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Effect of Irradiation on Grip Strength

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국문요약

악력의 방사효과

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이 연구의 목적은 우세한 손과 그렇지 않은 손에서 방사효과가 악력에 어떤 영향을 미치는가 알아보는데 있다. 연구대상은 의료기관에 있는 30명이며 연령은 32±9.23세, 체중분포 73.8±23.7 kg이며, 신장은 170.26±10.24 cm 이었다. 연구 대상자들의 악력은 4가지 다른 조건에서 측정되어졌다. 첫째 조건은, 방사효과가 잠재적으로 가능한 상태에서 우세한 손의 최대악력을 측정, 둘째 조건은, 방사효과가 잠재적으로 불가능한 상태에서 우세한 손의 최대악력을 측정, 셋째 조건은, 방사효과가 잠재적으로 가능한 상태에서 우세하지 않은 손의 최대악력을 측정, 넷째 조건은, 방사효과가 잠재적으로 불가능한 상태에서 우세하지 않은 손의 최대악력을 측정하였다. 연구결과로는 어떤 조건에서도 방사효과가 잠재가능과 불가능의 최대악력비교에서 이원분산분석(two-way ANOVA)결과 통계학적으로 어떤 차이점도 없었다($F[1, 116] = .0016$, $p<.05$). 이 연구결과는 정상인에 있어서 방사효과가 악력에 미치는 영향을 통계학적으로 발견할 수 없다는 결론을 내렸다. 그 이유로는 방사효과가 최대악력에 미치는 영향이 10~20%의 최대 근육 수축범위이며 척추상위 억제 기전(supraspinal inhibitory mechanism)이 방사효과의 활동을 억제한다는 이론에 의한다.

핵심단어: 악력; 방사.

Introduction

Grip strength provides a quick and objective index of the functional integrity of the upper extremities (Myers et al, 1980). It is widely used as an assessment measure in physical and rehabilitation medicine. Measurements using a hand dynamometer are adopted clinically to allow comparison between an individual's grip strength reading and established norms, or between the injured and the uninjured limbs. This measurement, however, is usually influenced by a number of factors, such as the position of the remainder of the body during testing. Comparison and interpretation of data without identifying and controlling such affecting factors would not be reliable.

For years, studies have been conducted to investigate the effect of body posture and arm position on subjects grip strength. Teraoka (1979) that, for all age groups and for both sexes, grip strength was higher for subjects who stood than for those who sat. He also reported higher grip strength for subjects sitting than for those who were supine. Teraoka's findings were further supported in a recent study by Balogun (1991) that grip strength in the sitting position with elbow at 90 degrees flexion has the lowest score. The highest value was recorded with the subject standing with elbow in full extension. Pryce (1980) studied the effect of wrist joint position on grip strength. He obtained significantly lower grip strength scores when the wrist was positioned in 15 flexion and 30 degrees ulnar deviation. His study agreed with the finding of Kraft (1972) who also found significantly lower scores when the wrist was held in 15 flexion. A study by O'Driscoll (1992), however, found that grip strength in a wrist position other than the self-selected position yields a decrease in score. Data in studies examining the effect of elbow joint position on grip strength also vary. Mathiowetz and associates (1985) obtained a significantly higher grip strength in the 90 degrees elbow flexed position than in the fully extended position. A recent study by Su (1994) found the highest mean grip strength measurement recorded when the shoulder was positioned at 180 degrees of flexion with elbow in full extension. Generalization of body position to produce optimal grip strength is difficult to compare as different testing protocols were used in these studies.

In addition, some minor factors such as the wrist extension angles, dynamometer settings and biofeedback are usually overlooked, but surely play a significant role in the test result. O'Driscoll (1992) found that the degree of wrist extension was inversely and linearly related to how large a setting on the Jamar Dynamometer was used. Most studies agree that level 2 or 3 is the optimal setting for maximum grip strength (Crosby, 1994; Hamilton, 1994; O' Driscoll, 1992). Biofeedback using visual challenge is also found to produce a good reliability with the highest and most realistic peak forces (Spiikerman et al, 1991).

