The Effects of Extensor Pattern Position and Elastic Taping of Non-Dominant Hand on the Grip Strength of Dominant Hand

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Abstract

Grip strength is an objective indicator for evaluating the functional movement of upper extremities. Therapists have been using it for a long time as an excellent barometer for evaluating the therapy process, therapeutic effects and prognosis of patients with injuries in upper extremities. This study investigated the effects of extensor pattern position and elastic taping of non-dominant hand on the grip strength of dominant hand among general adults. The subjects of this study were 23 males and 7 females from physical therapy departments of 3 Universities located in Busan who agreed to participate in the experiment and the resultant data were analyzed using SPSS version 12.0. The results of the study were as follows. First, there was a significant difference between the grip strength of dominant hand when the non-dominant hand was at the neutral position and that when the non-dominant hand was at the extensor pattern position and both hands were at the maximum strength simultaneously (Bonferroni-corrected $p<.001$). Second, there was a significant difference between the grip strength of dominant hand when the non-dominant hand was at the neutral position and that when the elastic taping of non-dominant hand was applied (Bonferroni-corrected $p<.001$). Third, there was no significant difference between the grip strength of dominant hand when the non-dominant hand was at the extensor pattern position and both hands were at the maximum strength simultaneously and that when the elastic taping of non-dominant hand was applied. The irradiation effects through the extensor pattern position of non-dominant hand and application of the elastic taping to non-dominant hand showed significant results in improving the maximum grip strength of dominant hand. This finding could be suggested as the probability for the indirect treatment of the upper extremities of hemiplegia and orthopedic patients due to the long-term fixing of upper extremities.

Key Words: Elastic taping; Extensor pattern position; Grip strength; Irradiation.

Introduction

Grip strength is produced by the forcible activities of the thumb and other fingers intended to deliver power (Napier, 1956), and it is required in diverse functional activities in daily life such as gripping a cup, gripping a hammer, gripping a tennis racket when exercising, or gripping a crutch or parallel bars in gait training (Park, 2002). Grip strength is assessed to examine the muscle power of the hand, to assess the degree of disorder of the hand, or to establish appropriate treatment plans (Incel et al, 2002; Innes, 1999; Massy-Westropp et al, 2004). When measuring grip strength, the posture of the upper extremity affect the result. Su et al (1994) reported that the highest grip strength was recorded when the shoulder joint was flexed by 180°, and the elbow joint was fully extended. Balogun et al (1991) reported that higher grip strength values were shown when the elbow joint was fully extended in a stand-

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ing position, than when the elbow joint was fully extended in a sitting position. Furthermore, that while higher grip strength values were shown when the elbow joint was fully extended in a sitting position than when the elbow joint was flexed by 90° in the sitting position. Reduced grip strength plays the role of predicting the disorders of elderly persons (Giampaoli et al, 1999), and it is related with nutritional statuses (Chilima and Ismail, 2000) and cognitive declines (Alfaro-Acha et al, 2006).

Standard procedure is that the affected side is intensively treated in order to improve the functional movements of the upper extremity in previous studies in recent studies it has been reported that indirect therapeutic approaches attempting to obtain the recovery of the affected side using the unaffected side of the body were effective (Kim and Yi, 2001). Clinically, applications of these indirect treatments are explained by the concept of cross education. Since the motor tract is connected bilaterally (Colebatch et al, 1991), 90% of the corticospinal tract fibers started from the hemisphere at one side control the motor of the contralateral upper extremity, and the remaining corticospinal tract fibers control the motor of the ipsilateral upper extremity to enable ipsilateral control (Chollet et al, 1991). As such, the small number of ipsilaterally descending corticospinal tracts causes motion orders to go down to the motor neurons with insufficient descending connections (Farmer et al, 1991). It has been shown that reinforcing the connection of the efferent pathway controlling the ipsilateral upper extremity of hemiplegia patients, through the activation of the brain area at the unaffected side, can improve the motor control of the upper extremity at the affected side (Weiller et al, 2002). For this therapeutic purpose, Knott and Voss (1968) used the maximum resistance to obtain the irradiation effect of applying resistance to the stronger side to reinforce the weaker side.

