Physiological effects of aquatic physiotherapy in women with lower limb lymphoedema compared to healthy women

Hildegard Reul-Hirche, Helen Swift, Robyn Box, Liisa Laakso

Royal Brisbane & Women’s Hospital
Herston, Brisbane, Qld

Back In Motion
Mermaid Waters, Qld

Oncology Physiotherapy
Grange, Qld

School of Physiotherapy and Exercise Science, Griffith University
Gold Coast, Qld

Introduction
The identification of specific information in relation to intensity and duration of exercise that contributes to a meaningful reduction in signs or symptoms of lymphoedema will assist in the development of safe and beneficial exercise prescription guidelines. Little is known however, about how exercising in a hydrotherapy pool will affect physiologic responses in women with secondary lower limb lymphoedema (LLLO).

Lymphatic system and exercise
Numerous studies have shown that physical activity improves lymph flow aiding the transport of fluid and proteins from the limbs (Coates, O'Brodovich, & Goeree, 1993; Havas, et al., 1997; McGeown, McHale, & Thornbury, 1987). Human studies have revealed that exercise has positive effects on lymph formation and propulsion (Havas, et al., 1997). While increases in lymphatic clearance have been demonstrated throughout two hours of steady state exercise (Havas, Lehtonen, Vuorela, Parviainen, & Vihko, 2000) as well as five minutes of arm crank ergometry in women who are healthy (Lane, Worsley, & McKenzie, 2005), there is a lack of information regarding lymphatic function in response to exercise in individuals with lymphoedema.

Lymphoedema and exercise
The role of exercise in lymphoedema management is important as other more intensive interventions may not be accessible to some individuals and may be expensive (Moseley & Piller, 2008). Evidence indicates that exercise is safe and has significant benefit to individuals with lymphoedema by reducing limb volume and improving subjective symptoms of how the limb feels, looks and moves (Moseley & Piller, 2008). The importance of regular exercise is emphasised for its numerous psychosocial and physical health benefits, including reducing the risk of recurring cancer and for weight management (Hayes, Reul-Hirche, & Turner, 2009). One study investigating cardiovascular arm exercise combined with deep breathing demonstrated a significant reduction in limb volume and subjective improvements in arm heaviness and tightness (Moseley, Piller, & Carati, 2005). Resistance exercise training has also been shown to have positive effects on individuals with secondary upper limb lymphoedema (Buckley, Piller, & Moseley, 2004; Johansson, Tibe, Kanne, & Skantz, 2004; McKenzie & Kalda, 2003).

While the majority of research has focused on breast cancer-related lymphoedema (BCRL) of the upper limb, there is little research in the field of lower extremity lymphoedema (Dick, Reul-Hirche, & Box, 2009; Moseley & Piller, 2008), which may be attributed to limited funding and low awareness. Some evidence demonstrates that passive leg exercise and elevation can significantly (p=0.001) decrease limb volume after 3 weeks (Moseley, Piller, Carati, & Esterman, 2004). Further, it can be assumed that exercise does not have any adverse consequences on LLLO (on limb size or quality of life (QOL)) as a 4 week (twice weekly) water-based intervention found no significant change in outcome measures (p>0.05) (Dick, et al., 2009).
There is insufficient evidence to establish whether there may be an immediate effect on a lymphoedematous limb following exercise. Although one study has reported small decreases in limb volume accompanied by reduced heaviness, movement limitation, skin dryness and tightness following 30 minutes of isotonic and isometric limb exercises (Buckley, et al., 2004), the findings were not statistically significant. There is also no evidence to support dose-specificity in relation to type, intensity or time of exercise required to contribute to a meaningful reduction in signs or symptoms of lymphoedema. It is clinically important for a therapist to have an understanding of the immediate changes exercise has on limb size and lymph fluid volume as this may have implications for exercise prescription and also for post-exercise limb care (for example, need for compression garments to be worn as soon as the exercise has finished).

**Lymphoedema and aquatic physiotherapy**

Aquatic physiotherapy (AP) is a specific mode of exercise that utilises the buoyant, viscous and hydrostatic properties of water to aid movement and compression of a lymphoedematous limb (Tidhar & Katz-Leurer, 2010). Intervention studies investigating AP on lymphoedema of the upper limb (Box, Barnes, & Robertson, 2004; Johansson, et al., 2004; Tidhar & Katz-Leurer, 2010) and lower limb (Dick, et al., 2009) have determined that there are no adverse effects on limb swelling or symptoms of lymphoedema associated with 40-45 minute bouts of AP. While it appears safe to undertake a session of 45 minutes duration, it is unknown what duration of AP may prove beneficial.

