Physiological characteristics of the body fluid in lymphedematous patients postbreast cancer surgery, focusing on the intracellular/ extracellular fluid ratio of the upper limb

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Abstract

Aim: The aim of this research was to determine the physiological characteristics of patients with lymphedema following breast cancer surgery, based on differences between the quantity of body water in the right and left fingertips, with a view to establishing whether or not this simple measurement could serve as a predictive index for the onset of lymphedema.

Method: The research was conducted at a hospital in Hiroshima, Japan (August 2004 to December 2004). Observations were made on 39 female breast cancer patients who had undergone surgery and 45 healthy female participants. Additional information was collected via interviews with the individual participants. The quantity of body water in all the participants was measured by using a bioimpedance spectrum analysis system. Comparisons of the intracellular/extracellular fluid ratios (I/Es) were made between the edema patients and the non-edema patients, with further testing being done between the affected and unaffected sides of the upper limb in the edema patients.

Results: In the edema patients, significant differences were recognized between the affected side’s upper limb I/E and the unaffected side’s upper limb I/E. In relation to the affected side’s upper limb I/E of the edema patients, even when the mean value and standard deviation were included, the value did not exceed 1.0 and the mean – 3 SD value of the affected side’s upper limb I/E in the non-edema patients was 1.04.

Conclusions: The results suggest that measurements of the affected and unaffected sides’ upper limb I/E showed a potential for use as a reliable predictive index for lymphedema.

Key words: intracellular/extracellular fluid ratio, lymphedema, postbreast cancer surgery, upper limb.

INTRODUCTION

This research was conducted as a result of the findings from a much larger project that is investigating the methods and procedures that are used nationally and internationally in the diagnosis, treatment, and after-care of patients with breast cancer. Additionally, the project looked at trends in prevalence, morbidity, and mortality rates on an international level, comparing the results to those found in Japan, where the mortality rate is actually lower than in other countries such as the USA, Britain, France, and Italy (Cancer Statistics in Japan – Editorial Board, 2005). This relative trend is continuing. Currently, the morbidity rate of patients
with breast cancer in Japan is between 4 and 5% (~1 in 30 patients) (Cancer Statistics in Japan – Editorial Board, 2005).

The postoperative quality of life (QOL) of patients with breast cancer was one area of the project that was felt to be of particular importance. Okazaki, Morimoto and Muto (2001) reported that a significant reduction in QOL was seen in patients with lymphedema resulting from impaired movement and subsequent anxiety. In reports by Kato, Kitagawa and Yoshizumi (1996) and Ueyama (2004) that investigated the diagnosis and treatment of edema, similar findings were shown.

Today, the mortality rate of patients with breast cancer in Japan is approximately threefold higher than it was in the 1960s (Health and Welfare Statistics Association Foundation, 2005). The number of patients that are affected with breast cancer, according to an age adjustment, which is the basis for mortality rates, is increasing year-by-year. The number increased by 3.25-fold, from 11 123 in 1975 to 36 139 in 1999 (Cancer Statistics in Japan – Editorial Board, 2005).

