
Effects of Continuous Passive Motion on the Edematous Hands of Two Persons With Flaccid Hemiplegia

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Key Words: occupational therapy (treatment)
• single subject research

Objectives. This study evaluated the effect of the use of a continuous passive motion device for the edematous hands of two persons with flaccid hemiplegia.

Method. The subjects were both 1 month post-cerebrovascular accident with left-sided hemiplegia. Each subject's routine therapy program was maintained throughout this ABA design study. During the first week, baseline data were gathered, during the second week the intervention was provided (2 hr of continuous passive motion device use), and during the third week data were gathered with treatment withdrawn. Edema was measured with a hand volumeter and finger circumference.

Results. The continuous passive motion device had an effect in reducing edema in the hands of the two subjects.

Conclusion. The continuous passive motion device is a readily available tool that could enhance the treatment of edematous hands of persons with flaccid hemiplegia by offering a contribution to already established treatment protocols. Further research is needed, however, to establish guidelines for use.

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Edema, the presence of large quantities of fluid in the intracellular spaces, is likely to develop in extremities that are in a dependent position or inactive because of weakness, paralysis, or pain (Vasudevan & Melvin, 1979; Worenson, 1989). Edema is reported in about 16% of cases of hemiplegia after a cerebrovascular accident (CVA). It is usually more marked in the upper extremity, and it may be confined to the hand (Exton-Smith & Crockett, 1957; Sorenson, 1989).

The most important factor in the causation of edema is that drainage of protein from the tissues by the lymphatics is impaired due to the loss of muscular activity. Edema that is allowed to persist will likely cause an extremity to become painful, disfiguring, and disabling. Collagen tissue is laid down in the protein-rich, glue-like fluid deposited between tissue layers and the folds of the joint capsule (Laseter, 1983; Mackin, 1986). When this condition is accompanied by immobilization, the tissues are allowed to set, thus leading to fibrosis and eventually to contractures.

After a CVA, the upper extremity recovers in the following sequence of stages: (a) flaccidity, (b) little or no active movement, (c) mass grasp, (d) lateral prehension, (e) palmar prehension, and (f) individual finger movements (Brunnstrom, 1970). During the flaccid stage, the person is especially susceptible to persistent edema due to a lack of active movement. Some traditional treatments of edema in the hands, such as toning gloves and compression boards, do not provide needed movement and contribute to the immobilization of the joints.

Both active and passive movement can reduce edema (Abramson, 1965; Sorenson, 1989). The pumping action of the muscles reduces edema by returning fluid to the venous flow (Hargens, 1981). Because persons with flaccid hemiplegia cannot engage in self-initiated hand exercises that incorporate pumping actions, they must rely on passive range of motion (Trombly, 1983).

Continuous passive motion, which provides repetitive movement of a joint either through full or partial range of motion, may have potential for reducing edema. Early use of continuous passive motion of the limbs was found to stimulate healing of injured joints (Salter et al., 1984). Since that time, continuous passive motion has been found effective for the treatment of limited range of motion and edema when applied to a variety of diagnoses including burns, arthritis, phalangeal fractures, and hemiplegia (Bentham, Brereton, Cochrane, & Lyttle, 1987).

Giudice (1990) evaluated the effects of continuous passive motion and hand elevation in the treatment of edematous hands of 16 subjects, including a subgroup of 11 subjects with hemiplegia. Each subject received both treatments, including 30 min of hand elevation alone and 30 min of hand elevation with continuous passive motion, one on each of 2 consecutive days. Giudice concluded that 30 min of continuous passive motion with elevation

resulted in a significantly greater reduction in hand edema than the 30 min of hand elevation alone. Her study provides preliminary support for the use of continuous passive motion in the reduction of hand edema.

The hypothesis of this study was that a continuous passive motion device, used in addition to ongoing occupational therapy and physical therapy, would reduce edema in the hands of persons with flaccid hemiplegia.

Method

Subjects

The two subjects selected for this study had each experienced a CVA resulting in a left-sided hemiplegia 1 month before the study. Both subjects met the criteria for the study, which included flaccid hemiplegia, no limitations in passive movement, at least moderate edema in the hand, and no history of neurological disorder. Each subject participated on a voluntary basis with the option to discontinue participation in the study at any time.

