This study examined the physical properties of six common brands of short-stretch compression bandages used to treat lymphedema. The physical properties examined were (a) maintenance of pressure over a 12-hr period, (b) variability of pressure across the width of the bandages, and (c) variability of pressure when the bandages were wrapped with a 50% overlap. The results of the study indicate that all six brands of bandages tested maintain pressure well over a 12-hr period. Each has a variance of pressure between the middle and edge of the bandage, with the edges measuring (in mmHg) between 6% and 28% lower than the middle. When the bandages were wrapped with a 50% overlap, all six brands measured fairly consistently in pressure readings (in mmHg) across the width. These results indicate that the six brands of short-stretch compression bandages tested have similar physical characteristics.

T he lymphatic system is one of the many complex systems that make up the human body. The main functions of the lymphatic system are to collect waste from tissue spaces and return it to the bloodstream, to protect the body from pathogens, and to provide immunity. A disruption in the functioning of the lymphatic system may result in lymphedema.

Lymphedema is an excess accumulation of protein-rich fluid usually in one or more extremities (Thomas & Taber, 1997). Approximately 140 million people worldwide have lymphedema (Collard, 1990). Primary lymphedema (congenital lymphedema) occurs most commonly at birth and is due to a lack of sufficient lymphatic vessels or improper functioning of the lymphatic system. Secondary lymphedema (acquired lymphedema) is more common and results from damage to or removal of lymph nodes. This condition is associated with cancer, infection, inflammation, radiation, surgery, or trauma. Unfortunately, no medication is available to cure lymphedema (Lerner, 1998). Current research, however, has shown that lymphedema can be reduced and controlled. Safe, noninvasive intervention programs to control lymphedema generally include the use of compression bandages, massage, exercise, and skin care (Boris, Weindorf, & Lasinski, 1994, 1997; Casley-Smith, 1992; Collard, 1990).

Though each component of a lymphedema treatment program is vital to the success of treatment, the focus of this study is on compression bandaging. Compression bandages are rolls of elastic material used to wrap a limb in multiple layers. Research evidence suggests that compression bandages used to treat lymphedema are most effective...
if they have low elasticity (short-stretch) and maintain an even pressure on the limb over time (Casley-Smith & Casley-Smith, 1997; Colridge-Smith, Scurr, & Robinson, 1987; Raj, Goddard, & Makin, 1980). The recommended pressure levels for various therapeutic approaches to treating lymphedema are summarized in Table 1.

Lymphedema in the limbs causes pain and swelling, which restricts movement and limits a person’s ability to engage in purposeful activities. Therefore, occupational therapy is commonly prescribed for patients with lymphedema. Commonly, occupational therapists and physical therapists apply short-stretch compression bandages to limbs in an effort to reduce the effects of lymphedema (National Lymphedema Network, 2000). In fact, the National Lymphedema Network recommends to lymphedema patients treatment centers that have on-site occupational therapy or physical therapy services. Most states have treatment centers specializing in lymphedema management, and more than 130 centers are currently listed on the National Lymphedema Network Web site (www.lymphnet.org).

The purpose of this study was to test the physical properties of commonly used brands of short-stretch compression bandages to treat lymphedema. The specific physical properties tested were (a) maintenance of pressure over a 12-hr period, (b) variability of pressure across the width of the bandages, and (c) variability of pressure when the bandages were wrapped on a solid cylinder with a 50% overlap.

Method
Bandages
To determine which brands of short-stretch compression bandages would be tested in the study, we contacted an occupational therapist in each of three major lymphedema clinics in southeast Wisconsin. The six bandages were the only ones noted by the therapists. The five bandage manufacturers (one manufacturer provides two brands of bandage) and two major vendors were contacted and reported that they were not aware of other short-stretch bandage brands used to treat lymphedema. The six brands of short-stretch compression bandages included in the study were Rosidal K1, Tensolan L2, Komprimed 3, Dema-Band 4, Compriplan5, and Durelast6. All bandages were 8 cm (3.15 in.) in width.

Table 1
Summary of Recommended Pressure Levels When Using Compression To Treat Lymphedema

<table>
<thead>
<tr>
<th>Technique</th>
<th>Recommended Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumatic pumps</td>
<td>40–60 mmHg (Leduc &amp; Leduc, 1990)</td>
</tr>
<tr>
<td>Manual massage</td>
<td>50 mmHg for deeper and 20 mmHg for superficial lymphatics (Stijns &amp; Leduc, 1977)</td>
</tr>
<tr>
<td>Manual massage</td>
<td>Exceeding 70–100 mmHg causes damage to lymphatics (Eliska &amp; Eliskova, 1995)</td>
</tr>
<tr>
<td>Compression garments</td>
<td>30–60 mmHg (Boris, Weindorf, &amp; Lasinski, 1997; Brennan, DiPomposo, &amp; Garden, 1996; Brennan &amp; Miller, 1998)</td>
</tr>
<tr>
<td>Compression garments</td>
<td>40–60 mmHg (Casley-Smith, 1992; Casley-Smith &amp; Casley-Smith, 1997)</td>
</tr>
</tbody>
</table>