By 2015, Kitagawa, Tsukuma, Ajiki and Oshima (1999) predict that this number will reach 48 163. The basic treatment of breast cancer focuses on invasive methods with dissection of the auxiliary lymph nodes (known as “lymph node dissection”). This is common practise in Japan and is carried out as part of radical, invasive surgery. A need to improve the QOL of patients and their family, both psychologically and physiologically, is growing and a move towards minimal operative procedures is becoming more popular. Attempts are being made to minimize the lymph node dissection procedure, an area that has been the subject of extensive investigation (Kimura, 2001; Miura, 2001; Okazaki et al., 2001; The Early Breast Cancer Trialists' Collaborative Group, 1995). However, some patients still report upper limb lymphedema on the affected side, which is a common after-effect of lymph node dissection. No effective therapeutic measures for lymphedema have been clearly established, primarily because the factors of occurrence have not been determined yet (Bernas, Witte & Witte, 2001; Hirota, 2004b; Paskett & Stark, 2000; Segestrom, Bjerle, Graffman & Nystrom, 1992; Stanton, 1996). Bernas et al. and Witte, Witte and Mortimer (1998) also suggested that the accurate rate of occurrence is unknown. We do know that the rate of occurrence of upper limb lymphedema has increased from 13.2% in 1998 to 31.5% in 2003 and that the number of patients that are affected with breast cancer is increasing in Japan. In a report by Kamiyama (2004), 3750–5000 cases of patients with upper limb lymphedema are estimated to present each year. When the number of years of life postbreast cancer surgery is taken into consideration, Kamiyama (2003) reported that the number of patients with upper limb lymphedema is estimated to range from 30 000–50 000. For such patients, their daily life and social activities are severely limited (a decrease in QOL) due to the mobility impairments caused by lymphedema from the upper limb to the chest region. For nurses who are caring for patients with lymphedema after breast cancer surgery, adjusting a patient’s life process and supporting self-sustainability are among the most important challenges that must be tackled in order to prevent and reduce the occurrence of lymphedema (Hirota, 2004b). No reliable predictive index of the occurrence of lymphedema that has been proven to be helpful in preventing the onset of edema currently exists. However, lymphedema is a state in which the amount of interstitial fluid in the tissues increases, as reported by Hirota (2001), Hirota (2004b), and Ohashi (2003). If we are able to statistically clarify the fluid characteristics and establish a correlation between the fluid ratios and the onset of edema, then the body fluid content could be considered for use as a reliable predictive index for the occurrence of lymphedema. However, no research has been found to clearly show the body fluid content and the ratio of intracellular fluid volume to extracellular fluid volume (I/E) in patients with lymphedema. The physiological characteristics of a patient with lymphedema after breast cancer surgery are revealed from their body fluid content, with the ratio of intracellular to extracellular fluid being established by bioimpedance (BIS) measurements to estimate the occurrence of upper limb lymphedema on the affected side after breast cancer. With this in mind, it was hypothesized that, if the physiological characteristics could be clearly measured and established, they could be used as a reliable predictive index for the occurrence of lymphedema, thus helping to significantly increase patients’ QOL and to further assist nurses in their attempts to support and care for patients.

METHOD

Participants

Thirty-nine patients after breast cancer surgery (24 right breast cancer patients and 15 left breast cancer patients) and 45 healthy women (hereinafter, referred to as “normal women”) took part in the study. During the selection process, the following women were excluded to help eradicate any individual compounding participant variables that could spoil the data: (i) women
<40 years; (ii) left-handed women; (iii) patients who had bilateral breast cancer; (iv) women who had a disease of the endocrine system or cardiovascular system; (v) women whose blood data for renal function, liver function, triglyceride level, or total cholesterol level deviated from the reference values; (vi) women who took diuretic drugs; (vii) women who were being treated for diabetes; and (viii) women who took carbamazepine or lithium (Leon et al., 1996; Sudo, Sugi, Miyamoto & Ogawa, 2001). The measurement period was from August 2004 to December 2004. The basic patient data were collected from medical charts and information from the patients’ respective physicians. Additional information was obtained from interviews with the individual patients regarding whether the patient smoked and, if she smoked, the frequency of smoking, as well as how much water the patient drank and whether or not the patient felt a dry sensation in her mouth. Initially, a unilateral analysis of variance was carried out for the test of three or more groups including age, Body Mass Index (BMI), percentage of extracellular fluid (%ECF), percentage of intracellular fluid (%ICF), percentage of total body fluid (%TBF), percentage of fat mass (%FAT), I/E, upper arm ECF, upper arm ICF, and upper arm I/E. If a significant difference was recognized among the groups in the unilateral analysis of variance, it was confirmed using Tukey’s test, in which the groups showed a significant difference. A paired t-test was carried out to compare the I/Es between the upper limbs on the affected and unaffected sides, depending on the existence or non-existence of edema in the patients. SPSS (Version 13.0J for Windows; SPSS, SPSS Inc, Chicago, Illinois, USA) was used as the statistical analysis software and the level of significance was set at 5%.

Procedure and materials

Prior to conducting the main research, a pilot study was carried out, with the Wilcox Sign Test used as a power analysis to confirm the significance of the results (significance level of 5%). Once this was confirmed, the main study was carried out.

