Clinical innovation: wider collaboration on lymphoedema research is needed — footwear and gait analysis

Extending teams that research and manage lymphoedema to include orthotists and podiatrists may extend our understanding of the condition and component parts of treatment. New technology, some of which is low cost, enables an increasing range of data and outcome measures. This article highlights the reality of a shortage of studies involving gait analysis and a lack of consideration of the impact of inappropriate footwear on exercise as a key component of lymphoedema management.

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Healthcare professionals specialising in lymphoedema management are familiar with the concept of working within a multidisciplinary team for maximum benefit to patients with lymphoedema. This team often includes nurses, physiotherapists (PTs), occupational therapists (OTs), doctors and, on occasion, social workers, but podiatrists and orthotists are rarely considered. This is surprising, given that complex foot problems, including difficult decisions on the bandaging of diabetic wounds, are often acknowledged in patients with lower-leg chronic oedema[1] *[Figure 1]*. The knock-on effect for joint alignment, however, is rarely discussed.

Podiatrists and lymphoedema

In a national study, podiatrists in Scotland reported they played a role in lymphoedema identification and management. They also had a key role to play in providing patient education[2]. Their top learning needs were:

- How to advise patient on skin care to avoid cellulitis
- Differential diagnosis of lymphoedema and other oedemas
- Awareness of current lymphoedema management techniques
- Identification of those at risk of lymphoedema.

Geyer and colleagues (unpublished) at the University of Pittsburgh Foot Research Study undertook a snapshot study during the International Lymphoedema Framework conference in 2011 in Toronto, Canada. This used 3-D scanning equipment in a joint assessment by a pedorthist (footwear specialist) and lymphoedema specialist, and completion of questionnaires by patients. Despite this pilot work and indicators from clinical practice, lymphoedema research involving podiatrists (or pedorthists) seems curiously absent.

Orthotists and lymphoedema

Similarly, there is a dearth of literature on the possible advantages of incorporating the expertise of orthotists into our understanding of the impact of lymphoedema on the body. Still, this group of professionals are expected to deal with complex issues, such as the longstanding effects of joint malalignment due to abnormal weight distribution through the joints *[Figure 2]*.

Orthotists are interested in the mechanics of human locomotion; in particular, forces and the impact these forces have on the body during standing and locomotion. They assess gait and prescribe orthoses to alter these abnormal forces, in order to reduce moments about joints to impact on pain and improve alignment (moment = force x distance). They also advise on footwear and, where required, prescribe specialist footwear to accommodate increased body mass and altered foot shape.

The increase in mass in a body segment due to the presence of excess fluid in lymphoedema results in an increase in the forces needed to achieve locomotion (force = mass x acceleration). There is strong evidence linking an increase in body mass index (BMI) to an increase in knee osteoarthritis, but not

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Figure 1. Bilateral foot deformity from lymphoedema.

Figure 2. Female with Primary lymphoedema requiring multiple orthoses.

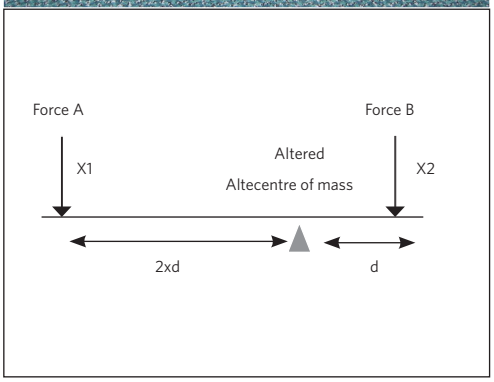

Figure 3. The potential change in forces around a joint in lymphoedema.

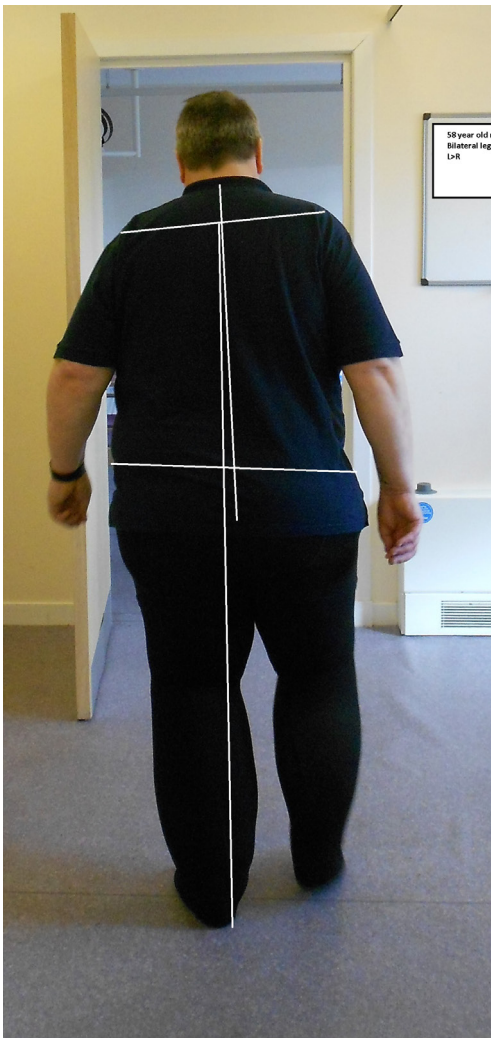

Figure 4. Left leg >Right leg volume shifts centre of gravity on walking gait.

the hip[3,4]. Logically, altered biomechanics and forces on joints combined with an increase in weight of the affected body segment could be linked to advancement of osteoarthritis and joint pain. Further research is required to investigate this supposition.