AP provides an enjoyable environment for individuals in which to exercise safely (Dick, et al., 2009). Water-based exercise may have the potential to facilitate lymph return and relieve symptoms associated with lymphoedema, however currently there is no data demonstrating how water immersion affects LLLO. In order to guide AP clinical guidelines and future research, the focus of this study was to measure the immediate physiological effects that occur in women with LLLO in response to AP; to compare these responses to those of healthy women; and to determine if responses vary in relation to the duration of exercise.

**Aims**

The aims of this study were to: 1) measure and compare the immediate physiological responses of a standardised AP program in women with secondary lymphoedema of the leg/s and in healthy women; and 2) to determine if the responses differ depending on the duration of exercise (15, 30 and 45 minutes).

**Hypothesis**

Based on current knowledge, we hypothesised that: 1) Changes in skin temperature, lymph fluid volume and limb circumference and volume in response to AP in women with secondary LLLO will be significantly greater than those in healthy women without lymphoedema; and 2) Increased AP duration will be related to proportional changes in skin temperature, lymph fluid volume and limb circumference and volume in women with secondary LLLO and in healthy women without lymphoedema.

**Method**

A sample of four women with secondary LLLO (3 unilaterally symptomatic, 1 bilaterally symptomatic) and two healthy women without lymphoedema was recruited. A repeated-measures, controlled trial design was implemented. Measurements of skin temperature and limb volume (perometry and bioimpedance spectroscopy) were taken prior to and immediately after exercising in the pool. Participants attended a 90 minute familiarisation session during which the physical measures were obtained and a forty-five minute AP session was conducted. On consecutive weeks participants attended three testing sessions comprising respectively of 15, 30 and 45 minute AP sessions where the outcome measures were obtained prior to entering and immediately after AP.

Each AP session consisted of a five minute warm-up, variable exercise period and five minute cool-down. To achieve a moderate intensity level of exercise participants were instructed to exercise at a level that was ‘somewhat hard’ for them during the exercise period. This protocol is in accordance with previous lymphoedema research which concluded that forty-five minutes of AP was safe for women with LLLO (Dick, et al., 2009). No more than two participants were tested at the same time to ensure measurements were recorded as soon as possible before and after each AP session.

**Techniques**

**Skin Temperature**

Skin temperature was measured to the nearest 0.1 degrees Celsius (°C) using the Fluke 61 infrared (IR) thermometer. Temperature measurements were taken as per Fig 1. Skin temperature over the left superficial temporal artery (reflective of core body temperature) was also documented.
Bioelectrical Impedance Analysis
BIA was examined using an ImpediMed XCA portable bioimpedance device. The side (either right or left) of the lymphoedematous limb was entered into the software as the ‘affected’ side. In participants with bilateral LLLO the dominant side (right or left) was entered as the ‘affected’ side. In ‘control’ participants the dominant side (right or left) was entered as the ‘affected’ side. The protocols for measurement at each anatomical site were consistent with those described by York and colleagues (2009).

Perometer
Limb circumference and volume of both legs were measured opto-electrically using the Peroplus 2000 perometer device. The software was set to report perometer circumferential measures (PERC) in centimetres at 10cm intervals along each limb, totalling 7 measurement points. To standardise the measurements between participants, the reference line was adjusted on the computer screen to start at 10cm and finish at 70cm from the positioning device.

Statistical Analysis
Due to lack of participant numbers the present study had limited data with which to perform a one-way repeated measures ANOVA. As it did not become obvious that participant numbers would be limited until late in the Honours program, the design of the study could not be adjusted to take in to account sufficient data points for analysis by single system design methods. Instead for this study, graphs were constructed using Microsoft Excel 2007 and were visually analysed (Domholdt, 2000), in addition to the statistical analysis mentioned previously.

Results
Skin Temperature
Visual inspection of Figs 2, 3 and 4, displaying the mean skin temperature changes of different segments of limb during different durations of AP, indicates that skin temperatures tended to remain consistent between women with LLLO and women without LLLO, and the corresponding limbs segments. Variations were seen from the trend of the line in Figures 2.b and 4.b, in the control group which may be attributed to outliers or lack of participant numbers contributing to type I error. There were no significant differences over time in the unaffected and non-dominant skin temperatures at the ankle, shin and thigh.
FIGURE 2. Mean skin temperature at the ankle according to duration of AP (a. Affected/dominant limb; b. Unaffected/non-dominant limb).