Before the examination, the patients urinated and any jewelry, socks, stockings, etc. were removed. First, their weight was measured to determine whether lymphedema was present. The patients were then seated and the measurements were taken. The perimeter radius of seven locations in the upper limbs was measured by using a plastic measuring tape. For the BIS measurement, a bioimpedance spectrometer (4000C; XITRON Technologies, San Diego, CA, USA) was used and the “four-electrode method” was employed to measure the total body fluid content. The right side of the body was used, based on previous studies by Kim, Tanaka, Nakanishi and Amagai (1992), Nakadomo, Tanaka, Watanabe, Watanabe and Maeda (1991), and Suzuki, Furukawa and Hasebe (1996), and the impedance value was measured between the right hand joint and the right ankle joint. Electricity was turned on for the electrodes on the middle of the third metacarpal of the dorsal surface of the right hand and the middle of the second metacarpal of the dorsal surface of the right hand. Following this, any difference between the wrist joint (between the styloid processes of the radius and the ulna) and the ankle joint (between the external condyle and the inner condyle) was observed and the automatically analyzed data were recorded (Fig. 1). Additionally, for both upper limbs, any differences of the humeri that were 35 cm away from the wrist joints inside the upper limbs was observed and the automatically analyzed data were recorded (Fig. 2). The measurement took place with the patient lying face-up on a bed and both upper limbs were away from the body trunk. The thighs were open at ~30°. The electrodes were attached after the areas were cleaned with 50% isopropyl alcohol. The measurements began 1–3 min later. A BIS measurement was carried out from 10.00 hours to approximately
11.00 hours, taking the effects of meals and mental stability into account. For the analysis, the FAT was calculated from the fat-free mass that was obtained as data. To compare the four components (FAT, TBF, ICF, and ECF) among the participants, the percentages of each component were compared to the individual participant’s body weight. These percentages were labeled as the %FAT, %TBF, %ICF, and %ECF. The I/E also was calculated. The weights of the upper limbs were not taken and the percentages of these weights were not calculated. Instead, the ICF, ECF, and I/Es that were obtained as data were used. Following this, and with the cooperation of three normal women, a second measurement (a pretest) was conducted 60 min after the first measurement and the results were compared. No changes were observed between the first measured values and the second measured values.

Method of evaluating lymphedema

From the results of previous studies by Kato, Kitagawa and Yoshizumi (1996), Mori, Urayama & Iwa (1984), Sakuda, Miyagoshi and Nishiki (2003), and Yamazaki, Baba and Koike (1988), the perimeter radius difference between the limbs on the affected and unaffected sides was used, as this is a very brief, reliable, and easy-to-perform method. The measurement areas were a total of seven locations: the back of the hand, immediately above the hand joint, 5 cm and 10 cm distal to the olecranon, 5 cm and 10 cm proximal to the olecranon, and the uppermost part of the upper arm. From the pretest results, the maximum value of the perimeter radius difference between the right and left upper limbs of the normal women was 1 cm. Those women with a perimeter radius difference of ≥1 cm were considered to be “edematous” patients, while those with a perimeter radius difference of ≤1 cm were classified as “non-edematous” patients (Mori et al.).

Ethical considerations

Before starting the measurement, the purpose of the research, method, significance, confidentiality, voluntary nature of research cooperation, as well as the freedom to withdraw from the study at any time and the publication of the results were explained verbally by using documents. The fully informed consent of all the participants was obtained. The study was assessed and approval was obtained from Graduate School of Health Sciences, Hiroshima University. Every effort was made to ensure that no psychological or physiological harm came to any of the participants.

RESULTS

For the age and BMI, no significant difference was recognized among the three groups: normal women, patients with right breast cancer, and patients with left breast cancer (Tables 1, 2). However, when looking at the factors involved in establishing a predictive indicator for the early onset of edema, the results strongly suggested that the correlation coefficient between the I/E of the affected upper limb and the perimeter radius differences do play an important role.

Comparison of the amount of total body fluid between the normal women and the patients with breast cancer

When checking for changes due to the existence or non-existence of lymphedema, a significant difference was seen for the %ICF and I/E (%ICF: P < 0.001; I/E: P < 0.001); multiple comparisons were carried out by using Tukey’s test (Table 3). It was determined that the edematous patients had a significantly lower %ICF than the normal women (normal women and edematous patients with right breast cancer: P < 0.01; normal women and edematous patients with left breast cancer: P < 0.05). No statistical difference was recognized between the normal women and the non-edematous patients or between the edematous patients and the non-edematous patients. It was determined that the edematous patients had lower I/Es than the normal women (normal women and edematous patients with right breast cancer: P < 0.01; normal women and edematous patients with left breast cancer: P < 0.05).
Table 1 Basic data of the participants

