# Effects of cam boot on plantar pressures during gait

Elizabeth Splitter*, Michelle Pettigrew, Jennifer Berry, John Ayres
*Department of,Physical Therapy, College of Health Professions*

During walking, plantar pressure is exerted through the foot from the time when the heel is in contact with the ground until the toes leave the ground. A cam boot (CB) is designed to spread this pressure across the entire plantar surface of the foot and is typically worn by one with a foot or ankle fracture. In an average person, a slight leg length difference (LLD) of less than a quarter-inch is normal; however wearing a CB increases this LLD one-half of an inch. This LLD caused by wearing the CB may result in a difference of plantar pressure between feet. Significant increases in pressure may lead to ankle, knee, hip, and low back pain. Presently, physical therapists do not even out the LLD by building up the unaffected foot when prescribing a patient with a CB. The purpose of our study is to test possible significant variations in plantar pressure between feet from LLD caused by wearing a cam boot. The results of our findings could lead to new evidence suggesting that equalizing the LLD caused by wearing a CB will also equalize plantar pressure between feet, resulting in a decreased chance of pain from body mal-alignment. Twenty-five female and nine male subjects between the ages of 18-45, who met the inclusion criteria, performed two walking trials: once wearing and once not wearing a CB. Plantar pressures were measured using the F-scan computerized insole system. Our results show there was a significant increase in plantar pressure on the foot not wearing the CB. We conclude that wearing a CB will increase the plantar pressures through the leg not wearing the boot.

## 1. Introduction

The research problem is whether or not wearing a CB causes a significant difference in plantar pressure variance between the left and right feet. The significance of the problem is that a difference in plantar pressures could be an indication of an induced LLD as a result of wearing the cam boot, which could result in ankle, knee, hip, and back pain.

In this study, the term plantar pressure is defined as the pressure exerted on the foot during the stance phase of walking (from the initial contact of the foot with the ground through pushing off the ground). When assessing plantar pressures, consideration will be given to initial contact, pre-swing to toe-off, and peak pressures. Initial contact is defined as the first impact of the foot with the floor, the event that begins stance. Pre-swing is defined as the last phase of stance that also is the second period of double limb support and toe-off as the point at which the toe leaves the ground. Peak pressure is defined as the maximum vertical force registered during walking.

When wearing a CB on one foot, an induced leg length difference may occur. Because the bottom of the cam boot is much thicker than a person's normal shoe sole, the leg wearing the CB becomes functionally longer than the leg not wearing the CB. Although there is no research that has answered with certainty if there is a direct relationship between having a significant LLD and having hip and back pain, there is some agreement in literature that a significant LLD adversely influences the hip and lumbar spine. [1]

There is not very much literature exploring the effect of LLD on plantar pressures, which prompted this study. The purpose of this study is to test the effect of wearing a CB on plantar pressures between left and right feet. Our null hypothesis is that there is no significant difference in plantar pressures while walking with a CB and walking without a CB.

## 2. Experiment, Results, Discussion, and Significance

The study consisted of 34 subjects between the ages of 18-45 with no leg length difference greater than ¼ of an inch, no major lower extremity strength deficit, no neurological conditions and no history of musculoskeletal dysfunction based on a health questionnaire and a screening examination.

The screening examination consisted of measuring leg length difference, manual muscle testing (MMT) for hip flexion, hip extension, hip abduction, knee flexion, knee extension, ankle plantarflexion, and ankle dorsiflexion. All MMT were performed by instructions per *Daniels and Worthingham's Muscle Testing*.[2] If the subject met the

criteria, and signed the informed consent, they were included in the study and given an identification number to maintain confidentiality.

The *F-Scan* system was chosen to measure the peak plantar pressure, initial contact pressure and pre-swing to toe-off in this experiment. The *F-Scan* captures foot plantar pressure contact time and force, and displays a selection of calculated data for analysis. To use the *F-Scan*, the subject strapped the lightweight receiver unit and battery pack to their waist, attached the *F-Scan* cuffs to their ankles, and placed the *F-Scan* insole into their shoes. The receiver unit stored all of the information measured by the insoles allowing the subject to move about freely, and virtually anywhere. The Mobile receiver unit attaches to a PC via USB cable to transfer test parameters and data.

Each subject, while wearing the *F-Scan* and insoles, was asked to walk on a firm surface for 40-45 feet to obtain the data. The first reading taken was the subject's baseline reading, which involved the subject walking at his normal pace in a straight line without the CB on. The subject held a button that was used to start the recording process. Subjects were asked to walk 31 feet before pushing the button to allow for their feet to settle into the insoles. Once they pushed the button, the receiver unit started recording the subject's data. The subject walked until the unit beeped to indicate that it had finished recording. The distance walked was dependent upon the individual's stride length and was usually around 10 feet. The receiver unit was then reconnected to the computer to download the data into the *F-Scan* software. The computer then analyzed the data. After the data had been saved, the subject was then asked to repeat the same process with the CB on their right foot

A significant difference was found when the 2-tailed p value was less than or equal to .025, using the Bonferroni adjustment. Overall there is a higher peak pressure on the left with the CB than without. This difference was significant with a 2-tailed p value of .004. Without the CB, twenty people had higher pressures on their left foot than on their right, and only ten people had higher pressures on their right foot. With the CB, twenty-two people had higher pressures on their left foot than on their right, and only eight people had higher pressures on their right foot.

Table:1
Average foot pressures when walking with and without CAM boot (PSI)

| | With Orthosis | Std. Deviation With | Without Orthosis | Std. Deviation Without | Sig. (2-tailed p value) |
|---|---|---|---|---|---|
| Right max peak pressure | 68.70 | 34.80 | 65.57 | 24.26 | 0.663 |
| Right initial contact | 59.27 | 21.62 | 42.67 | 16.01 | 0.000 |
| Right toe off | 38.33 | 17.51 | 55.87 | 23.19 | 0.000 |
| Left max peak pressure | 125.30 | 73.39 | 106.27 | 54.69 | 0.004 |
| Left initial contact | 79.20 | 55.24 | 65.67 | 33.34 | 0.022 |
| Left toe off | 106.10 | 61.94 | 96.27 | 56.36 | 0.010 |

The results of this study indicated that wearing a CB increased plantar pressures on the short leg side, the side opposite of the CB. These findings supported the hypothesis that there is a significant difference in plantar pressures while walking with and without a CB.

## 3. Conclusion

In conclusion, people between the ages of 18 and 45 who have no pre-existing LLD will exhibit an increase in plantar pressures while wearing a CB on one leg. There will be a greater increase in plantar pressures on the side that is not wearing the CB. Given these findings, when a patient has either a true or CB induced LLD, the therapist should build up the shorter side to within ¼ inch to even out plantar pressures in order to reduce the risk for potential problems such as knee, hip, and back pain.

## 4. Acknowledgments

Special thanks to Dan Runyan, BS, MS, RPT, for supplying all of the equipment used to collect data in this research project, and for his assistance in operating the computer system while subjects were being studied. Thank you to Robert Manske, PT, DPT, MEd, SCS, ATC, CSCS for providing advice and assistance. Also, thank you to all of the subjects who participated in this study.

[1] Veterans Affairs Canada Website. Available at: http://www.vac-acc.gc.ca/providers/sub.cfm. Accessed April 11, 2006.

[2] Hislop H. Montgomery J. Daniels and Worthingham's Muscle Testing Techniques of Manual Examination, 7th Ed. Philadelphia: W.B. Saunders Company; 2002.