Therapists use hand grip as a way of strength training and also as an evaluation tool for assessing the integrity of upper limb. When looking at hand grip we often see patients activate the muscles of other body parts while attempting a maximum hand grip performance. This phenomenon is a result of a mass movement pattern in normal activity, which promotes the required selective irradiation, when performing against resistance. Irradiation was also described as associated movements, motor overflow, activity transfer to the contralateral limb, cross-education of the unused limb, crossed reflex phenomenon, synkinesis, and mirror movements which can be observed in the contralateral side as subjects perform voluntary maximal contract. Irradiation has been used as a strategy of treatment in proprioceptive neuromuscular facilitation (PNF) and in cross exercise to prevent or decrease atrophy, to maintain motor coordination, and to increase muscle strength of the affected limb in the clinical setting (Devine, 1981). The studies, regarding the effect of irradiation, however, are limited and poorly documented in terms of quantitative muscle strength (Devine, 1981; Lazarus, 1992; Moore, 1975). The lack of research warrants our need to study the effects of irradiation on grip strength.

The purpose of this study was to determine whether the use of irradiation would enhance hand grip strength. Measurement of both dominant and non-dominant hands were compared. Quantification of the hand grip via hand dynamometer might be useful in determining whether to incorporate irradiation into the rehabilitaion process.

Methods

Subjects

Our sample consisted of thirty subjects (11 male, 19 female) who are employees of a health care facility in New Jersey. The subjects' age range was 22 to 63 years old. On average, they weighed 73.8±23.66 kg and were 170.3±10.24 ㎝ tall (Table 1). All subjects reported themselves in good health. Gross ROM of upper extremities was found to be within functional limits and the subjects were able to assume test position without difficulty. Two subject were left-hand dominant; the remaining twenty-eight subjects were right-hand dominant. No subjects were ambidextrous. Prior to testing the subjects completed a screening form.

Table 1. Subjects demographic data

	Mean	S.D.	Min.	Max.
Age (years)	32.9	9.23	22	63
Height (㎝)	170.3	10.24	180	210
Weight (kg)	73.8	23.66	47.67	149.8

Instrument

An adjustable-handle Jamar dynamometer[1] was used to measure grip strength. The device was factory-calibrated. The second position of the handle (Bechtol, 1954) was used for all subjects during testing.

Testing Protocol

Each subject was required to perform the following four experimental conditions: 1. maximum hand grip with dominant hand without potential irradiation; 2. maximum hand grip with dominant hand with potential irradiation; 3. maximum hand grip with non-dominant hand without potential irradiation; and 4. maximum hand grip with non-dominant hand with potential irradiation.

Procedure

Upon arrival to the physical therapy department, subject screening forms were attained, gross assessment of upper extremity ROM was examined, and ability to maintain testing position was checked. The subjects were given instructions including the standard position and process of the measurement for testing. One pre-trial (at self-selected condition) was allowed to familiarize subject with the instrument. The sequence of the testing conditions was determined by a blind-

1) Manufactured by Jamar Jackson, MI 49203 USA

fold drawing from four hidden cards.

The subjects were positioned sitting in armless chair with subjects shoulders adducted and neutrally rotated, while forearm and wrist joints were held in neutral position as suggested by the American Society of Hand Therapists. The elbows extended fully. The hip and knee joints were kept at 90 degrees of flexion and neutral position of the head and ankles was asked. The subjects were also asked not to lean for back support. Encouragement was given to maintain standard position throughout testing.

For conditions without possible irradiation, the inactive upper extremity was held as relaxed as possible in the testing position. For conditions with possible irradiation, the non-tested hand gripped a tennis ball maximally in synchrony with the testing hand. One grip measurement was taken in kilogram units for each experimental condition. To minimize the effects of fatigue, the resting time given between trials was a minimum of two minutes.

During the test, standardized verbal commands were given by the tester: "You should squeeze the dynamometer as hard as you can.", Are you ready?", "Go!", "Squeeze, squeeze, squeeze!" The subjects performed maximum hand grip for a period of five seconds, and the contraction was timed with a digital watch. At the fifth second, the subject were asked to, "Release". The subjects were not allowed to view the data of her or his performances. All data were collected by the same tester and one recorder.

Statistical Analysis

The descriptive statistics show a trend for differences among the trials. Descriptive statistics were calculated for the mean and standard deviation of the four different conditions. Differences between the means for the dominant and non-dominant upper extremity were tested for statistical significance using a two-factor analysis of variance (ANOVA) for repeated measures. The two-factors were groups (dominant, non-dominant) and trials (with a ball; possible irradiation, without a ball; no irradiation) and a two-factor ANOVA (2×2) was used to analyze data for differences between right and left hand grip strength, and the effects of irradiation. An alpha level of .05 was used as the criterion for all tests of statistical significance.

Results

The means and standard deviations of the subject's grip strength at the four experimental conditions are presented in Table 2.