Subject 1 was a 75-year-old woman whose left upper extremity had flaccid tone throughout with no active movement; no limitations in passive movement of the elbow, wrist, and hand; and moderate edema in the hand, as diagnosed by the treating physiatrist. She also reported an aching pain in the joints of the hand. Measurement with a jeweler's rings showed that the index finger on the affected left hand measured two sizes larger than the index finger on the nonaffected right hand. The subject used a wheelchair independently for transportation. The wheelchair was equipped with a fabricated armboard and an elevating wedge for positioning of the left upper extremity.

Subject 2 was a 62-year-old man whose left upper extremity had flaccid tone throughout with no active movement; no limitations in passive movement of the elbow, wrist, and hand; and moderate edema in the hand. This subject had no complaints of pain in his left hand and displayed a decreased awareness of the left upper extremity. The jeweler's rings showed that the finger on the affected left hand measured two sizes larger than the corresponding finger on the nonaffected right hand. He used a wheelchair independently for transportation. The wheelchair was equipped with a fabricated armboard for positioning of the left upper extremity.

Procedures

A single-subject ABA withdrawal design was used for this study (Ottenbacher, 1986; Ottenbacher & Bonder, 1986). Edema was measured by the same person with two methods: volumeter and the jeweler's rings (Bear-Lehman & Abreu, 1989; Waylett-Rendall & Seibly, 1991). The volumeter measures the amount of water displaced by the fingers, hand, and wrist as a total unit. The jeweler's rings measure the circumference of the base of one finger.

Measurements were taken daily for 3 weeks at the same time of day. According to Waylett-Rendall and Seibly (1991), the volumeter was found to be accurate to within 1% of the total volume when successive measurements were performed with a prosthetic hand. Preliminary intrarater assessment of this study was performed by the primary investigator with five persons without impairments. The combination of normal daily fluctuation in body fluid levels and measurement error resulted in a 5% change or margin of error with the use of the volumeter.

During this 3-week study, baseline measures were taken in the first week. Daily measures were taken after the subject had received 2 hr of continuous passive motion treatment the second week, and in the third week daily measures were taken at the same time while no continuous passive motion treatment was administered. The Toronto Mobilimb H2 Hand¹ set at a 45° angle was the continuous passive motion device used. The device is lightweight (18 oz) and employs advanced electronics to maintain ongoing motion. A reverse on-load safety mechanism prevents excessive force.

Subjects' medications and therapeutic interventions, 1 hr of occupational therapy and 2 hr of physical therapy daily, were maintained during the study to avoid changes due to other treatments.

Data Analysis

The measurements were plotted on a graph for both visual and statistical analysis (Ottenbacher, 1986). Visual analysis was completed by observation of patterns that developed over the 3-week data collection period. Observations of upward, downward, or inconsistent patterns were noted.

The split-middle method of trend estimation was used to determine the statistical significance of the findings (Wolery & Harris, 1982). In this method, data from each week are plotted on graph paper, the data points are divided in half, midpoints of the first half and the second half are determined, and the midpoints are connected. The resulting split-middle lines are evaluated according to the degree of change. Because there are no established criteria for determining the significance of the degree of change, the lines are drawn for illustration of direction and degree of change.

The mean of the data gathered with the volumeter was also calculated for each of the 3 weeks. These means were used for comparison of edema levels over time. In addition to this visual analysis, a Pearson's product-moment correlation coefficient (*r*) was calculated to establish the strength of the correlation between the two measurements.

¹Manufactured by Toronto Medical, PO Box 26, Yellow Springs, Ohio 45387.

Results

Volumeter data and data gathered with the jeweler's rings are shown in Figures 1, 2, 3, and 4. The correlation between the two measurements was fairly strong with a Pearson's $r = .57$ for the first subject and $r = .56$ for the second subject (Pagano, 1986).

Visual analysis of the figures indicates an effect in the amount of edema in the flaccid hands. The pattern during the first (baseline) week reveals an unstable situation where edema appears to be increasing. The pattern in the second (treatment) week with the use of the continuous passive motion device indicates a reduction in edema. The pattern in the third (withdrawal of treatment) week did not show a continued increase in edema as seen in the first week.

