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Original Article

Determining Sincerity of Effort Based on Grip Strength Test in Three Wrist Positions

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ABSTRACT

Background: Several grip strength tests are commonly used for detecting sincerity of effort. However, there is still no widely accepted standardized sincerity of effort test. Therefore, this study aimed to examine whether grip strength test in three wrist positions could distinguish between maximal and submaximal efforts.

Methods: Twenty healthy individuals (10 men and 10 women) with a mean age of 26.7 ± 3.92 years participated in this study. All participants completed two test conditions (maximal and submaximal efforts) in three wrist positions (neutral, flexion, and extension) using both hands. Each participant exerted 100% effort in the maximal effort condition and 50% effort in the submaximal effort condition. The participants performed three repetitions of the grip strength test for each session.

Results: The results showed that there is a significant main effect of the type of effort ($p < 0.001$), wrist position ($p < 0.001$), and hand ($p = 0.028$). There were also significant types of effort and wrist position interactions ($p < 0.001$) and effort and hand interactions ($p < 0.028$). The results also showed that grip strength was highest at the wrist in neutral position in both the maximal and the submaximal effort condition. Grip strength values of the three wrist positions in the maximal effort condition were noticeably greater than those in the submaximal effort condition.

Conclusion: The findings of this study suggest that grip strength test in three wrist positions can differentiate a maximal effort from a submaximal effort. Thus, this test could potentially be used to detect sincerity of effort in clinical setting.

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1. Introduction

Work-related musculoskeletal injuries are common in the workplace. Such injuries result in a noticeable expense and decreased productivity in both public and private sectors. As a result, there is an increase in demand to find objective means of assessing an individual's physical capacity to work and readiness to return to work following an injury. Thus, functional capacity evaluation has been developed and used as a tool for determining an individual's functional abilities and limitations to work, which may help in reducing the cost associated with work-related musculoskeletal injuries [1,2]. Furthermore, the measurement of hand grip strength has been used in ergonomics or clinical settings to determine the degree of disability, individual's ability to return to work, worker's compensation, and progress in rehabilitation [3,4].

However, some individuals may not make sincere efforts while performing the tests due to a number of reasons, including secondary financial gain, secondary emotional gains, and avoiding returning to work [4,5]. Failure to accurately evaluate injured worker's sincerity of effort (SOE) may bring about an ineffective rehabilitation program and increase workers' compensation medical costs. Thus, it is necessary to have a standardized method that can determine SOE.

A number of methods using the hand grip dynamometer for determining SOE have been developed. Some methods such as electromyography [6,7], the torque–velocity test [8], and the force–time curve test [9,10] are complex and require lengthy administration time. In clinical practice, however, methods that are simple, affordable, and easy to be administered, such as the five-rung grip test [11,12], rapid exchange grip test [13,14], and coefficient of variation [15,16], are commonly used for detecting SOE.

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Stokes [17] was the first to introduce the five-rung test to identify SOE. The method involves testing grip strength at five handle positions of the dynamometer. The SOE is interpreted from the shape of the grip strength, with the bell-shaped curve indicating a maximal effort and a flat curve indicating a submaximal effort. In 1984, Lister [18] introduced the use of the rapid exchange grip test to differentiate between maximal and submaximal efforts. This test involves grip strength tests, with rapidly alternating between both hands and then comparing the grip strength values of the rapid exchange gripping with those of static gripping. To indicate a sincere effort, the rapid grip strength values are expected to decrease with respect to the static grip strength values. The other method, which is the coefficient variation, measures variability of a set of the grip strength tests. It is assumed that submaximal efforts would show greater variability than maximal efforts [15,16].

To date, there is still no widely accepted standardized protocol for assessing SOE. A study by Shechtman and Goodall [14] reported that most therapists combined several tests to detect SOE. Nevertheless, neither the individual SOE tests nor their combination can accurately detect SOE in clinical practice [5]. It should also be pointed out that all the three SOE tests mentioned previously involve grip strength tests in neutral position of the wrist. However, it has been reported that wrist position is one of the most important factors influencing grip strength performance [19–22]. Therefore, the purpose of this study was to examine whether grip strength test in three wrist positions (i.e., neutral, full flexion, and full extension) could differentiate between maximal and submaximal efforts.