<table>
<thead>
<tr>
<th>Participant type</th>
<th>N</th>
<th>Age (years) mean ± SD</th>
<th>Body Mass Index (mean ± SD)</th>
<th>Postoperative course (years) mean ± SD</th>
<th>Standard radical mastectomy (N)</th>
<th>Breast muscle conservation mastectomy (N)</th>
<th>Breast-conserving surgery (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>45</td>
<td>54.2 ± 6.95</td>
<td>22.9 ± 1.11</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Patient with right breast cancer</td>
<td>24</td>
<td>55.0 ± 6.35</td>
<td>22.5 ± 2.62</td>
<td>10.3 ± 9.14</td>
<td>11</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Edema (+)</td>
<td>18</td>
<td>55.5 ± 6.63</td>
<td>23.2 ± 2.48</td>
<td>11.7 ± 9.76</td>
<td>9</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Edema (–)</td>
<td>6</td>
<td>53.3 ± 5.65</td>
<td>20.3 ± 1.65</td>
<td>6.2 ± 5.78</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Patient with left breast cancer</td>
<td>15</td>
<td>55.6 ± 7.38</td>
<td>22.6 ± 2.57</td>
<td>10.2 ± 5.21</td>
<td>3</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Edema (+)</td>
<td>10</td>
<td>56.0 ± 8.00</td>
<td>23.3 ± 2.70</td>
<td>10.7 ± 3.97</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Edema (–)</td>
<td>5</td>
<td>54.8 ± 6.72</td>
<td>21.1 ± 1.57</td>
<td>9.2 ± 7.59</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 Upper limb perimeter radius and perimeter radius differences among the participants

<table>
<thead>
<tr>
<th></th>
<th>Normal women (n = 45)</th>
<th>Patients with right breast cancer</th>
<th>Patients with left breast cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Edema (+) (n = 18) Mean ± SD</td>
<td>Edema (–) (n = 6) Mean ± SD</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right upper limb (cm)</td>
<td>22.16 ± 1.471</td>
<td>26.29 ± 3.346</td>
<td>21.54 ± 1.583</td>
</tr>
<tr>
<td>Left upper limb (cm)</td>
<td>21.95 ± 1.457</td>
<td>22.81 ± 2.446</td>
<td>21.34 ± 1.528</td>
</tr>
<tr>
<td>Perimeter radius difference (cm)</td>
<td>0.57 ± 0.125</td>
<td>6.39 ± 2.668</td>
<td>0.75 ± 0.055</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.45 ± 2.427</td>
<td>26.37 ± 3.090</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>22.37 ± 0.857</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26.46 ± 0.889</td>
<td>22.46 ± 0.889</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26.31 ± 3.266</td>
<td>6.3 ± 3.266</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.72 ± 0.109</td>
<td>0.72 ± 0.109</td>
</tr>
</tbody>
</table>
breast cancer: $P < 0.001$; normal women and edematous patients with left breast cancer: $P < 0.01$). However, no significant difference was recognized between the normal women and the non-edematous patients or the edematous patients and the non-edematous patients.

Table 4 shows the results of a unilateral analysis of the variance of the upper limb ECF, upper limb ICF, and upper limb I/E. A significant difference was recognized for the ECF and I/E of both the right and left upper limbs. A multiple comparison was carried out for the I/E by using Tukey’s test, with the results detailed in Table 5. It was confirmed that both the edematous patients with right breast cancer and the edematous patients with left breast cancer showed significantly lower I/E values for the upper limb on the affected side.

Comparison of the intracellular/extracellular fluid ratios between the affected and unaffected upper limbs

The paired t-test was conducted in order to confirm whether or not changes occurred in the affected side’s upper limb I/E or the unaffected side’s upper limb I/E, depending on the presence or absence of edema, in all 39 patients with breast cancer. For the non-edematous patients, significant differences were not observed in the affected side’s upper limb I/E and unaffected side’s upper limb I/E. However, for the edematous patients, the affected side’s upper limb I/E indicated a significantly lower value than the unaffected side’s upper limb I/E ($P < 0.001$). For the edematous patients, the affected side’s upper limb I/E, even when the values included the mean value and standard deviation, did not exceed 1.0. The mean – 3 SD value of the affected side’s upper limb I/E in the non-edematous patients was 1.04. (Fig. 3).