The statistical analysis demonstrates the same pattern noted in the visual analysis. In both subjects, the split-middle line inclines at a 75° angle during the first week. During the second week, the split-middle line of trend estimation from data on the first subject declines at a 75° angle and that of the second subject declines at a 15° angle. During the third week, the line of trend estimation

declines 7° in the first subject and 50° in the second subject.

The mean of the data for each week of the study repeats this pattern. For the first subject, the means from the volumeter data are 314.4 ml for the baseline week, 285.4 ml for the treatment week, and 305 ml for the withdrawal week. For the second subject, the means from the volumeter data are 577.2 ml for the baseline week, 549.6 ml for the treatment week, and 562 ml for the withdrawal week. In this and each of the other aspects of the analysis, the treatment phase of the study resulted in a reduction in the amount of edema in the hands of both persons with flaccid hemiplegia. Although Subject 2 displayed a decrease in edema followed by an increase in edema during the treatment phase, the average overall volume was reduced during this phase. The reason for the upswing at the end of the treatment week cannot be determined by the parameters of this study.

Discussion

The analysis of the data indicates that the use of continu-

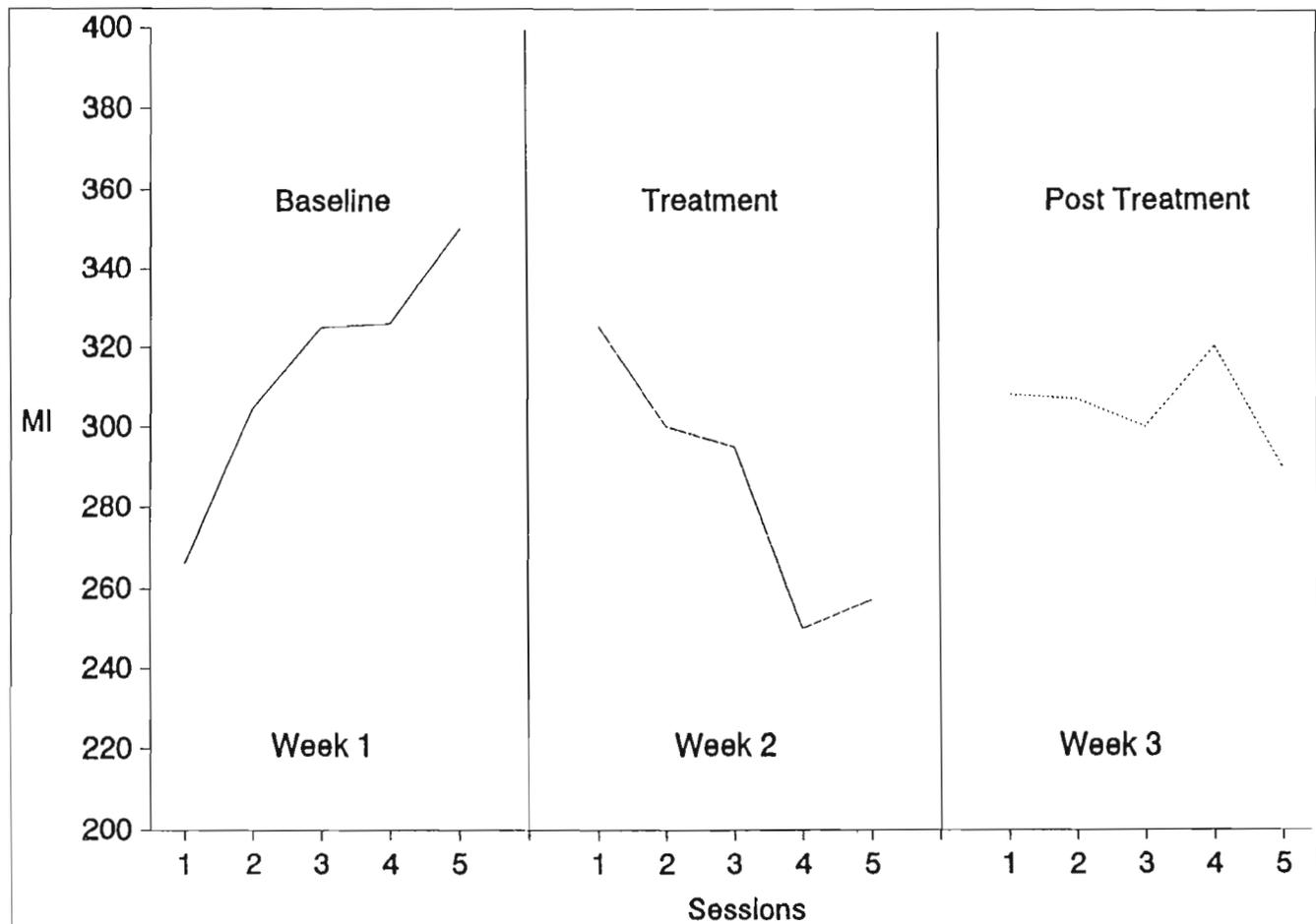


Figure 1. Subject 1: Volumeter measurements throughout all phases of the study.

