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Influence of Hand's Temperature, Anthropometrics Measures and Wearing Chemical Protection Gloves on Hand Grip Strength

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Abstract— Objectives: To determine whether, hand's temperature, wearing glove, body mass index (BMI), and hand anthropometry have an influence on the hand grip strength in healthy male students. **Methods**: This cross-sectional descriptive study on eighteen healthy male volunteers, the mean of age (Standard Deviation) is 29.78 (2.9) years. Their ages and anthropometric characteristics including BMI, hand length, hand width, hand depth, hand palm and wrist circumference were measured. The hand was exposed to different bath temperatures ($10°, 25°$ *and* $40°C$) and hand grip strength was measured using a Jamar hydraulic hand dynamometer with and without wearing chemical protection gloves. The data were analyzed using Shapiro–Wilk parametric test, Pearson correlation coefficient, and ANOVA. **Results**: ANOVA results show a significant effect of wearing a glove on hand grip strength, but there is no significant effect of changing skin temperature on hand grip strength. With respect to anthropometry measurements, a Pearson correlation coefficient matrix demonstrated an only significant correlation between the hand grip and hand width, but the other factors haven't any correlation with hand grip strength. **Conclusion**: Only wearing glove has an influence on the hand grip strength. Hand width has a significant impact on hand grip strength, but the other factors have no significant impact on hand grip strength in this study.

Keywords— protective glove, hot, Jamar dynamometer, grip strength, hand size.

I. INTRODUCTION

Grip strength is an important aspect that must be considered when designing whatever things people use in their daily life due to the fact that grip is an essential element that is needed in many routine activities [1,2]. It is caused by bending all the fingers together except the thumb. Thus, it is defined as the total contact force measured when a person applies a power grip to the handle with his/her maximum voluntary contraction effort. Grip strength depends on a large number of variables [3-25].

Many Researchers suggest that there are strong correlations between grip strength and various anthropometric traits, such as age [3], body mass index (BMI) [4], hand length and width [5-11], and upper arm circumference [12]. A significant change in grip strength was found according to palm length [13, 14] and a correlation between the size of the wrist and total grip strength [15]. Hand length, age, and forearm circumference significantly impacted on hand grip strength [16]. Also, a research has been undertaken to determine the relationship between forearm circumference and grip strength among athletes and basketball players [17]. They suggest that forearm circumference is a good predictive of grip strength in men but not in women [18]. In a study of the relationship between hand grip strength and weight, stature, arm circumferences and subcutaneous skin folds, males attained greater values for anthropometric variables and greater hand grip strength values than their female counterparts [19]. Also, grip strength has been studied as a predictor of general health [3], heart disease [20], cerebrovascular disease, disability, cognitive decline [21], future fracture risks [22,23] and mortality [19,24,25].

Local cooling of the hand decreases manual performance through both physical and neuromuscular pathways [26]. Local cooling decreases flexibility [27] due to increased viscosity within joints and soft tissues that interferes with smooth joint movements [28]. Cold also affects muscle activity through decreased metabolism utilization, enzyme activity, calcium, and acetylcholine release, and delayed cross-bridge formation [29]. This result decreases the contraction velocity and the maximal strength [30]. Data on healthy adults and hand grip strength especially with the effect of the hot environment on the hand strength are scarce. A study that assessed the hand grip strength in healthy adults from 21 countries found that men in the hot countries exhibited intermediate hand grip strength compared with the highest levels of hand grip strength noted among European and North American populations [31]. Other than this recent study, there is still a dearth of available literature on hand grip strength in the hot climate using protective gloves.

Industrial assemblers, machinists, construction workers, janitors, and housekeepers used gloves in different workplaces in order to protect their arms and hands from chemicals, heat, cold, and from physical trauma, such as cuts and blisters. The effect of glove use on hand grip performance has been investigated. Sudhakar and Schoenmarklin [32] concluded that a certain amount of muscle force is lost in the hand-glove interface based on the measurement of normalized peak and mean EMG values taken of isometric contractions. Fleming et al. [33] indicated that glove type and the handgrip contraction have an effect on physiological fatigue and subjective perception of fatigue. Since it was reported that protective gloves reduce hand heat losses in a cold air environment by 60–90% and those heat losses were 50–100% greater from the fingers than the palm and back of hand [34]; wearing gloves may be another risk factor among those whose jobs require repetitive motions and large exertion forces on the hand.