Hydration: Comparison of the amount of total body fluid

According to Iida (1989), the %ICF and %ECF, and thus the I/E, were: %ICF : %ECF = 40% : 20%, or 2:1, thus I/E = 2. However, the results that were observed in this study showed that the %ICF fell slightly below the commonly stated 40%. The %ECF slightly exceeded 20%. Given that lymphedema is a tumefaction of organs or tissues that results from the accumulation of high-protein interstitial fluid through the addition of tissue interstitial failure in the cellular protein-processing function to a lymph transport disorder (Foeldi & Kubik, 1999; Hirota, 2001; Hirota, 2004b), it was assumed that the lymphedematous region increases the %EFC and that the I/E presents as a low value. From the
results, looking at the presence or absence of lymphedema between the normal women and the patients with right breast cancer and the patients with left breast cancer, a statistically significant difference was recognized in the %ICF and I/E. Furthermore, from the results of conducting multiple comparisons by Tukey’s-test, the %ICF was observed to be 30.41% in the edematous patients with right breast cancer and 30.57% in the edematous patients with left breast cancer, while the %ICF in the edematous patients was determined to be significantly lower than in the normal women. The I/E of the edematous patients was thus considered to significantly decrease, whereby it was 1.21 for the edematous patients with right breast cancer and 1.24 for the edematous patients with left breast cancer. The I/E of the normal women was >1.4. A reduction of the %ICF means that a tendency toward intracellular dehydration was recognized, thereby indicating that the hydration level of the patients genuinely decreased. This phenomenon results from the general movement of the water content from the ICF to the ECF when the water content is not replenished. Hydration is less than the necessary amount, or the ECF becomes hypertonic. The %ECF indicates changes in the hydration level for a short time while the %ICF reflects changes in the hydration level in the long term. As to the causes of such long-term changes in the hydration level, some possibilities would include hospitalization, a decrease in physical activities due to surgery and, thus, postoperative complications influencing the body composition. No significant difference was recognized between the edematous and non-edematous patients.

Comparison of upper limb water content
The intracellular and extracellular water content throughout the body is usually shown as a percentage of the individual’s weight, so the local intracellular and extracellular water content in the upper limb requires the weight of the upper limb. However, because it is difficult to measure the weight of the upper limb itself, the upper limb water content was used as a measure instead of the water content percentage and the I/E observations focused on that measurement. As to the presence or absence of lymphedema between the normal women and the patients with left or right breast cancer, in both the right and left upper limb, significant differences were recognized in relation to the ECF and I/E; consequently, multiple comparisons for I/E were conducted by using Tukey’s test. For the edematous patients, in the upper limb on the affected side, the I/E

<table>
<thead>
<tr>
<th>Variable</th>
<th>Normal women (n = 45)</th>
<th>Patients with left breast cancer (n = 10)</th>
<th>Patients with right breast cancer (n = 18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>%ECF</td>
<td>24.03 ± 1.817</td>
<td>24.20 ± 2.024</td>
<td>24.56 ± 1.919</td>
</tr>
<tr>
<td>%ICF</td>
<td>33.93 ± 2.824</td>
<td>30.41 ± 3.396</td>
<td>30.57 ± 3.547</td>
</tr>
<tr>
<td>%TBF</td>
<td>57.96 ± 3.588</td>
<td>55.56 ± 6.431</td>
<td>58.38 ± 5.739</td>
</tr>
<tr>
<td>%FAT</td>
<td>21.46 ± 4.943</td>
<td>24.71 ± 8.739</td>
<td>20.90 ± 5.076</td>
</tr>
<tr>
<td>I/E</td>
<td>1.42 ± 0.135</td>
<td>1.21 ± 0.361</td>
<td>1.24 ± 0.381</td>
</tr>
</tbody>
</table>

Unilateral analysis of variance: ECF, extracellular fluid; TBF, total body fluid; I/E, intracellular/extracellular fluid ratio; F, fat mass; TBF, total body fluid.
value was significantly low (right: 0.71; left: 0.68). In view of this, it was felt that it was appropriate to compare the edematous patients and the non-edematous patients without separating the patients who had right breast cancer from those who had left breast cancer.

The lymphedema predictive index

As the affected side’s upper limb I/E of the edematous patients did not differ between the patients with left breast cancer and the patients with right breast cancer, the affected and unaffected sides’ upper limb I/E were compared for the presence or absence of edema. In the non-edematous patients, no differences between the affected side’s upper limb I/E and the unaffected side’s upper limb I/E were observed. However, in the edematous patients’ affected side’s upper limb I/E, a significantly lower value than the unaffected side’s upper limb I/E was found ($P < 0.001$). Consideration then was given as to what the value should be for the cut-off point if the affected side’s upper limb I/E is supposed to be a predictive index for the occurrence of lymphedema. In the affected side’s upper limb I/E of the edematous patients, the mean ± SD did not exceed 1.0 and the mean – 3SD value of the affected side’s upper limb I/E in the non-edematous patients was 1.04. Furthermore, in the upper limb I/E of the normal women and the non-edematous patients, the I/E did not fall to <1.0. From this, when the affected side’s upper limb I/E value fell to a level of <1.04, the possibility of edema occurring was considered.