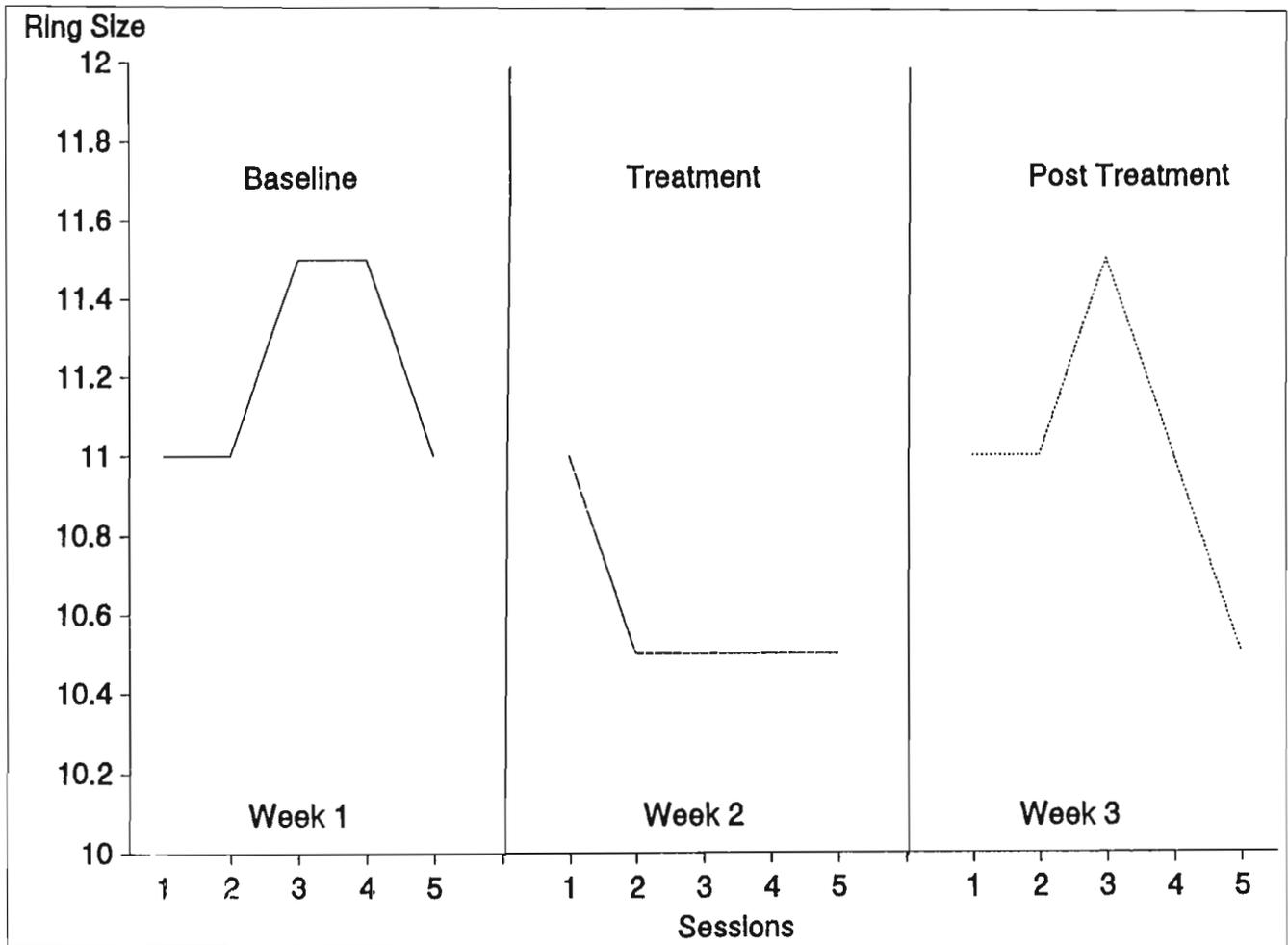


Figure 2. Subject 1: Jeweler's ring measurements throughout all phases of the study.

ous passive motion may have value in the treatment of edematous hands of persons with flaccid hemiplegia. Both subjects displayed a reduction in edema of their involved hands during the treatment phase. The literature indicates that immobilization of the edematous hand allows for the formation of contractures (Laseter, 1983; Mackin, 1986). The findings of this study suggest the potential use of continuous passive motion in addition to the use of devices such as toning gloves and splints, which provide compression and positioning, but immobilize the joints.

Both the visual and statistical analyses of the data indicate a positive response during the treatment phase, but the continual effect during the withdrawal phase is somewhat unclear. In both subjects, the mean of the data gathered during the third week was higher than that of the second week, but lower than that of the first week (see Figures 1 and 3). The edema increased somewhat during the withdrawal phase, but did not return to baseline. It is not known whether the edema would have decreased further with the continued use of the continu-

ous passive motion device or whether the device had reached its maximal effect.

This design eliminated the difficult task of matching subjects and the influence of between-group variance. The single-subject design allowed the edema to be evaluated with each subject's own hand as the control data while also providing an assessment of change over time.

Further research might include subjects with some beginning movement and mild edema. The data could then be separated for evaluation to determine the levels of recovery with which the continuous passive motion device is most effective.

The measurement devices used in this study can also be evaluated. The volumeter has a greater sensitivity to change in the fluid in the fingers, hand, and wrist. It did, however, have a greater margin of error in the preliminary intrarater reliability assessment. The jeweler's rings did not indicate any error in intrarater reliability, but they were not as sensitive to small changes in edema. The use of the two measurement devices allowed the investigator options in the study. For example, the jeweler's rings