2. Materials and methods

The participants in this study were 20 healthy individuals (10 men and 10 women) with a mean age of 26.7 ± 3.92 years. Demographic characteristics of the participants are shown in Table 1. All the participants were right-hand dominant and had no past history of upper extremity problems. Prior to testing, all the participants read and signed the informed consent. This study was approved by the University Institutional Review Board.

All grip strength tests were performed using the hand grip dynamometer of the Evaltech (BTE Technologies, Inc., Hanover, MD, USA), which was calibrated daily before testing. The grip attachment was set in the second handle position. Each participant completed two test conditions (i.e., maximal and submaximal efforts) in three different wrist positions (i.e., neutral, full flexion, and full extension) using both hands. To familiarize the participants with the testing procedures, practice trials were given prior to the beginning of the tests.

The participants were randomly assigned to begin with the maximal or submaximal effort condition. Each participant was instructed to exert 100% effort in the maximal effort condition and 50% effort in the submaximal effort condition. For all tests, the starting position was standing with feet flat on the floor, shoulder-width apart. The hand grip strength test started with the wrist in neutral position. The tested arm was positioned according to the American Society of Hand Therapist recommendation: the shoulder adducted and neutrally rotated, the elbow flexed at 90°, and the forearm and wrist in neutral position [23]. Each participant was asked to perform the grip strength test for three repetitions in each hand, beginning with the left hand. Each repetition lasted 3 seconds with a 5-second interval for alternating between both hands. After all the tests were completed in neutral position of the wrist, the tests were repeated in full flexion and full extension of the wrist position. To ensure that the participants maintained a proper position during the test, reminders were provided by the researcher as needed. Two-minute rest periods [24] were provided at the end of the tests in each wrist position and between the maximal and submaximal effort conditions. For all tests, the participants were given standardized verbal instructions, but no visual or auditory feedback was provided.

The data of this study were analyzed using SPSS® (version 19.0; IBM, Armonk, NY, USA). Shapiro–Wilk test was used for normality test. Factorial repeated measures analysis of variance was employed to determine the effects of the type of effort, wrist position, and hand. If significant interactions were present, simple main effect tests were performed and the least significant difference method was used for *post hoc* tests. Paired *t* test was used for comparing the ratios of grip force between maximal and submaximal efforts. The level of significance was set at $p < 0.05$. Model assumptions of normality, homogeneity of variance, and linearity were tested, and the results were satisfactory.

Table 1
Demographic characteristics of the participants ($N = 20$)

Characteristics	Mean ± SD
Age (y)	26.70 ± 3.92
Height (cm)	167.10 ± 8.55
Weight (kg)	61.08 ± 9.05
BMI (kg/m^2)	21.80 ± 2.24

BMI, body mass index; SD, standard deviation.

3. Results

Mean grip strength as a function of wrist position for the combinations of types of efforts and hands is presented in Fig. 1. From the factorial repeated measures analysis of variance, the results showed that there is a significant main effect of the type of effort [$F(1, 19) = 133.662$, $p < 0.001$], suggesting that grip strength of a maximal effort differs from that of a submaximal effort. Significant main effects of wrist position [$F(2, 38) = 66.405$, $p < 0.001$] and hand [$F(1, 19) = 5.641$, $p = 0.028$] were also observed, suggesting that grip strength differs for different wrist positions and hands.

The results also showed significant types of effort and wrist position interactions [$F(2, 38) = 48.611$, $p < 0.001$]. Simple main effect analysis showed that for all wrist positions, there were significant differences of grip strength between maximal and submaximal efforts ($p < 0.001$). When performing with a maximal effort, there were significant differences of grip strength between neutral and flexion, and neutral and extension wrist positions ($p < 0.001$); however, there was no significant difference between flexion and extension wrist positions ($p = 0.123$). For a submaximal effort, there were significant differences of grip strength between neutral and flexion ($p < 0.001$), neutral and extension ($p = 0.011$), and flexion and extension ($p = 0.001$) wrist positions.

