like footwear influences vibration threshold perception at the foot sole. Due to the demands of the current footwear market, sport shoes have been constantly developed in order to provide comfort and performance for the user. This development may also have negative consequences for the foot, since much of the work from muscles and sensory organs may be reduced through special properties of the footwear. This study has the objective to investigate the influence of footwear on vibration threshold perception of athletes. A comparison was performed between athletes that practice sport with and without shoes.

## METHOD:

**Data Collection:** Before data collection, all subjects signed a consent form according to the norms of Chemnitz University of Technology for research with human subjects. 40 female gymnasts and volleyball players participated in the study. Inclusion criteria were age between 15 and 30 years, and a sport experience of at least 3 years, with regular competition. Two groups were divided according to the practiced sport: Shod Group (SG), with 20 volleyball players (age 21.9 (±3.7)years, height 177.9 (±6.2)cm and weight 70 (±7.3) kg), and Barefoot Group (BG), with 20 gymnasts (age 19.0 (±3.7)years, height 164.0 (±5.7)cm and weight 56.1 (±6.1)kg). The SG had an average experience of 7.7 years with the sport, while the BG had in average 9.6 years of sport practice. Data collection procedures were as follows:

1. The subjects laid down on a supine barefoot position for 10min, in order to adapt to the room temperature. After that, the foot temperature was measured at the plantar mid-foot

area. The same procedure was repeated after the vibration threshold measurements. The foot temperature was measured to avoid the influence of this parameter on the values of the vibration thresholds (Nurse et al., 1999).

2. The vibration thresholds were measured by a Vibration Exciter. The vibration was produced through an 8mm diameter metal probe, which kept contact with the foot during the data acquisition. The amplitude and frequency of the vibration could be adjusted through an oscillator connected to the Vibration Exciter. For the vibration measurements the subjects sat down on a table and placed their foot on a plate located at the top of Exciter. Knee angle during the measurements was approximately 90°. Subjects were instructed not to exert any pressure with the foot during the data acquisition. The vibration thresholds were measure at five points the foot sole: Heel (H), Mid-foot (MF), Metatarsal Head I (METI), Metatarsal Head (METV) and Hallux (HA). The order of the measurements was randomized for the five foot points. Acquisition frequency was set at 30Hz (Prätorius & Milani, 2004). In order to identify the vibration thresholds, the amplitude of the vibration was raised until that level that subjects could perceive the stimulus. Subjects were required to give a verbal sign to indicate recognition of the stimulus. The amplitude in µm (micrometers) at the verbal sign of the subjects was taken as the vibration threshold. Three measurements were performed at each of the five selected foot locations.

**Data Analysis:** Means and standard deviations from the vibration thresholds were calculated for the individual subjects as well as for both groups for all five measured foot locations. An overall mean threshold value (mean value calculated from the threshold values measured at the 5 foot points) was calculated for both groups. In order to compare the threshold values between the groups, the *t*-test for independent samples was used. Level of significance was set at p<0.05. To compare the thresholds measured at the different points on the foot sole for the subjects within the same group, the ANOVA *one-way* was used (p<0.05).

## RESULTS:

The results of the temperature measurements show very close values for both groups. Mean temperatures before the vibration measurements were 27.9° and 28.1° for the BG and SG respectively. The temperature for both groups decreased after the vibration measurements in similar amounts, with 1.1° for the BG and 1.3° for the SG.
The results of the overall means calculated for both groups are shown in figure 1 below.

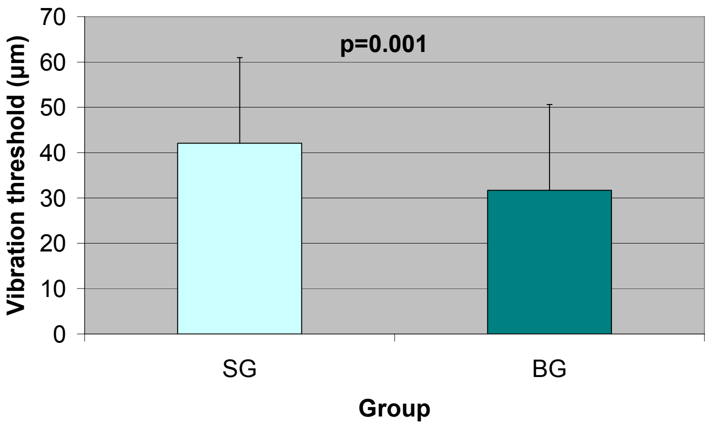


Figure 1 - Comparison of the overall mean thresholds (µm) between the groups

The results of the vibration thresholds show that the BG has better foot sensitivity than the SG. The overall mean threshold value is lower for the BG (31.7µm) in comparison with the SG (42.1µm). The difference between the groups for this parameter was significant (p=0.001).