Because of the high cost of work injuries, it is important to identify whether wearing gloves in hot environments during grip activities increases the risk of injuries. Determining whether gloves with the varied skin hand temperatures affect grip strength is an important step in answering this question and in preventing these injuries. Therefore, the purpose of this study was to determine whether the use of chemical protection gloves in low and high skin temperatures affect the isometric grip strength in a healthy young population, compared with no glove use.

II. METHODOLOGY

2.1. Participants:

Eighteen healthy male students have participated in this study, their age between (23-37 years) with mean and standard deviation (SD) 29.78 (3.9) years. All participants are right-hand dominant. Anthropometric measurements of the participants are presented in Table 1.

2.2. Anthropometric Measurements:

Body Mass Index (BMI) was measured using a standard analog weighing scale and a standard height scale and was calculated using the formula: $BMI = Wight\ (kg)/\ height\ (m)^2$. The forearm circumference of each study subject was measured using a flexible measuring tape (cm). The hand length was measured from the crease of the wrist to the tip of the middle finger with the hand held straight and stiff. Hand breadth (hand width) was measured as the maximum breadth across the palm of the hand (at the distal ends of the metacarpal bones) [35]. Palm length is measured as the length of a straight line from the folded line at the level of the lateral spot on the wrist to that near the middle finger. These measurements had done by an anthropometrical measurement instrument.

Table 1: Mean, SD and Rang of participants anthropometric measurements.

Measurement	Mean	SD	Range
BMI (kg/m^2)	26.0	5.0	19.1 – 39.8
Hand length (cm)	18.2	0.8	17 – 20
Hand width (cm)	8.4	0.5	7.5 – 9.5
Forearm Circumference (cm)	17.1	0.8	15.6 – 19
Palm length (cm)	10.3	0.4	9.5 – 11.2
Hand Depth (cm)	3.1	0.3	2.7 – *3.6*

2.3. Apparatus:

The main device used in this study was a Jamar® hand dynamometer which measures the force of hand's grip (grip strength) in Kilograms force. Gloves were chemical protection ones (Scorpio® 08-352). Three Thermometers used to adjust the temperature degrees of water contained in three bowls. Water at three temperature levels was $10°, 25°$ *and* $40°C$. Stopwatch was used to schedule the rest time. Anthropometry meter, tape, and bath weight scale were also employed in this experiment.

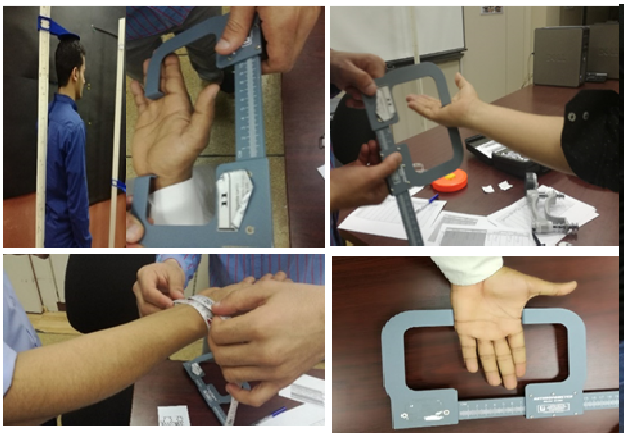

Figure. 1. Anthropometric Measurements

Figure. 2. Submerging in hot water bowl

2.4. Procedures:

The anthropometric measurements of the participant's hands were taken as shown in Figure 1. When the weight was taken, the subject was required to dispose of all excess weights like shoes, mobile, keys etc. Also, the height was taken while the subject is barefoot. Then, a simplified show is introduced to the participants about how to use the dynamometer properly and adjusts the handle of dynamometer as appropriate with participant's hand. The trials started according to the sequence as planned in a randomized block design, every participant is considered as a block. After that, the participant was asked to submerge his hand in the pre-specified bowl for 90 seconds, as shown in Figure 2. The hand-skin temperature was not measured in this experiment but past research has suggested that the hand-skin temperature can be assumed to be close to the water bath temperature [36]. Also, Morton and Provins [37] reported that the finger temperature of their participants dropped at a rate of around 10°C/min. After the participant dried his witted hand using soft tissues, he held the dynamometer while he is in standing position and started the trial. The starting point of the trail when the shoulder flexion with $180°$ and end point at $90°$ [38]. From the starting until the end of the trial the participant exerted what he can do as a maximum effort, by his dominant hand, against the dynamometer handle. The obtained reading from the dynamometer display was recorded and then reset it to the initial point. The participant is asked to redo the trial in the same condition, two trials for each condition [39]. Finally, the participant had a rest of five-minute break among testing sessions.