A limb affected by lymphoedema would exhibit abnormal anthropometrical characteristics (e.g. length to circumference ratio) with an altered centre of mass. Changing the centre of mass in a limb segment alters the moment about that joint, requiring the muscles to increase the force to control the body segment compared with the non-affected limb. *Figure 3* illustrates the increase in force required when the equilibrium of a joint is affected by the movement of the centre of mass doubling the force required by the set of muscles B to maintain the stability of the limb. If movement is required, then the muscles B have to work twice as hard as set A.

An additional problem is that swelling in a body segment often restricts or alters range of motion (ROM). Restricted ROM results in compensation at other joints or gait deviations. Aggithaya et al[5] conducted a study on the effects of yoga on people with lymphoedema. As part of the study, gait deviations were captured. The most common gait abnormality was antalgic gait. This is typically an altered gait pattern to avoid pain, a notably shortened stride length and a stance phase that is shorter than swing phase of gait. Structural and functional abnormalities were observed in hip, knee and ankle joints combined with muscle weakness. These factors result in altered biomechanics during gait.

Gait analysis

The abnormal distribution of weight that occurs with lymphoedema, particularly when unilateral, can disturb normal gait and daily

functional activities. Problems not only arise when the legs are severely oedematous *[Figure 4]*, but a heavy oedematous arm can also affect balance and gait. Simple observation can establish that a swollen arm has the potential to significantly redistribute weight/balance affecting the biomechanics of other muscles and joints and therein gait, yet there is a dearth of research on this aspect. Specifically in relation to lower limb, the shift in centre of gravity can combine with difficulties in obtaining suitable footwear; in the vulnerable, this can lead to an increased risk of falls. In addition, these problems combine to impact on one of the most important components of lymphoedema management — exercise.

Clinical gait analysis is often conducted using the observational skill of the clinician, however, with the improvement in technology in recent years, video analysis is easily achievable using mobile technology, such as telephones and video cameras *[Figure 4]*. In addition, forces can be captured during gait by mapping pressure from in-shoe pressure monitoring systems. These have their own limitations depending on the system, such as trailing wires or limited pressure sensors.

To capture ground reaction forces during locomotion, access to a force plate normally located in gait laboratories is required. This technology is relatively expensive to install and run, however, it can be used to determine where the forces need to be realigned and measured pre- and post-treatment to accurately capture the effect of treatments on gait. Furthermore, electronic shape capture can be used to monitor changes in volume and can also be used to manufacture custom orthoses. With improvements in scanning technology, such as handheld scanners and CAD/CAM systems, accuracy and speed of manufacture are increasing.

Surprisingly, there has been little use made of modern advanced technology for gait analysis in the study of lymphoedema and its management. Studies of specific treatment modalities with other conditions may provide an indication of the potential of the incorporation of gait analysis as an outcome measure.

Gait analysis, along with other outcome measures, has been used in studies of chronic venous insufficiency (CVI). In a study of the effects of Complex Decongestive Physiotherapy (CDP) on CVI in older patients[6], pain-free gait was shown to improve significantly with CDP. Similarly, in early stage CVI (up to C3 Clinical-Etiology-Anatomy-Pathophysiology (CEAP)) kinesiotaping produced significant pre-/post-treatment improvements in both lower limbs in gait dorsiflexion range of ankle motion (ROAM) (95% CI, 1.02-2.49), cadence (95% CI, 3.45-1.47), stride length (95% CI, 21.48-10.83), step length (95% CI, 1.68-6.61) and stance phase (95% CI, 61-107), which were not seen in their non-kinesiotape sample population[7]. Given the importance of ankle dorsi-flexion for effective calf muscle pump and venous (and probably lymphatic) return, such data are important to consider. Furthermore, there is some indication that gait analysis is a useful outcome measure pre/post liposuction as a management intervention[8].

Differential analysis of which treatment components are significant, and which concurrent outcome measures retain significance, may also be illuminated by this additional data. A study by Piesla et al[9], for example, indicated that pain was more significant to gait disturbance than swelling (oedema); therefore, if pain is not present or if pain is not eased by lymphoedema management then gait would not be a significant outcome measure. However, due to the population studied by Piesla et al[9], they did not need to concern themselves with the sheer size and weight of the limb, which would be additional variables for many lymphoedema patients.

Summary

Orthotists investigate the altered biomechanics of the body and the impact of this on function and gait. They design orthoses for individuals to address problems that have been identified. By improving gait and the range of movement of affected joints, orthotists could improve quality of life, pain and prevent early onset of osteoarthritis. Further research in this area is recommended in order to capture the impact and health economics of orthotic treatment and inclusion of the orthotist in the MDT.

Podiatrists have a far greater understanding of foot pathology and dynamics than most nurses, PTs, OTs or doctors. Collaborative research has the potential to inform our understanding of the effect of lymphoedema and its management on gait and the likely sequelae. Such understanding may reduce

the complex comorbidities of this population and inform management strategies for the growing population of obese patients with co-existing lymphoedema, and the separate particular problems of lipoedema.

The authors are currently pursuing funding for just such a study. In the meantime, lymphoedema specialists and others caring for people with lymphoedema, chronic oedema and lipoedema may do well to consider orthotists and podiatrists as part of their multidisciplinary team when assessing this group of patients. WINT

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