Effects of Compression Materials on Hand Dexterity in the 40's Healthy Subjects: A Preliminary Study

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Purpose: The aim of this preliminary study was to use hand function tests to Hand dexterity levels provided by the type of compression garment and compression bandages in asymptomatic subjects and to collect baseline data for the comparison of hand functions in the patients with chronic arm lymphedema.

Methods: The subjects of this study were 32 healthy volunteer female with a mean age of 45.8 years. Grip strength and hand functions were tested in three conditions—no compression, compression garment, and compression bandages—using the nine-hole peg test (NHPT), the box and block test (B&BT), Minnesota Manual Dexterity test (MMDT), and the hand-held Jamar dynamometer.

Results: The grip strength was significantly low in the bandage condition ($p<0.05$). The performance in both compression groups (i.e., bandage and compression garment) decreased as the thickness of the compression material increased ($p<0.05$).

Conclusion: The findings of this study suggest that grip strength and hand function scores are influenced by the characteristics of the compression applied. Future study is needed to determine the level of hand function between patients with chronic arm lymphedema and healthy individuals.

Keywords: Hand dexterity, Nine-hole peg test, Box and block test, Minnesota manual dexterity test

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I. Introduction

Lymphedema can occur in the upper extremity following axillary lymph-node dissections for the staging and treatment of breast cancer.[1] With increasing lymphedema, the joints in the involved area become stiff and their overall range decreases.[2] The joint range of motion is also negatively affected by the sheer increase in mass. This lost range, coupled with the increased fluid tension in the subcutaneous tissue, can cause symptoms ranging from discomfort to outright pain in the lymphedematous arm,[3] adversely affecting arm use in functional activities of self-care and work.[4]

The gold standard treatment for lymphedema is complex decongestive physical therapy (CDPT) which consists of meticulous skin care, manual lymph drainage (MLD), compression, and remedial exercise.[5] The conservative treatment program is aimed at reduction of edema and prevention of the disabling sequelae.[4,5] During the treatment phase, it is important that the patient adhere to all 4 components of therapy and, more importantly, maintain the compression bandages on the limb 24 hours per day.[6,7] Once the patient reaches a plateau in volume reduction for the affected limb, the patient begins the maintenance phase.[6] The maintenance phase is a life-long, self-care program. During this phase, the patient continues with a daily home maintenance program that includes self-MLD, skin care, compression, and exercise.[4-6] Especially, it is very important that the patients wear well-fitted compression garments or compression bandaging to maintain edema in everyday.[6,7] Compression therapy in edema management remains the standard treatment of venous and lymphatic

disease.[8] It is evident that the benefits of compression therapy are similar to those of massage (i.e., increased interstitial pressure, increased lymph reabsorption, breakdown of fibrosclerotic tissue, and improvement in venous and lymphatic pump actions.[9,10] However, massage does not exert the longer-lasting effects experienced with compression, and so patients with chronic edema or lymphedema must be provided with compression as an essential part of their treatment, and should always be fitted with a compression sleeve or bandages during their daily lives.[2,11]

Dexterity is an important component of hand function; it is the ability to move the fingers skillfully, and to make coordinated movements and manipulate small objects with the fingers rapidly and accurately in the environment.[12] Poor dexterity as a result of compression support may lead to difficulty in performing the activities of daily living, and especially functional tasks.[1,13] However, no previous study has investigated the effects of compression support on hand dexterity. Therefore, the aim of this study was to use hand functions test to hand dexterity levels provided by the type of compression bandages and compression garment in asymptomatic subjects. This preliminary study was taken to collect baseline data for the comparison of hand functions in the patients with chronic edema.

II. Methods

1. Subjects and Periods

The subjects comprised a convenience sample of 32 healthy women volunteers with aged 45.8±2.5 years and had a BMI of 22.3±3.5 kg/m^2. Experimental period was from July 1st, 2010 to July 15th, 2010.

They all met the following inclusion criteria: 40～49 years of age; right handed; no shoulder, elbow, hand, or cervical injuries or dysfunction during the previous year; no limitation of range of motion in any joints of the dominant hand; no history of neurological impairment affecting balance, vision, or coordination; and no skin disease. All subjects signed informed consent forms.