Apparatus

In previous studies, researchers have measured with pressure sensors the pressure exerted by bandages on patients’ lower extremities, on wooden orthoses (Colridge-Smith et al., 1987), and on water-filled devices (Raj et al., 1980). Unfortunately, these studies did not provide enough detail to replicate the devices used to measure pressure. Therefore, we developed a pressure-measuring device for the present study (see Figure 1). This device was composed of a 4-in.-diameter plastic cylinder with five force-sensing resistors (.5-inch diameter each) placed in a line at 1-in. intervals. Pressure on these resistors decreased the resistance in the circuit, which increased the flow of the current.

A 9-volt battery supplied the electromotive force to the circuit, and a current-to-voltage converter was developed to allow measurement of applied force to the force-sensing resistors in volts using a digital voltmeter. A radial switch allowed flow of the current in the circuit to the voltmeter through each force-sensing resistor individually. A blood pressure cuff applied pressure to each force-sensing resistor individually to convert voltage readings to pressure in mmHg immediately following data collection in each trial. This was done to ensure that the conversion of voltage to pressure was appropriate in each trial because the force-sensing resistors may exhibit some degree of variability or lack of reliability. Although we did not complete reliability studies with the sensors, the sensor manufacturer reports that the coefficient of variation of the sensor values only requires recalibration after every 50 uses or every 3 months.

Figure 1. Pressure-measuring device.
In all trials, the short-stretch compression bandages were wrapped onto the cylinder, using a modified vice grip to ensure even pull across the width of the bandage. The bandages were placed on the cylinder and stretched to exert a pressure of approximately 45 mmHg on the resistor at the center of the bandage because this pressure is within the recommended therapeutic range. The bandages were held in place with a bench vice to ensure that they would not move during the testing period.

**Maintained Pressure Over Time and Across the Width of the Bandages**

To determine whether the bandages maintained their pressure or stretch over time, a comparison of initial and final pressure readings was made for each bandage over a 12-hr period. Pressure readings were recorded for the sensor under the center of the width of the bandage as well as for a sensor located near the edge of the bandage. The recordings are summarized in Table 2. The change in pressure was calculated in both loss of pressure in mmHg and percentage of the initial reading. The range among all bandages for both the middle and edge sensors was a loss of 0 mmHg to 4 mmHg of pressure or 0% to 9.3% of the initial pressure. In all trials, the bandage was stretched to achieve approximately 45 mmHg of pressure over the middle sensor, though the edge sensor exerted less pressure. In all cases during the 12-hr testing period, the stretch of the bandages maintained a pressure at both the middle and edge sensors that remained within the recommended therapeutic range (see Table 1).

**Variability of Pressure Across the Width of the Bandages**

To determine whether a significant difference existed in pressure readings across the width of the bandages, readings were taken every hour over a 12-hr period from sensors located under the center of the width of the bandage as well as for a sensor located near the edge of the bandage. A mean was determined for these 13 readings for each bandage for both sensors. In all cases, the mean for the edge sensor was less than the mean for the middle sensor. A percent difference was calculated between the two means (middle vs. edge) for each bandage, and a paired t test was performed to determine whether the difference in readings was significant. The results are summarized in Table 3. The percent difference between the middle and edge sensor means varied from 5.9% to 28% and was shown to be significant for all bandages.

### Results

#### Maintained Pressure Over Time

To determine whether the bandages maintained their pressure or stretch over time, a comparison of initial and final pressure readings was made for each bandage over a 12-hr period. The change in pressure was calculated in both loss of pressure in mmHg and percentage of the initial reading. The range among all bandages for both the middle and edge sensors was a loss of 0 mmHg to 4 mmHg of pressure or 0% to 9.3% of the initial pressure. In all trials, the bandage was stretched to achieve approximately 45 mmHg of pressure over the middle sensor, though the edge sensor exerted less pressure. In all cases during the 12-hr testing period, the stretch of the bandages maintained a pressure at both the middle and edge sensors that remained within the recommended therapeutic range (see Table 1).

#### Variability of Pressure Across Width of Bandages

To determine whether a significant difference existed in pressure readings across the width of the bandages, readings were taken every hour over a 12-hr period from sensors located under the center of the width of the bandage as well as for a sensor located near the edge of the bandage. A mean was determined for these 13 readings for each bandage for both sensors. In all cases, the mean for the edge sensor was less than the mean for the middle sensor. A percent difference was calculated between the two means (middle vs. edge) for each bandage, and a paired t test was performed to determine whether the difference in readings was significant. The results are summarized in Table 3. The percent difference between the middle and edge sensor means varied from 5.9% to 28% and was shown to be significant for all bandages.