The neurophysiological concept of irradiation is defined as the diffusion of responses to resistance, and if the intensity and time of stimulations are increased, the responses will increase (Adler et al, 2000; Knott and Voss, 1968). Irradiation is applied to give the maximum resistance to the stronger side in order to reinforce the movements of the weaker side when treating patients with injuries in the nervous system. In this case, the maximum resistance is to block the movement pattern of the stronger side and reinforce the weaker side (Knott and Voss, 1968). As for the conceptual utilization of irradiation, irradiation is best utilized in proprioceptive neuromuscular facilitation (PNF) as a method to induce interactions between the two sides of the body and increase oblique and spiral movement patterns, or to promote the muscle contractile force of the paralyzed or weakened affected side through resistance exercises of the unaffected side (Adler et al, 2000). In particular, this method uses contralateral effects to promote weakened contractile force of hemiplegia patients who cannot selectively contract muscles, or patients with muscle atrophy resulting from long-term fixations (Fujiwara et al, 1999).

Methods of promoting weakened muscle contractile force include a method using elastic taping. Braakman et al (1998) reported that the risk of re-fracture was reduced through the improvement of muscle strength in fracture patients applied with elastic taping. In addition, Shelton (1992) reported that elastic taping was applied to patients with reduced muscle power of the quadriceps femoris, and it showed increases in the muscle power of the quadriceps femoris. Taping has been widely used for the reinforcement or protection of joints, for the reduction of edema, and for supports at times of acute injuries (Leanderson et al, 1996). However, elastic taping methods are also being developed to directly attach elastic tapes to the skin and muscles at the times of musculoskeletal system injuries in order to reduce pain and improve functions, such as muscle power and muscular endurance (Gilleard et al, 1998; Kowall et al, 1996; Larsen et al, 1995; Rettig et al, 1997).

Based on this theory, relationships between the postures of the shoulder joint, the elbow joint, the forearm, or the wrist joint (Balogun et al, 1991; Mathiowetz et al, 1985; Su et al, 1994), and grip strength (Deutsch et al, 1987; Park, 2002) have been analyzed in preceding studies. However, there has been no study on how the state of the non-dominant hand affects the maximum grip strength of the dominant hand. Consequently, the purpose of this study is to examine the simultaneous maximum grip strength of healthy adults with the extension pattern position of the non-dominant hand intended to produce irradiation effects, and the effect of the application of elastic taping to the non-dominant hand on the increases in the grip strength of the dominant hand.

Methods

Subjects

The subjects of the study were 23 males and 7 females in the physical therapy departments of three universities located in Busan. Those who had no limitation in the range of movement of the wrist and elbow joints that might remarkably affect grip strength, and had no orthopedic disorder such as deformity, fracture, arthritis, or tenosis, whose muscles are not in a tired state due to excessive exercises, and whose musculoskeletal systems have not been injured within the last four weeks were selected. of the subjects, 27 were right-handed, and 3 were left-handed (Table 1).

Table 1. Characteristics of the subjects (N=30)

Variable	Mean±SD	Range
Age (yrs)	25.3±1.7	22～30
Height (㎝)	171.6±8.0	155～184
Weight (㎏)	66.6±11.2	47～90

Measurements

A Jamer Dynamometer[1)] was used to measure grip strength. Throughout this experiment, elastic Tapes[2)] were applied to the upper extremity muscles of the non-dominant hand.

Procedures

The American Society of Hand Therapists (ASHT) suggested a standardized measurement posture for grip strength tests (Bohannon, 2007). This posture was sitting on a chair with no armrest while adducting the shoulder joint and rotating it to the neutral position, flexing the elbow joint by 90°, and placing the forearm and the wrist joint in the neutral position (Bohannon, 2007). The grip strength was measured only for a short period so that the subjects could maintain the elbow joint 90° during the data collection following the researcher's verval direction. This measurement posture was used in this study. Each subject went through the three experimental processes listed below.

1. The grip strength of dominant hand when the non-dominant hand was at the neutral position.
2. The grip strength of dominant hand when the non-dominant hand was at the extensor pattern position and both hands were at the maximum strength simultaneously.
3. The grip strength of dominant hand when the elastic taping of non-dominant hand was applied (Figure 1).

In the processes of this experiment, an extensor pattern position was made by having the subject take the maximum extension position of the shoulder joint and the internal rotation position of the upper extremity. The subject was then asked to grip a 7.5 ㎝ long bar with a diameter of 3.5 ㎝ with the non-dominant hand for isometric contractions of both hands, and was asked to induce simultaneous maximum grip strength contractions on both hands. The elastic taping was made by attaching elastic tapes to the flexor carpi ulnaris, extensor carpi ulnaris, and triceps brachii among the extensor synergic movement muscles of the upper extremity beginning from

1) Hydraulic Hand Dynamometer-5030J1, J.A. Inc., NJ, U.S.A.
2) Myo Tape, Myo-CoLand Inc., Pusan, Korea.

