EFFECTIVENESS OF THE KINETIC WEDGE FOOT ORTHOSIS MODIFICATION TO REDUCE RELATIVE PLANTAR PRESSURE

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INTRODUCTION

Humans are the only species to successfully walk using an erect bipedal posture. The unique design of human feet, more so the first metatarsophalangeal (MTP) joint allows us to walk in a relatively upright position, to facilitate the efficiency of the inverted pendulum (Winter, 1995). An obstruction, inability or delay of the inverted pendulum to move through the sagittal plane is referred to as sagittal plane blockade. One source of sagittal plane blockage is the inability or delay of the first MTP joint to permit adequate dorsiflexion from late stance phase, to toe-off during gait. This condition is referred to as **Functional Hallux Limitus (FHL).** Podiatric clinicians suggest that FHL can result in slight disruptions of the inverted pendulum's centre of gravity (CoG) through the sagittal plane (Winter, 1995; Dananberg, 1986, 1993).

According to clinicians, FHL can produce momentarily elevated plantar pressures under the first MTP joint and Hallux. FHL can also lead to compensatory gait adaptations to restore the pendulum. One compensatory strategy used by individuals with FHL is to use the lesser MTP joints, rather than the first MTP joint to facilitate the inverted pendulum during stance. This strategy can be illustrated with elevated plantar pressures under the lesser metatarsal heads. Clinicians suggest this compensatory action may be a contributor to overuse injuries of the plantar tissues of the foot. Such inappropriate tissue stress can be expressed as plantar calluses under the metatarsal heads and hallux. The podiatric community uses custom foot orthoses (CFO) with the Kinetic Wedge modification (Langer) to improve MTP joint function and thereby reduce lateral forefoot plantar pressure. The purpose of this study was to determine if a CFO with a Kinetic Wedge modification reduces relative plantar pressures under the first MTP joint, the hallux and the fifth metatarsal during late stance.

METHODS

Fifteen subjects having moderate to severe FHL by a chiropodist were included in the study. Each subject was supplied a pair of CFOs manufactured with the Amfit CAD/CAM system. Plantar pressure data were recoded during multiple walking trials using the *F-Scan* system (Tekscan Inc.). Each subject was tested with the CFO without the Kinetic Wedge modification (NKW) and with the CFO plus the Kinetic Wedge modification (KW). Data for KW were collected after 30 minutes of practice. Plantar pressure data under the first MTP, hallux and fifth metatarsal for both conditions (NKW and KW) were compared. Relative peak plantar pressure under each of the three segments of the foot was used to represent maximum pressure.

RESULTS AND DISCUSSION

The average maximum plantar pressure under the first MTP joint achieved by all subjects during NKW was 1.871 kg/cm^2 ($\pm$0.459). The average maximum plantar

pressure under the first MTP joint achieved by all subjects during KW was 1.554 kg/cm^2 ($\pm$0.409). Overall, application of the Kinetic Wedge modification to custom foot orthoses resulted in an average decrease of 0.317 (16.03%) kg/cm^2 in maximum plantar pressure under the first MTP joint during stance (SD = 0.326). The decrease in first MTP joint plantar pressure during stance was statistically significant ($p < 0.05$). Placing the first MTP joint in a relatively greater dorsiflexed position allowed the joint to avoid functional limitations. In addition to avoiding functional limitations, dorsiflexion of the first MTP joint may have established an anatomical forefoot rocker. Such a shaped surface would create a path of lesser resistance as the body centre of mass progresses forward over the first MTP joint.

Considering a significant reduction of first MTP joint plantar pressure, a significant reduction of hallux plantar pressure was expected. The average maximum plantar pressure under the hallux segment experienced by all subjects during NKW was 2.66 kg/cm^2 ($\pm$0.832). The average maximum plantar pressure experienced under the hallux segment by all subjects during KW was 2.28 kg/cm^2 ($\pm$0.781). Overall, application of the Kinetic Wedge modification to custom foot orthoses resulted in a decrease of 0.373 kg/cm^2 (14.05%) in maximum plantar pressure under the hallux segment during stance (SD = 0.743). The decrease in hallux segment plantar pressure during stance was not statistically significant ($p>0.05$).

Since the data showed an improvement first MTP joint plantar pressure, a reduction of plantar pressures experienced by the lesser metatarsal heads pressure was also expected (Dananberg, 1993 and Dananberg *et al.*, 1996). The average maximum plantar pressure experienced under the 5th metatarsal segment by all subjects during NKW was 1.749 kg/cm^2 ($\pm$0.608). The average maximum plantar pressure experienced under the fifth metatarsal segment by all subjects during KW was 1.748 kg/cm^2 ($\pm$0.789). Overall, application of the Kinetic Wedge modification to custom foot orthoses resulted in a decrease of 0.0005 kg/cm^2 (SD = 0.363) in maximum plantar pressure under the fifth metatarsal segment during stance. The decrease in fifth metatarsal segment plantar pressure during stance was not statistically significant ($p>0.05$). According to the results, modified CFOs did not reduce the tendency of subjects to use the compensatory strategy of first MTP avoidance.

No significant change between treatments may have been related to the amount of practice time provided to subjects before KW data collection. Perhaps months, weeks, or even days of modified CFO use be required to result in significant kinetic changes at each site of the foot.

REFERENCES

Winter, D.A. (1995). *Gait & Posture*. **3**, 193-214.

Dananberg, H.J. (1993). *J.A.P.M.A.* **83**, 433-441.

Dananberg, H.J. (1986). *J.A.P.M.A.* **76**, 648-652.

Dananberg, H.J., Phillips, A.J., Blackman, H.E. (1996). *Ad. Pod. Med. Surg.* **2**, 67-87.

Dananberg, H.J. (1995). *Spine: State of the Art Reviews*. **9**, 389-405.

ACKNOWLEDGEMENTS

The chiropody staff of Total Foot Care, M. Louis Goudreau and staff of Rehabilitation Engineering of The Rehabilitation Centre, Ottawa Hospital and Mr. Graham Curryer