

# An investigation into the effects of experimentally induced plantar insensitivity and limitation of joint mobility on pressures under the foot during normal walking.

Sally R Pembery, David N Dunning, N Chockalingam  
Faculty of Health, Staffordshire University, Stoke on Trent, ST4 2DF, UK  
email: d.n.dunning@staffs.ac.uk

## Introduction:

Neuropathy is a major complication of diabetes affecting up to 50% of sufferers of both types of the disease. Altered gait patterns have been shown to be associated with neuropathy (Nurse et al 2001) as has limitation of joint motion (LJM) (Veves et al. 1995) and muscle and tendon stiffness. Lavery et al (2002) noted that the ankle joint stiffness is associated with increased metatarsal pressure and Orendorf et al (2006) noted LJM as a factor in ulceration of the metatarsal region. This study will investigate effects of induced insensitivity and LJM on pressures under the foot to compare with changes in gait in diabetic neuropathy as shown in the literature (Williams et al 2007).

## Method:

13 healthy individuals (40.6yrs, SD 9.0; 74.5kg, SD 13.2; 163cm, SD 7.84) with no history of neurological or systemic disorders were recruited 8 of which completed the study. Sensation loss was induced by using an immersion technique involving suspended immersion in iced water at a constant 0°C (32°F) for 10 minutes to the level of the malleoli. Plantar cutaneous sensation was verified using a 20 set Semmes Weinstein Monofilaments Test (SWMT). LIM was achieved using a standardised combined strapping protocol. This consisted of a figure of 6 plus a heel lock and stirrup strapping technique as described in Brukner et al (2002). Foot pressure data was collected using a 0.5m pressure plate (RSScan, Olen, Belgium). Pressure plate measurements were performed during barefoot walking before (base line) and after reduction of plantar sensation (iced) and LJM (iced and taped). A three step protocol was used and the data recorded was analysed using 10 standard regions comparing maximum pressure. Also the time to heel lift and the time to Toe off were also recorded and compared.

## Results:

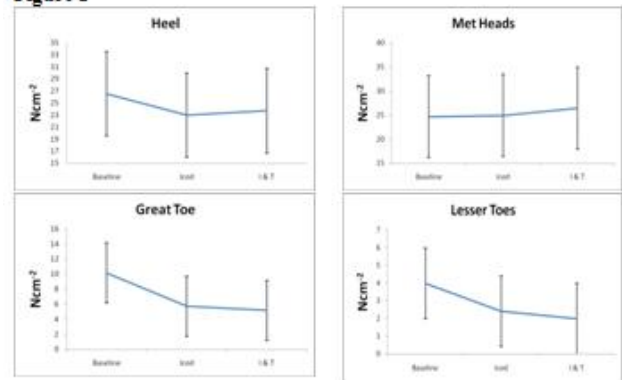
The SWMT showed a reduction in sensation commensurate with scores that would be found in diabetic neuropathic patients. Range of motion was also reduced by an average of 4.2° with the strapping. Maximum pressure data showed a significant reduction at the great toe, the lesser toes and the heel (P 0.013, 0.0, 0.001 respectively) between baseline and iced and also between baseline and iced and taped for the great and lesser toes (P 0.0, 0.006 respectively) whilst maximum pressure at all the metatarsal heads showed a trend to increase. (Figure 1) All subjects showed an increase in the time to last foot contact in the iced condition when compared to base line data. (Figure 2). A review of the literature on gait and diabetes revealed a consensus showing a pattern of characteristics.

## Discussion

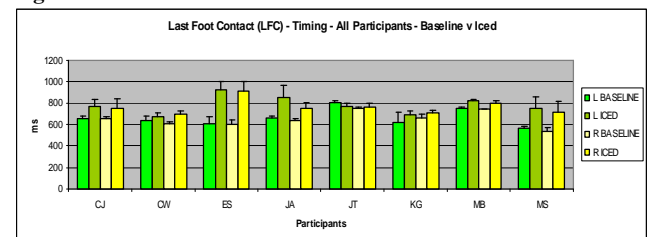
Consistent with the results presented in this study, a reduction of peak pressures under the heel & toes and a shift of load to the central forefoot were reported in neuropathic patients in comparison to controls, (Kersting et al, 1992). Boulton et al, (1987) reported reduced or absent toe function and a load shift from the toes to the metatarsal heads during toe off in patients with early diabetic neuropathy. One of the key differences observed following the iced condition was an increase in the time of foot contact. This points to a reduction in walking speed. This is consistent with previous studies in which reduced walking speed was shown to be associated with people with diabetic neuropathy compared to age-matched controls and similar studies of induced plantar insensitivity, (Mueller et al, 1994, Katoulis et al, 1997 & Taylor et al, 2004a, Eils et al, 2002 & 2004)

**Conclusion:** The study showed a correlation between the induced neuropathy with artificially created LJM and similar studies of diabetic neuropathic patients pointing to the local affects as a being the main cause of these factors and not the effects of the disease process in diabetes.

**Figure 1**



**Figure 2**



## References

- Nurse M. A., Nigg B. M., (2001) The effect of changes in foot sensation on plantar pressure & muscle activity. *Clinical Biomechanics* Vol 16 Iss 9 pp 719-727.
- Williams D.S.B., Brunt D., Tanenberg R.J., (2007) Diabetic Neuropathy Is Related to Joint Stiffness During Late Stance Phase. *Journal of Applied Biomechanics* Vol 23 Iss 4 pp251-260.
- Boulton A. J, Betts R. P., Franks C. I., Newrick P.G., Ward J.D., Duckworth T. (1987) Abnormalities of foot pressure in early diabetic neuropathy. *Diabetic Medicine* Vol 4 pp 225-228