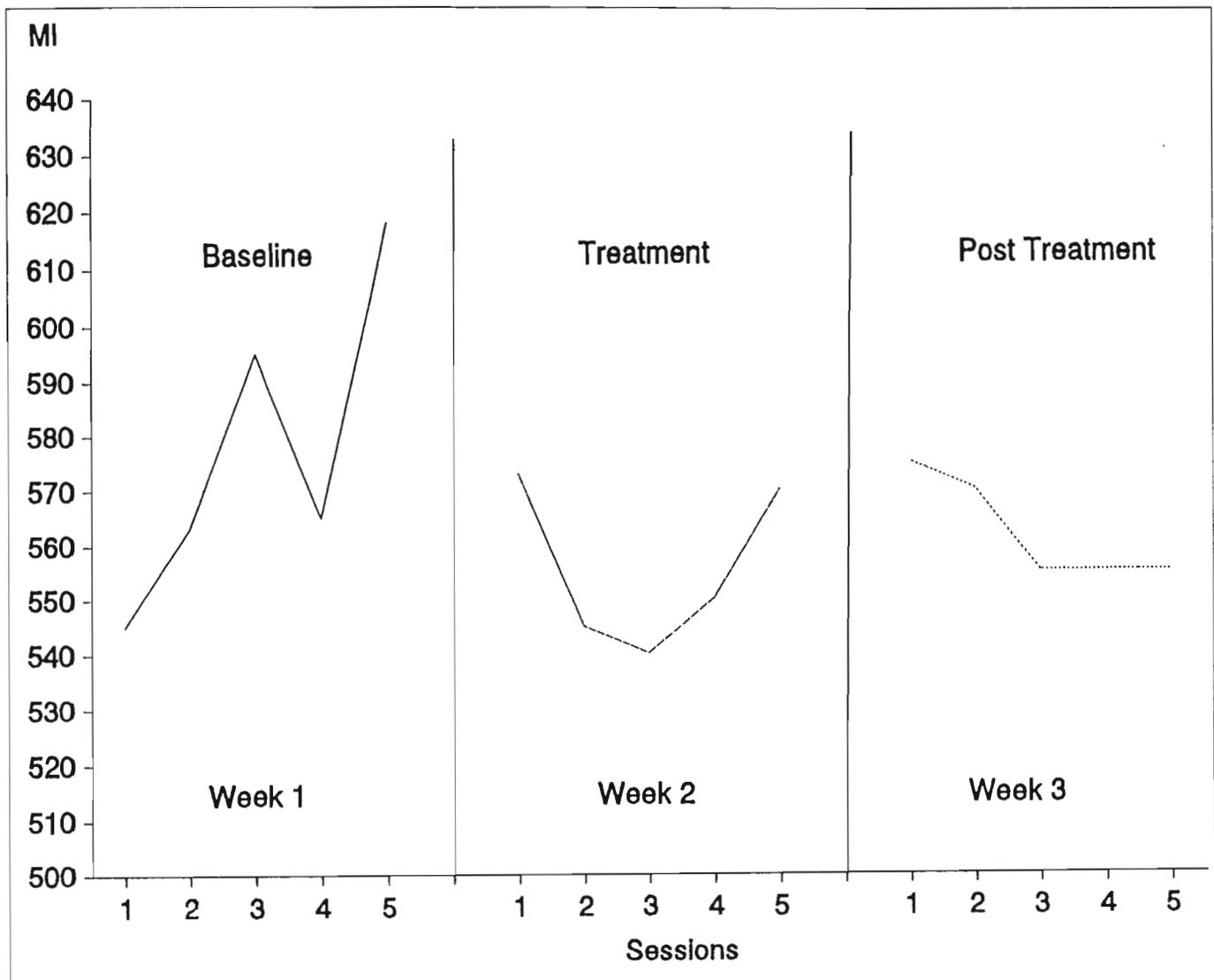


Figure 3. Subject 2: Volumeter measurements throughout all phases of the study.

were used to compare finger circumference with the contralateral hand; the more sensitive measurement, the volumeter, provided information about small changes in edema in the entire hand. Evaluation of the results indicated a fairly positive correlation between the two types of measurements.

Some subjective observations were made by the investigator and the subjects regarding the treatment tool. The Toronto Mobilimb H2 Hand device was generally easy to use with the subject seated in a wheelchair with an attached armboard. It was portable and the subject was free to perform other activities during treatment such as eating, reading, and visiting with others. Although the device did provide sufficient flexion of the proximal interphalangeal joints and the distal interphalangeal joints, it provided only partial flexion at the metacarpalphalangeal joints. Cloth adhesive tape had to be used in addition to

the device straps to anchor the device to the fingertips. Neither subject reported discomfort resulting from the treatment; one subject reported that the use of the device relieved the aching feeling in the joints of her hand.

The continuous passive motion device was used in addition to the scheduled therapeutic intervention. This study in no way suggests that the use of the continuous passive motion device could replace the hands-on treatment received in occupational therapy and physical therapy. This device, however, could enhance treatment by providing the continuous passive range of motion that is needed over longer periods of time. The continuous passive motion devices designed for treatment of other joints such as the knee, elbow, and wrist are prescribed for use during the hours that clients are not in therapy sessions. The use of a hand continuous passive motion device during out-of-therapy hours would provide supplemental