Furthermore, the significant interaction between types of effort and hand was also observed [$F(1, 19) = 11.165$, $p = 0.003$]. Simple main effect analysis showed that for both hands, there were significant differences of grip strength between maximal and submaximal efforts ($p < 0.001$). When exerting with a maximal effort, there was significant difference of grip strength between left and right hands ($p = 0.006$). By contrast, there was no significant difference of grip strength between left and right hands during performing a submaximal effort ($p = 0.475$). However, there were no significant wrist position and hand interaction ($p = 0.727$), and types of effort, wrist position, and hand interaction ($p = 0.321$).

Table 2 shows the mean ratios of neutral/flexion (N/F) and neutral/extension (N/E) of maximal and submaximal efforts of both hands. The results showed that there were significant differences

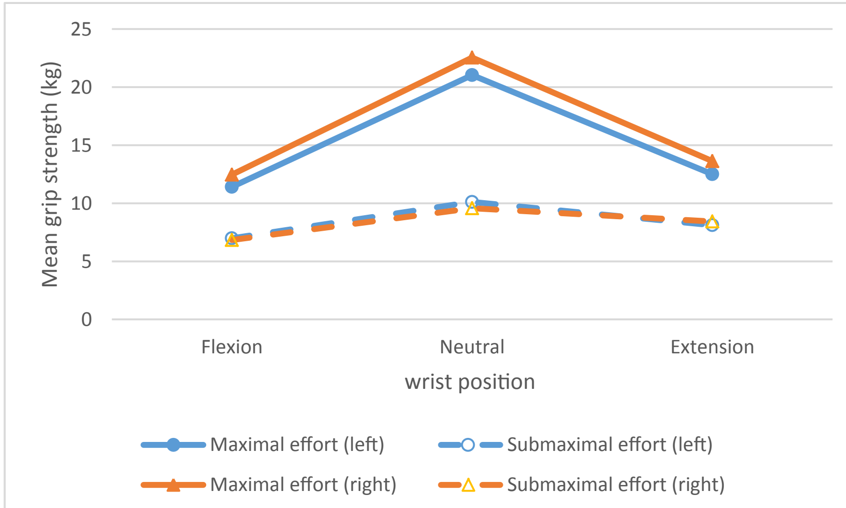

Fig. 1. Grip strength as a function of wrist position for maximal and submaximal efforts of left and right hands.

Table 2
Mean and standard deviation of N/F and N/E ratios in the maximal and submaximal effort conditions of both hands

	Hand side	Type of effort	Mean ratio (SD)	t	p
N/F	Left	Maximal	1.93 (0.42)	4.260	<0.001**
		Submaximal	1.45 (0.38)		
	Right	Maximal	1.85 (0.37)	3.480	0.003*
		Submaximal	1.42(0.45)		
N/E	Left	Maximal	1.70 (0.34)	4.034	0.001*
		Submaximal	1.27 (0.39)		
	Right	Maximal	1.68 (0.59)	3.612	0.002*
		Submaximal	1.14 (0.38)		

* *p-value* < 0.05; ** *p-value* < 0.001.
N/E, neutral/extension; N/F, neutral/flexion; SD, standard deviation.

between maximal and submaximal efforts in the ratios of N/F [$p < 0.001$ (left hand), and $p = 0.003$ (right hand)] and of N/E [$p = 0.001$ (left hand), and $p = 0.002$ (right hand)].

4. Discussion

Various assessments are commonly used in determining SOE in a clinical setting [11–16]. However, there is still a lack of strong evidence that these assessments can accurately identify SOE [5]. Therefore, the present study proposed an alternative assessment and aimed to investigate whether grip strength test in various wrist positions could detect SOE. Reliability tests of all conditions in this assessment were performed. The results showed that the reliability of all conditions in this assessment was high (Intraclass correlation coefficient (ICC) = 0.74–0.94, $p < 0.05$).