Table 2. Average grip strength (kg) of all subjects at different experimental conditions

Dominant	Without a ball	42.93	16.28
	With a ball	42.97	17.22
Non-dominant	Without a ball	39.77	16.30
	With a ball	39.97	15.37

No statistically significant differences were found between experimental conditions ($F[1, 116] = 3.92$, $p \leq .05$), although better performance were seen with potential irradiation, both in dominant (42.97 vs. 42.93) and non-dominant hands (39.97>39.77). In non-dominant hand grip strength, the differences with potential irradiation were greater than in those of dominant side.

For the total group, the four different conditions indicated that a non-significant interaction occurs in the two-factor ANOVA. Table 3 presents the ANOVA results for the main effect of trials. No interaction between the dominant /non-dominant hand irradiation was revealed (Table 3).

Table 3. Results of the two-way analysis of variance (ANOVA) performed on the data of four different conditions

Source of Variation	df	MS	F
Dominant / Non-dominant (Factor A)	1	285.210	1.140
Irradiation (Factor B)	1	.410	.002
Factor A × B	1	.205	.001
Within cells	116		

In consideration of the differences between potential irradiation and non-potential irradiation on the strength of the dominant and non-dominant hand's grip strength, the influence of potential irradiation could not be found statistically.

Discussion

The results presented the influence of irradiation did not elicit increased hand grip strength, either the dominant or the non-dominant hand. In terms of theory, supraspinal inhibitory mechanisms may work for controlling irradiation (Lazarus, 1992). Several researchers have demonstrated that the influence of irradiation was reduced voluntarily but not eliminated in normal subjects and the supraspinal inhibitory mechanisms did not control irradiation efficiently in patients with central nervous system dysfunction (Cernacek, 1961; Todor and Lazarus, 1986).

Electromyography (EMG) has been the most common measure of irradiation to compare the muscles activation at the contralateral limb (Cernacek, 1961; Devine, 1981; Hoppf, 1974; Lazarus, 1992; Moore, 1975; Todor and Lazarus, 1986). Moore (1975) reported the effect of irradiation was 10% to 20% range of maximal voluntary isometric contraction in normal subjects. Another study (Devine, 1981) reported 8.5% to 23.9% range of maximal voluntary isometric contraction in contralateral agonist and 9.4% to 16.2% in contralateral antagonist in healthy subjects. That amount of activity may not be enough to influence hand grip strength significantly. In addition, in Todor and Lazarus's study (1986), some subjects demonstrated the activation of contralateral antagonist muscles was greater than the EMG activity from contralateral agonist muscles. In other words, when the subjects squeezed a ball maximally, the contralateral side of finger extensors was activated greater than the activation of finger flexors. Grip strength, therefore, was limited by the activity of finger extensors. In our study, the effect of irradiation of grip testing showed a decrease of maximum grip in 12 (40%) subjects: grip strength increased in 13 subjects (43.3%) and unchanged in 5 subjects (16.6%) comparing dominant hand with and without potential irradiation.

The limitation of our study is that the maximal effort was not controlled quantitatively. Lazarus (1992) studied patients and normal subjects under different intensity of active limb force. He reported that both groups demonstrated a significant increase in the amount of irradiation with increasing active limb force. Therefore, further study should consider an objective control procedure of quantitative active limb force measures.

In data collection, our study focused on preventing fatigue because a cumulative fatigue factor may increase the effect of irradiation (Spiikerman, 1991). Furthermore, Hamilton (1994) commented on the four methods of 1. the score of one trial; 2. the mean score of two trails; 3. the mean score of three trials, and 4. the highest core of three trials of data collection. He determined grip strength scores were not significantly different in reliability. Thus, our study recorded one trial of the grip strength in each condition. On the other hand, Kroll (1967) mentioned that, "If the error variances are random and uncorrelated, then the proper procedure is to use the mean of all available trials". Additionally, Mathiowetz and associates (1984) spoke in their study of maximal grip strength on a series of 27 healthy female subjects showed the reliability based on the mean score of three tests was greater than that of the mean score of two tests or a single test. Hence, further study might try to figure out the effect of irradiation on grip strength by using the mean score of three tests.

Conclusion

In this study, the effect of irradiation on grip strength of healthy subject was examined. The result did not demonstrate significant differences either in comparison of the dominant, non-dominant or potential irradiation. Finally, our study concluded that healthy subject show her or his hand grip strength without significant effect of irradiation of the dominant or non-dominant hand.

These results suggest that effect of irradiation is not enough to alter subjects hand grip strength in healthy subjects. Further study should be attempted by using electromyography or a more sensitive instrument to catch the little amplitude of irradiation effects, and to demonstrate the muscle tension quantitatively.

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