2.5. Experimental design

The experimental design was set as six conditions, 2 (with and without gloves) × 3 bath temperatures ($10°, 25°$ and $40°C$). If the trial is with gloves, the participant wears the most appropriate glove size before performing trial. The mean of 12 consecutive trials of hand grip strength for each participant was used for the correlation analyses. After establishing normality of the data using the Shapiro–Wilk parametric test, Pearson correlation coefficient was used to determine the influence of anthropometric data on hand grip strength. Mean of the two trials in each condition was used in the analysis of variance (ANOVA). Minitab® Software was used for the Statistical analysis, (α=.05).

III. RESULTS

3.1. The effect of anthropometric measurements on hand strength

A Pearson correlation coefficient matrix for BMI, age, hand length, hand width, forearm circumference, palm length, hand depth and hand grip strength is presented in Table 2. Hand grip strength demonstrated significant correlations only with hand width ($p< 0.05$).

Table 2: Pearson correlation coefficient matrix for the anthropometric measurements and hand grip strength.

	BMI	Age	Hand Length	Hand Width	Wrist Circumference	Palm Length	Hand Depth	Hand Strength
BMI	1							
Age	.413	1						
Hand Length	.062	-.136	1					
Hand Width	.685*	.512*	.322	1				
Circumference	.819*	.353	.226	.668*	1			
Palm Length	.158	-.006	.338	.349	.308	1		
Hand Depth	.544*	.242	.278	.557*	.524*	.310	1	
Hand Strength	.225	.224	.314	.517*	.059	-.121	.200	1

* Correlation is significant at the level of 0.05 level (2-tailed).

3.2. The effect of hand skin temperatures and gloves on hand grip strength

The result of this study showed that hand grip strength is correlated with the hand width. From the obtained result, we concluded that hand width can influence the hand grip strength. The hand width of an individual can be measured easily and conveniently be used as a predicting measure of hand grip strength. Contrary to the other studies [40,41], this study concluded that hand circumference had no significant impact on hand grip strength as well as no significant influence of forearm circumference and hand length on hand grip strength. This study disagreed with the Kong and Kim result [42] where they found that the larger the hand length, wrist circumference and palm length, the stronger total grip strength. Also, this study disagreed with the Alahmari et al. study [16] where they concluded that age, BMI, forearm circumference, and hand length have an impact on Saudi people hand grip strength.

ANOVA results showed a significant effect of wearing a glove on hand grip strength. The strength of the hand grip when using glove was less when compared to bare hand. This result is confirmed by previous studies [32-34]. Tipton [43] found that the effect of wearing a glove produced significant grip strength reductions. In the same way, Rock et al. study [44] concluded there is a significant reduction effect of wearing a glove on hand grip strength. The results also showed that there is no significant effect on hand grip strength according to change in hand temperatures. This result differs from the result obtained by Cheng et al. [45] which is show reduction in hand strength

after cooling by $14^{o}C$. In the other hand, Cornwall [46] found that little or no change in muscle strength occurred with muscle temperature changes between $27^{o}C$ and $40^{o}C$. No interaction was found between wearing glove and hand skin temperature on the grip strength.

VI. DISCUSION AND CONCLUSION

The present study explored the relationship between grip strength, hand skin temperature, and hand anthropometric measures while wearing gloves on hand strength. Hand temperatures don't have any influence on hand grip strength, but the wearing gloves had an effect on it. Hand width had also significantly impact on hand grip strength. In addition, BMI, hand length, palm, width and circumference of the hand had no effect on hand grip strength. The information obtained from this study is valuable to all who participate in industrial safety sectors. The information obtained from this study may also be helpful to those who design tools and workstations and those who develop injury prevention programs for people who wear gloves in hot workplaces.

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