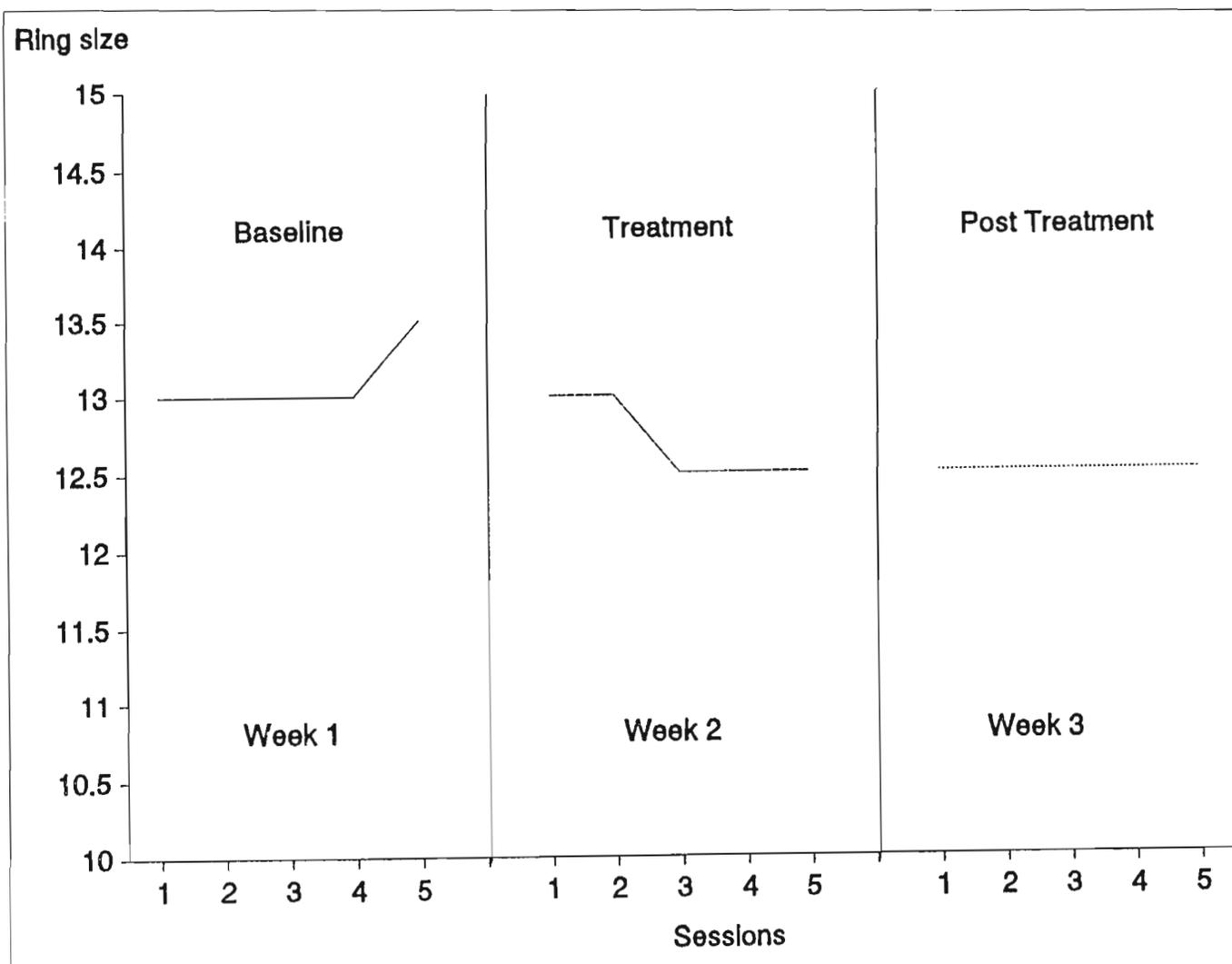


Figure 4. Subject 2: Jeweler's ring measurements throughout all phases of the study.

treatment.

Although the manufacturer recommends that, in general, the device be used for 8 hr per day for maximal benefit for edema reduction, it was used for only 2 hr daily and only over a 5-day period for practical purposes and client tolerance. The ability of the person to tolerate 8 hr of time and the effects that would be observed on the edematous hand were not assessed. Both subjects were able to tolerate 2 hr of continuous passive motion treatment per day but no more.

This study was also limited to two subjects. Further research is needed to investigate the use of the continuous passive motion device with a larger number of subjects who are hemiplegics with flaccid upper extremities. The evaluation of a larger sample size could provide efficacy information on which to base guidelines for the use of this device.

Conclusion

Occupational therapists are continually searching for new

technologies to enhance the effectiveness of treatment. The continuous passive motion device is a readily available tool that is used to treat edematous upper extremities. Further research is needed to establish guidelines for the use of the continuous passive motion device for the treatment of edematous hands of persons with flaccid hemiplegia. With guidelines, the use of the continuous passive motion device could enhance the effectiveness of already established treatment protocols by preserving the integrity of the joints while supplying additional means of edema reduction. ▲

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