Figure 2 presents the results from the comparison of the vibration thresholds measured at the 5 selected foot points between both groups.

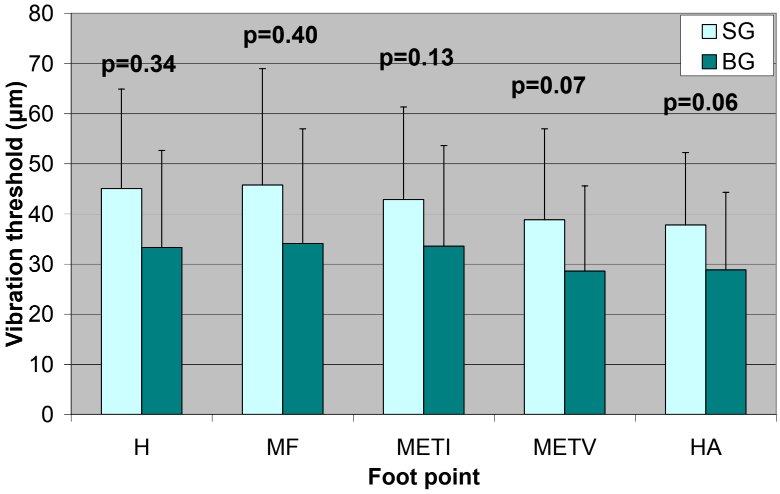


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**Figure 2 - Vibration thresholds (μm) measured at the five selected foot points: comparison between the groups**

The results in figure 2 indicate differences as well as a high variability on the vibration thresholds measured at the five points when comparing both groups. For all measured points, threshold values from the barefoot group (BG) were lower than the values from the shod group (SG). Although the differences between the groups vary from 24% to 27%, no significance could be attested to the results

Figure 2 also shows that the threshold values measured at the five points have little variation within the groups. The ANOVA produced no significant results for the comparison of the vibration thresholds measured at the five selected foot points within each group (p= 0.58 for the SG and p= 0.80 for the BG).

**DISCUSSION:**

The purpose of this study was to compare the vibration thresholds between female athletes that practice sport with (represented by volleyball players) and without shoes (represented by gymnasts). The results show that the grand mean threshold value is significantly lower for the BG in comparison with the SG.

When comparing the results measured at the 5 selected points within the groups, both groups show the same tendency for the lower threshold values. The points with the lowest vibration thresholds were the Hallux and the 5$^{th}$ metatarsal head for the SG and BG, respectively. The highest thresholds were found at the Midfoot for the SG and at the 1$^{st}$ metatarsal head for the BG. Although the values differed at the five measured points, no significant difference was found for the comparison among those. This result matches with the results found by Nurse & Nigg (1999), in which the authors found no differences for the vibration thresholds measured in 4 points at the foot sole. However, differences appear when comparing the present data with data from the study by Inglis et al. (2002). The latter authors found the lowest threshold values at the medial ball and lateral arch regions, which differs from the results of the present study.

The overall mean thresholds found in this study match with the ones described on the literature (Prätorius & Milani, 2004; Inglis et al., 2002). Although these values show highly significant differences between the groups, no significant differences could be found for the comparison of the threshold values measured at the 5 selected foot points between the shoe and barefoot groups. However, the results present lower threshold values for the BG at all 5 measured points, with differences varying from 24% to 27%, indicating better vibration sensitivity for the BG for all the measured foot areas. The non significant results for the

comparison between the foot points can be explained by the high inter-subject variability, which is also described in the literature (Bartlett et al., 1998).
The demographical data from both groups show very close mean values for the age, but clearly evidence that the SD is an average taller and heavier than the BG. There is no definitive statement on the literature about the influence of anthropometrical variables, like height and weight, on the result of vibrations measurements. Authors like Bartlett et al. (1998) indicate that the height of the subjects should be taken in account when analysing data from vibration measurements. However, most of the research about vibration at the foot sole in normal subjects shows no influence of such anthropometrical parameters on the threshold values (Hilz et al., 1998; Halonen, 1986). Assuming that the anthropometrical parameters do not influence the vibration thresholds, the difference found for both groups may be explained by the use of footwear during the sport practice.
Another fact to be considered is the different technical demands from both sports. In comparison with volleyball, gymnastics is a spot which requires more from the balance capability of the athletes, especially from static balance. The capability to maintain static balance is very important on the judgment of some technical elements, for example at the balance beam. The literature indicates that better foot sensitivity produces increased balance control (Meyer, Oddsson & de Luca, 2004), which may also explain the better vibration sensitivity of the barefoot group.

## CONCLUSION:

The results of the vibration measurements indicate that athletes which practice sport barefoot, represented by gymnasts, have better vibration sensitivity at the plantar foot than athletes which practice sport with shoes, represented by volleyball players. The better vibration sensitivity may be explained by the sport practice without footwear and also by the technical demands of the analysed sports.

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