---

**Table 2**

<table>
<thead>
<tr>
<th>Brand and Sensor</th>
<th>Initial (mmHg)</th>
<th>Final (mmHg)</th>
<th>Difference (mmHg)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosidal K</td>
<td>44</td>
<td>44</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Middle</td>
<td>43</td>
<td>39</td>
<td>–4</td>
<td>9.3</td>
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<tr>
<td>Edge</td>
<td>45</td>
<td>44</td>
<td>–1</td>
<td>2.2</td>
</tr>
<tr>
<td>Tensolan L</td>
<td>43</td>
<td>42</td>
<td>–1</td>
<td>2.3</td>
</tr>
<tr>
<td>Komprimed</td>
<td>43</td>
<td>41</td>
<td>–2</td>
<td>4.7</td>
</tr>
<tr>
<td>Durelast</td>
<td>31</td>
<td>31</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dema-Band</td>
<td>47</td>
<td>47</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Middle</td>
<td>35</td>
<td>33</td>
<td>–2</td>
<td>5.7</td>
</tr>
<tr>
<td>Edge</td>
<td>45</td>
<td>44</td>
<td>–1</td>
<td>2.2</td>
</tr>
<tr>
<td>Comprilan</td>
<td>33</td>
<td>32</td>
<td>–1</td>
<td>3.0</td>
</tr>
<tr>
<td>Middle</td>
<td>44</td>
<td>42</td>
<td>–2</td>
<td>4.5</td>
</tr>
<tr>
<td>Edge</td>
<td>41</td>
<td>39</td>
<td>–2</td>
<td>4.9</td>
</tr>
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**Table 3**

<table>
<thead>
<tr>
<th>Brand and Sensor</th>
<th>M</th>
<th>SD</th>
<th>% Difference in Means</th>
<th>t</th>
<th>p</th>
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</thead>
<tbody>
<tr>
<td>Rosidal K</td>
<td>44.0000</td>
<td>0.0000</td>
<td>–6.899 &lt;.001</td>
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<td></td>
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<tr>
<td>Middle</td>
<td>41.5679</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensolan L</td>
<td>44.1538</td>
<td>0.3755</td>
<td>–12.179 &lt;.001</td>
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<tr>
<td>Middle</td>
<td>41.5385</td>
<td>0.9674</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Komprimed</td>
<td>42.5380</td>
<td>0.9674</td>
<td>–40.695 &lt;.001</td>
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<tr>
<td>Middle</td>
<td>31.8460</td>
<td>0.8987</td>
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<tr>
<td>Durelast</td>
<td>46.8462</td>
<td>0.3755</td>
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<tr>
<td>Middle</td>
<td>33.3846</td>
<td>0.9608</td>
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<tr>
<td>Edge</td>
<td>44.6923</td>
<td>0.4804</td>
<td>–60.930 &lt;.001</td>
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</tr>
<tr>
<td>Comprilan</td>
<td>44.0000</td>
<td>0.0000</td>
<td>–6.899 &lt;.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Middle</td>
<td>32.0000</td>
<td>1.0000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge</td>
<td>39.8622</td>
<td>0.8992</td>
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<td></td>
</tr>
</tbody>
</table>

**Note:** n = 13 for each bandage.
readings were taken from three sensors located under the wrapped bandage (see Table 4). For all bandages, the greatest difference between any two readings of the three sensors was 4 mmHg. Therefore, each bandage exhibited an even distribution of pressure when wrapped with a 50% overlap.

Discussion

All six major brands of short-stretch compression bandages tested in this study exhibited physical properties consistent with the recommendations for therapeutic compression in treating lymphedema. Although a slight decrease in pressure was found at the middle and edge of each bandage when tested over a 12-hr period, the difference was not statistically significant, and pressures always remained within the recommended therapeutic range. A significant variability in pressure was found across the width of all six bandages. We contacted one manufacturer who noted that the bandages are designed to have less pressure on the edges to assist in even distribution of pressure when wrapped with a 50% overlap. When wrapped on a plastic cylinder with a 50% overlap, each bandage exhibited an even distribution of pressure consistent with therapeutic recommendations.

In testing the physical properties of these short-stretch compression bandages, all exhibited good therapeutic qualities and none was shown to be inferior or superior to the rest. We recommend further studies to test the physical properties when the bandages are (a) reapplied, (b) washed, and (c) applied to an edematous limb. Bandages used to treat lymphedema are commonly doffed and reapplied during the day; therefore, the physical properties may change. Because bandages soil and require washing, this may affect their physical properties as well. Finally, this study examined the physical properties of the bandages when applied to a solid cylinder. The physical properties may vary when these same bandages are applied to soft tissues.

References