A B C

Figure 1. Three experimental conditions. A: neutral position, B: extensor pattern position, C: elastic taping.

their origins and ending to their insertions. In addition, an elastic taping for the internal rotation of the upper extremity was applied by an expert of the state (Kim, 2004).

The order of measurement was randomly determined, all measurements were conducted by the same testers to minimize errors. Furthermore, two measurements were conducted in the same position to take the average values, and the study subjects were allowed to take a rest for five minutes after finishing each measurement, so that they would not be tired. Among the oral orders used in proprioceptive neuromuscular facilitation to promote irradiation effects, the measurer issued the oral order “Apply your maximum strength” along with other oral orders such as “hard”, “harder”, “more harder” and “stop” (Lee, 1999; Mathiowetz et al, 1984).

Statistical Analysis

The data of this study were analyzed using the SPSS version 12.0 program. The one-way repeated ANOVA was used to examine differences in grip strength values among the three postures. The comparative analysis of the three postures was post-hoc tested by the Bonferroni's correction. The statistical significance level α used in the analysis was .05.

Results

The grip strength values of the dominant hand were tested with the neutral position of the non-dominant hand, with the extensor pattern position of the non-dominant hand, and when elastic taping was applied to the non-dominant hand. Based on the results, the average of the maximum grip strength of the dominant hand was the highest at 109.45 ℓb, when elastic taping was applied to the non-dominant hand, followed by that at 107.65 ℓb, with the extensor pattern position of the non-dominant hand, and then at 99.86 ℓb with the neutral position of the non-dominant hand in the order of precedence (Table 2). Based on the results of the post-hoc tests, there were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and that of the dominant hand at the time of the simultaneous maximum grip strengths of both hands with the extensor pattern position of the non-dominant hand (Bonferroni-corrected $p<.001$). Moreover, there were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and the grip strength of the dominant hand when elastic taping was applied

Table 2. The grip strength data of the neutral position, extensor pattern position and elastic taping Unit: ℓb

	Neutral position	Extensor pattern position	Elastic taping	F	p
Grip strength	99.86±21.29[a]	107.65±23.22	109.45±23.43	33.24	<.001

[a]Mean±SD.

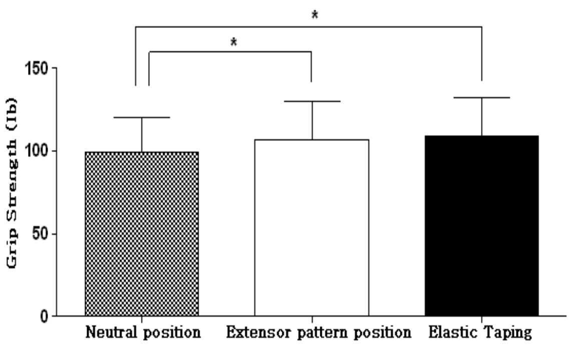

Figure 2. Comparison of the grip strength data of the neutral position, extensor pattern position and elastic taping.

to the non-dominant hand (Bonferroni-corrected $p<.001$). However, there was no significant difference between the grip strength of the dominant hand at the time of the simultaneous maximum grip strengths of both hands, and the grip strength of the dominant hand when elastic taping was applied to the non-dominant hand (Figure 2).

Discussion

This study was conducted to apply the irradiation effect obtained through the simultaneous maximum grip strengths of both hands with the extensor pattern position of the non-dominant hand, and through elastic taping applied to the non-dominant hand to healthy adults in order to examine their effects on the grip strength of the dominant hand. Based on the results of the post-hoc tests, there were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and the grip strength of the dominant hand at the time of the simultaneous maximum grip strengths of both hands with the extensor pattern position of the non-dominant hand ($p<.05$). The stimulation of voluntary motions made by irradiation is generally achieved by the internal reception, or proprioception, caused by the tension of the contracting muscles and related structures (Kim and Min, 1991). The treatment strategy using proprioceptive neuromuscular facilitation used irradiation effects to induce muscle contractions to the fixed site of the affected side through resistance movements of the unaffected side (Adler et al, 2000). That is because, applying irradiation to promote the voluntary contraction of weak muscles remarkably increases the efficiency of movements through the simultaneous voluntary contractions of locally paralyzed muscles responding to the resistance (Kim and Min, 1991). On the other hand, Lee (1999) reported that the effect of irradiation effects on grip strengths of healthy adults could not be statistically found. This was due to the effect of irradiation effects on the maximum grip strength being in the range of 10～20%, and the supraspinal inhibitory mechanism suppressing irradiation effects (Lazarus, 1992). However, in numerous studies, it was reported that in general adults, irradiation effects were not removed, but were reduced. Furthermore, in patients with damaged central nervous systems, the supraspinal inhibitory mechanism could not control irradiation effects (Cernacek, 1961; Todor and Lazarus, 1986). Lazarus (1992) identified irradiation effects in an experiment conducted on general adults and patients. In a study conducted on general adults, Devine et al (1981) reported that 8.5～23.9% of the irradiation effect of the maximum isometric contraction affected the contralateral agonist, and 9.4～16.2% of it affected the contralateral antagonist. Moreover, Todor and Lazarus (1986) reported that in several subjects, at the time of the maximum muscle contraction, the electromyographic activity of the contralateral antagonist was higher than that of the contralateral agonist. This means that if the subject holds a ball with the maximum grip strength, the extensor of the contralateral fingers will be activated more than the flexor. It is considered that, in this study too, the electromyographic activity of the extensor of the non-dominant hand at the time of the simultaneous maximum grip strengths of both hands, with the extensor pattern position of the non-dominant hand, affected the muscle activity of the flexor muscles among the muscles of the dominant hand that works when measuring the grip strength of the dominant hand.