FIGURE 3. Mean skin temperature at the shin according to duration of AP (a. Affected/dominant limb; b. Unaffected/non-dominant limb).
Perometer
There were non-significant differences in the amount of volume change with respect to duration of AP (Fig 5). On visual inspection AP duration of thirty minutes displayed the greatest reduction in limb volume in the affected and unaffected legs of women with lymphoedema and in the dominant leg of healthy women. The volume change in the non-dominant leg of healthy women appeared to be similar regardless of AP duration. A one-way repeated measures ANOVA revealed that there was a significant difference (p = 0.006) at 30cm along a lymphoedematous limb between AP duration. Pair-wise comparison of means with no adjustments revealed that the difference occurred between 15 and 30 minutes of AP.

Bioelectrical Impedance Analysis
Lymphoedema index (L-dex) and bioimpedance ratios did not change significantly (p>0.05) between groups. Further, L-dex of the lower limbs was not significantly different (p > 0.05) between varying durations of AP sessions. Fig 6 displays the amount of change in L-dex of the lower limbs following each session of AP. Visual inspection demonstrates that for individuals with LLO there is a larger degree in L-dex change following 30 and 45 minutes of AP than compared to 15 minutes of AP.
Discussion
Analysis of physiological parameters following AP indicates similarities in skin temperature, bioimpedance, limb circumference and limb volume responses experienced by women with lymphoedema and women without the condition. Visual analysis also suggests skin temperature is analogous between lymphoedematous and non-lymphoedematous legs. The finding is consistent with research by Lawenda and colleagues (2009) who found that on palpation, skin temperature typically feels normal between limbs. Changes in core body temperature were also observed to be similar between women with and without LLLO. The finding provides preliminary indications to suggest that while lymphoedema is considered an inflammatory process (Mellor, et al., 2000), individuals with LLLO are able to efficiently thermo-regulate their core body temperature during exercise. The result provides additional support for evidence advocating the safety of exercise in individuals with lymphoedema (Buckley, et al., 2004; Dick, et al., 2009; Hayes, et al., 2009; Moseley, et al., 2004).

A difference between groups in limb circumference at 20cm along the affected leg was detected. However as several exercise-induced physiological processes (i.e., interstitial fluid volume versus. intramuscular volume) have the possibility to influence limb circumference and volume, further adequately powered research needs to be conducted before conclusions are drawn. Overall, there was insufficient data to support or reject the proposed hypothesis that changes in skin temperature, lymph fluid volume and limb circumference and volume in response to AP would be greater in women with LLLO compared to women without LLLO.

Comparative analysis of physiological parameters following progressively increasing durations of AP indicated greater changes in circumference, volume and core body temperature after 30 and 45 minutes of AP than at 15 minutes. Duration of AP did not appear to influence skin temperature of the limbs. The observed reduction in limb circumference and volume is consistent with the findings of Buckley and colleagues (2004) that demonstrated a non-significant reduction after 30 minutes of isotonic and isometric lower limb exercises. Since exercise is an important part of lymphoedema management, the finding implicates the importance of diligent exercise prescription. A one-way repeated measures ANOVA revealed a significant effect between 15 and 30 minutes AP duration and lower limb circumference at 30cm along the lymphoedematous limb. There is insufficient previous research to explain the circumference change at only one point along the limb, thus future sufficiently powered research is indicated.

Although there was not a statically significant difference between AP durations, visual analysis suggested the change in L-dex (and hence lymph fluid volume) was greatest following AP durations of 30 minutes or more. The changes in L-dex after 30 and 45 minutes of AP (compared to 15 minutes) are consistent with the physiological changes observed in limb circumference and volume measures, and measures indicative of core body temperature, thus providing some support for the second hypothesis. However, before firm conclusions can be drawn, further research is required to establish the reliability of BIA measures in bilateral LLLO. Overall, there was insufficient data to support or reject the hypothesis that increased AP duration would be related to proportional changes in skin temperature, lymph fluid volume and limb circumference and volume in women with secondary LLLO and women without lymphoedema.

Summary and Conclusion
The study described above outlines a pilot trial investigating the physiological effects of AP in women with secondary LLL, in order to understand whether effects differ between lymphoedematous and non-lymphoedematous limbs, and the nature of AP duration as a dosing factor. Due to low statistical power, the results are not conclusive but provide a way forward for further research. In the current study, changes in skin temperature, limb volumetric measures and lymph fluid volume were observed to be similar between women with and women without lymphoedema. The results suggest that homeostatic responses to exercise...
do not change in individuals with controlled secondary LLLO. Skin temperature between symptomatic and asymptomatic legs was also not significantly different. The relationship of physiologic response to duration of AP appeared to be stronger following 30 and 45 minute sessions than after the 15 minute session. A minimum duration of 30 minutes of AP may prove to be most beneficial for women with secondary LLLO for reducing the size of the symptomatic leg. Further, adequately powered research regarding the homeostatic response in women with LLLO following AP at differing doses is required for appropriate exercise prescription in order to gain optimum outcomes.

References