In this study, the grip strength test started with the wrist in neutral position, and 2-minute rest periods were provided at the end of the tests in each wrist position and between the maximal and submaximal effort conditions. The protocol used in this study was based on a study by Trossman and Li [24], which asserted that at least 1-minute rest interval should be provided between trials on grip strength tests. This study provided 2-minute rest intervals between trials; thus, it should allow sufficient time for the muscle to recover. Consequently, the order of the test in various wrist positions should not affect the results of this study.

The findings of this study demonstrated that, in both maximal and submaximal efforts, grip strength was highest at the wrist in neutral position and decreased markedly in full flexion and full extension of the wrist. These results are consistent with previous studies [19–22], which asserted that wrist position has an impact on grip strength capabilities. For instance, a study by Pryce [19] found the maximum grip strength at wrist position of 15° extension and 0° deviation, and the grip strength reduced substantially as the wrist position changes in the degree of flexion/extension or deviation. Another study by Lamoreaux and Hoffer [20] also reported that compared with the wrist in neutral position, a marked decrease of grip strength was observed in radial and ulnar deviation of the wrist. Moreover, Li [22] found that flexion deviation had a greater effect on finger forces than the deviation of the wrist toward extension. The decrease of grip force in flexion and extension of the wrist may be explained by the length–tension relationship of the muscle [25]. Wrist flexion and extension result in less optimal length of the muscle, which lead to an impairment of grip force production.

The present study supported the findings from previous studies [26,27] that when performing the test with a maximal effort, grip strength of the dominant hand was greater than that of the nondominant hand in all wrist positions. The dominant hand is better than the nondominant hand in maximum isometric strength exertion and controlled force exertion [27]. However, this difference was not observed in submaximal efforts. In addition, the findings from this study also showed that the grip strength values of the three wrist positions in the maximal effort condition were considerably greater than those in the submaximal effort condition. The curve of the maximal effort condition illustrates a noticeably greater curvature than that of the submaximal effort condition (Fig. 1). Therefore, the results of this study are in agreement with those of a previous study by Niebuhr and Marion [26] that grip strength test can be used to differentiate between maximal and submaximal efforts. However, it should be noted that the present study conducted grip strength measurements in different wrist positions, whereas in the previous study [26] grip strength was measured by varying handle positions of the dynamometer.

Furthermore, the substantial differences between maximal and submaximal efforts in the ratio of N/F and N/E were also observed in this study. The ratios of N/F were >1.8 in the maximal effort condition, whereas the ratios were <1.5 in the submaximal effort condition. The ratios of N/E were >1.6 in the maximal effort condition, while those were <1.3 in the submaximal effort condition. There are a few explanations for the differences between maximal and submaximal efforts. A maximal effort is a lower-order task that involves simple motor control and can easily be replicated. On the contrary, a submaximal effort, which is a higher-order task, needs complicated sensory feedback and is difficult to replicate [28]. In this study, for the submaximal effort condition, the participants were asked to exert 50% of the maximal effort. Although, it might be difficult to accurately exert 50% of the maximal effort, the participants were asked to try their best to control their efforts. By giving the target number of 50% effort, all the participants could aim to adjust their efforts about the same level.

The limitations of this study include the use of healthy participants. All of them were right-handed young adults. Thus, the results from this study cannot be generalized to other populations. Moreover, in the submaximal effort condition, although the participants were asked to exert 50% effort, it was difficult to ensure that all the participants gave 50% of their maximal effort. Further studies are needed to conduct in other groups of populations, especially those with upper extremity injuries, and in clinical settings to validate the test.

In conclusion, this is the first study that aimed to determine whether the grip strength test in three different wrist positions can determine SOE. The findings of this study suggest that the grip strength test in three wrist positions can differentiate a maximal effort from a submaximal effort. Thus, there is a potential that this test could be an alternative assessment used to detect SOE in clinical setting. However, to validate the test further studies are still warranted.

Conflicts of interest

All authors have no conflicts of interest to declare.

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