In addition, there were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and the grip strength of the dominant hand when elastic taping was applied to the non-dominant hand ($p<.05$). Cutaneous stimulations induce reflex contractions of muscles underlying the skin. These cutaneous stimulations can reduce the threshold value of recruitment of motor units so that motor units can be easily excited (Kandel et al, 1991). It is considered that, in this study too, the elastic cutaneous stimulations made through the application of elastic taping stimulated the afferent receptors of the skin to induce the reflex contractions of the muscles underlying the stimulated skin. Thus, the application of elastic taping to the non-dominant hand increased the muscle activity of the extensor muscles of the non-dominant hand, thereby also affecting the muscle activity of the flexor muscles of the dominant hand, and consequently increasing the grip strength.

Furthermore, there was no significant difference between the grip strength of the dominant hand at the time of the simultaneous maximum grip strengths of both hands, and the grip strength of the dominant hand when elastic taping was applied to the non-dominant hand ($p>.05$). This indicates that the size of change in grip strength made by the application of elastic taping with the neutral position of the non-dominant hand is similar to the size of the irradiation effect created through the simultaneous maximum grip strengths of both hands, with the extensor pattern position of the non-dominant hand.

There are, however, some limitations to this study: First, that although efforts were made to exclude associated movements, it was almost impossible to completely exclude them. Subject actions appeared in some subjects, such as twisting the hand, flexing the elbow joint further, or flexing the trunk. Second, studies and applications of the time point of the maximum reinforcement of muscle strength after applying elastic taping were insufficient. That is, it is considered that, since the time to apply elastic taping was limited to five minutes, there were limitations to the exertion of the maximum muscle strength. In addition, studies were not conducted on potential effects of elastic taping that may be reflected on the next process if the next test is conducted before the effect of elastic taping does not disappear after elastic taping was removed. Third, it could not be identified whether the grip strength of the non-dominant hand was the result of the maximum muscle contraction, and the failure to use the equipment that could produce values to show if both hands simultaneously contracted maximally is a point that should be improved in future studies. Fourth, since grip strengths were measured only in sitting positions, possibilities that might appear in other positions could not be examined.

It is considered that further studies should be conducted on actual patients by applying irradiation effects created using extensor pattern positions, and elastic taping to the unaffected upper extremity when treating patients with problems in the muscle strength of the upper extremity or hemiplegia patients. This is required for studying their effects on the changes in the functions of the paralyzed or weakened upper extremity or hands.

Conclusion

In this study, experiments were conducted on 23 males and 7 females to examine whether the simultaneous maximum grip strengths of both hands with the extensor pattern position of the non-dominant hand, and the application of elastic taping affected increases in the grip strength of the dominant hand. There were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and the grip strength of the dominant hand at the time of the simultaneous maximum grip strengths of both hands, with the extensor pattern position of the non-dominant hand. And there were significant differences between the grip strength of the dominant hand with the neutral position of the non-dominant hand, and the grip strength of the dominant hand when elastic taping was applied to the non-dominant hand the non-dominant hand. Based on the aforementioned results, it can be seen that the irradiation effects created using the extensor pattern position of the unaffected upper extremity, and the application of elastic taping affected increases in the grip strength of the dominant hand. Thus, it is expected that when treating patients with problems in the grip strength of the upper extremity or hemiplegia patients, the application of the irradiation effects or elastic taping using the unaffected upper extremity can be used to treat the paralyzed or weakened upper extremity or hands.

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