2. Setting and Measurements

The research experiments were performed in a quiet and well-lit room. A researcher interviewed each participant to obtain demographic information, and measured baseline grip strengths and hand dexterity. Grip strength measures were made using the hand-held Jamar dynamometer (Sammons Preston Rolyan, USA) with standardized positioning and instruction[11], and fine motor dexterity and gross hand dexterity were measured using the nine-hole peg test (NHPT) and the box and block test (B&BT), respectively. Grip strength and hand dexterity were tested in the three following conditions:

1) No-compression condition.
2) Garment condition: wearing a ready-made compression glove (exerting a pressure of 25～32 mmHg) with a separate, long, finger-type handpiece and a wrist-to-shoulder compression sleeve (Schiebler, Germany) on the dominant hand.
3) Bandage condition: two 4 cm elastic bandages (Mollelast, Lohmann-Rauscher, Germany), cotton tubular stockinettes (6 cm, Tricofix, BSN-Jobst, USA), a 10 cm foam padding roll (CompriFoam, BSN-Jobst, USA), and a 6-, a 8-, and two 10 cm short stretch bandages (Comprilan, BSN-Jobst, USA).

3. Data Collection

The grip strength test and three hand dexterity tests (NHPT and B&BT) were administered in the three aforementioned conditions.

Grip strength. The dominant or affected upper extremity was tested three times using procedures recommended by the American Society of Hand Therapists, and scores are expressed in kilograms. The participant was told to keep her shoulder adducted, the elbow flexed at 90º, and the forearm and wrist in the neutral position without resting the arm on the table or chair, and to place her fingers on the second position of the handle of the dynamometer. The participant was asked to squeeze as hard as possible for 3～5 s; verbal encouragement was provided whenever necessary.

Dexterity test. The NHPT (Smith & Nephew, UK) was used to measure fine hand dexterity. Participants were tested at a desk and chair of appropriate height with their feet supported on the floor. The procedure described by Mathiowetz et al.[14] was followed in this study. The pegboard was centered in front of the subject with the container sides on the same side as the hand being tested. The instructions employed were those used by Mathiowetz et al.[14] The subject was required to pick up nine

dowels and place them into nine corresponding holes. The time required for peg placement and removal was evaluated and the time taken to complete the test was recorded. High interrater reliability and moderate test–retest reliability have been demonstrated, ranging from 0.80 to 0.93 and norms for adults up to 75 years of age and above for both genders were established.[14]

The B&BT was used to measure gross hand dexterity in this study. This test requires the subjects to transfer 2.5 cm cubes one at a time from one (full) box across a 15.2 cm barrier to a second (initially empty) box. The participant was instructed to pick up the pegs with their dominant or affected hand and place them one at a time into the holes as rapidly as possible and then to remove the pegs one at a time with the same hand. Scores are recorded as the number of blocks moved per minute for each hand. The repeated one-way analysis of variance (ANOVA) and Scheffé's post hoc were used to determine the effects of each of the conditions on hand dexterity.

The Minnesota Manual Dexterity test (MMDT) produced by the Lafayette Instrument Company has been used in many studies and has been proved to have high specificity for evaluating hand ability.[16-18] The MMDT dimensions consist of one plastic collapsible board, 85.4 cm long, 22.8 cm wide, and 0.5 cm thick. The collapsible board also has 60 holes, 3.9 cm in diameter and 0.5 cm deep. There are also 60 cylindrical blocks measuring 3.7 cm in diameter and 1.9 cm high. The cylindrical blocks are red on one side and black on the other side. The MMDT incorporate five subtests: the Placing Test, The Turning Test, the Displacing Test, the One-hand Turning and Placing Test, and the Two-hand Turing and Placing Test. The Turning Test and the Placing Test were the two subtests selected for this study.

Bandaging was performed by a trained occupational therapist and the order of the trials was randomized. This randomization endured that the "each condition" was perfectly balanced with respect to order. This strategy was used to minimize the combined effect of time, practice, and fatigue on the results.

4. Statistics

Means and standard deviations were calculated for all test scores for each condition. The repeated one-way analysis of variance (ANOVA) and Scheffé's post hoc were used to determine the effects of each of the conditions on hand dexterity. The collected data were analyzed using standard statistics software (SPSS ver. 17.0), and the alpha level was set at 0.05 for all tests.