**DISCUSSION**

The initial stage of the research did not investigate the impact of hydration levels on the results. However, a second level of research was conducted that targeted this area to obtain a more comprehensive dataset for analysis and comparison. Van Loan, Withers, Matthie and Maycin (1993) reported that the %TBF is reduced in obese people because their hydration level per weight decreases. A trend toward obesity, which is considered to be a risk factor of breast cancer or a cause of lymphedema, was not seen in this study so it was considered to be appropriate to measure and compare hydration levels. In previous studies using the same device, the ratio has been reported to be close to

| Table 5 Comparison of the affected side of the upper limb I/E and the healthy side of the upper limb I/E of all breast cancer patients according to the presence or absence of edema |
|----------------------------------------|------------------|------------------|--------|-------|
| Patient type                           | I/E: affected side of the upper limb | I/E: healthy side of the upper limb | t-value | P-value |
|----------------------------------------| Mean ± SD          | Mean ± SD          |        |        |
| Non-edematous ($n = 11$)               | 1.30 ± 0.088       | 1.30 ± 0.065       | 0.06   | 0.954  |
| Edematous ($n = 28$)                   | 0.70 ± 0.094       | 1.24 ± 0.076       | 21.99  | <0.001 |

Paired t-test. I/E, intracellular/extracellular fluid ratio.
%ICF : %ECF = 1:1 (Tsutsumi, Hasegawa & Yamamoto, 1998) or the I/E is 1.15 (Amiya, Tanaka & Shoji, 1997). In other countries, the I/E is 1.24 (Van Loan & Mayclin, 1998) or the I/E is 1.31 (Van Loan et al.). Although these previous studies were slightly different from this study, in terms of the participants’ age and body fat percentage, the results were similar to those of this study. Further investigations into the fluid ratios between patients with edema and those who were healthy and comparative analyses of patients who were affected and unaffected by edema revealed findings that could offer a genuine method for use as a predictive index. Other areas of this research support previous studies of a similar nature, such as those conducted by Amiya et al., Iida (1989), Van Loan & Mayclin, Tsutsumi et al., and Van Loan et al.. The results of this study clarified the fluid characteristics and ratios and found a subsequent link to the possible onset of lymphedema. It is these findings, in particular, that differentiate this research somewhat from previous studies.

There were several limitations to the research. The sample size was small and all the participants were Japanese women. It would be useful to conduct further studies by using a much larger sample size and on a more multicultural level as genetic and environmental factors might influence the results. However, the target population was carefully selected to try to control as many compounding variables as possible, so as not to spoil the data. The use of standard protocols throughout the research also helped in enhancing the internal validity of the research. Although the sample was small, the research method was specific and was conducted in a way that gave the research solid ecological validity. Based on the analysis of the results and on a practical application of the test, we found that there is a great deal of support to indicate that, having now fully quantified the fluid characteristics and ratios, we are in a position to use this test to reliably predict the onset of edema at a very early stage. This is beneficial to doctors, nurses, care workers, and other health professionals in improving the QOL and postoperative care of patients with cancer. Although the research was conducted in Japan, the investigation is by no means culture-bound in its findings. As noted earlier, the symptoms that are showed by patients with lymphedema postoperatively are universal and increasing in prevalence. Efforts have been made to establish a reliable method to predict the early onset of edema, but because thus far most tests lack reliability and consistency due to the unknown rate of occurrence (Bernas et al., 2001; Witte et al., 1998) and a degree of ambiguity exists regarding the specific factors of occurrence (Bernas et al.; Hirota, 2004b; Paskett & Stark, 2000; Segestrom et al., 1992; Stanton, 1996), this has proven to be a very problematic area, with treatment generally being given on a somewhat retrospective basis. The findings in this research seem to have clarified these issues and the results could have beneficial implications for patient care.

CONCLUSIONS

Having established a reliable method for testing, it should be possible to offer an effective procedure in assisting with the early detection of edema. In Japan, historically the psychological aspects have not been viewed as being as significant as the physical aspects. However, in recent years there has been a shift towards acknowledging the importance of psychological care and support and how this complements medical treatments for cancer patients postoperatively. This general shift towards a more holistic approach in Japan in terms of care, together with the findings from this research, should make it possible to establish a more reliable and effective framework for postoperative care.

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