III. Results

1. Grip strength

Table 1 presents the scores for grip strength. The effect of each compression condition on the grip strength was determined by ANOVA. The grip decreased gradually in the bandage condition compared to the no-compression and garment conditions ($p<0.05$). Post-hoc testing revealed that the grip strength was significantly smaller in the bandage ($p<0.05$) than in the no-compression condition.

Table 1. Grip strength under each condition (n=32)

Variable	No-compression condition (a)	Garment condition (b)	Bandage condition (c)	Scheffé
Dynamometer (kg)	37.02±8.40	35.98±7.93	31.30±8.74	a>c*

*p<0.05

2. Hand dexterity scores

Table 2 presents the dexterity scores under each condition. The dexterity scores of the NHPT, B&BT and MMDT differed

Table 2. Dexterity scores under each condition (n=32)

Variables	No-compression condition (a)	Garment condition (b)	Bandage condition (c)	Scheffé
NHPT (second)	17.22±2.47	18.73±3.76	26.04±4.88	a<c*, b<c*
B&BT (number)	79.29±7.57	70.68±9.22	67.74±0.54	a>c*, b>c*
MMDT placin g(second)	58.29±5.44	58.12±6.91	65.17±14.10	a<c*, b<c*
MMDT turning (second)	43.59±6.97	47.59±6.97	53.88±8.66	a<c*, b<c*

*p<0.01

significantly between the experimental and control groups only for the NHPT score in the bandage condition ($p<0.05$).

The performance under each condition tended to worsen globally in among the NHPT, B&BT and MMDT. Post-hoc testing revealed that the NHPT and MMDT scores were higher and the B&BT scores lower in the bandage condition ($p<0.01$) than in the no-compression and garment conditions.

IV. Discussion

The use of compression materials is recommended in a variety of disease to protect or treat affected arm.[19] Patients with chronic edema often prefer to work with bare hands, however, because wearing compression sleeves or bandages hinders their performance in daily living.[20,21] Dexterity and upper arm functions tests are generally used to assess performance decrease due to gloves, temperature and disease et al.

Patients with chronic edema often prefer to work with bare hands, however, because wearing compression sleeves or bandages hinders their performance in daily living.[21] In our investigation, the changes in hand dexterity were evaluated by means of three objective and standardized tests of hand function, namely the NHPT, B&BT and MMDT. The statistically significant difference was for hand dexterity testing using the NHPT, B&BT and MMDT in the bandage condition. This suggests that the level of compression and the materials used to apply that compression have a great impact on hand dexterity. It became increasingly difficult to complete each test as the thickness of the compression material increased.

The hand dexterity test scores under each condition were unsurprising, in that dexterity for the bandage condition was consistently worse than for the no-compression and garment conditions. There are two reasons for this: (1) the flexibility of the bandage material may not allow as much hand function as the garment, and (2) grip strength under the bandage condition was the lowest of all of the conditions because the bandage material resists joint mobility. As the compression material became thicker, the level of hand function deteriorated further. There are several factors to be considered in this regard, such as the amount of pressure and the type of compression that is applied. The amount of pressure imposed by the garment and bandage varies depending on the type of material and its mode of application. Nonelastic bandage material provides more working pressure than does an elastic garment, and might be preferred to treat edema, but its lack of flexibility inhibits the hand function in activities of daily living. Improved compression materials need to be developed for patients with edema.

Grip strength is important for function, and it is reported that 20 lb of grip force is needed for the completion of most activities of daily living, with females typically being able to apply up to 55 lb of force.[14,22] The recorded grip was higher than the normative values for their age group. We thought that this is result from selection bias and the difference of task types in two country.

The limitations of this study include the lack of stage-specific data for grip strength and hand function levels provided by the two types of compression methods. The reason why we selected female subjects in their 40s is that this age group has the highest incidence rate of breast cancer in South Korea, and this condition is known to result in chronic arm lymphedema.[23]

The findings of this study suggest that the grip strength and hand function scores of females in their 40s are influenced by the compression type. Following this preliminary study, it is suggested that future study be designed to determine the level of hand function between patients with chronic arm lymphedema and healthy individuals in the 40s and to ascertain the effects on response to compression type.

Author Contributions

Research design: Kim SJ
Acquisition of data: Rhee HS, Yu JH
Analysis and interpretation of data: Kim SJ
Drafting of the manuscript: Kim SJ
Administrative, technical, and material support: Kim SJ
Research supervision: Kim SJ

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