# The influence of Pinch Type and Pinch Width on Two Handed Pinch Strengths

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## ABSTRACT

This article aims to examine the influence of different factors on pinch grip strengths using the two hands. These factors include pinch widths and three different types of pinches: lateral (key), chuck, and pulp-2. Pinch grips were tested for static maximal voluntary contraction (MVC) strengths using the two hands in a snap-type action at two different widths of 3.8 cm and 7 cm among 33 healthy male volunteers. The results showed that strength differences between different types of grips depended on the width of the grip, chuck and lateral pinches where not significantly different from each other and pulp-2 pinch has the lowest pinch strengths

**Keywords:**
Two-handed strength; Grip width; chuck pinch, lateral pinch

## 1. Introduction

Ergonomic is the measurement, analysis, evaluation, and design of system involving human machine task environment interaction for the purpose of enhancing performance, safety and health (Grandjean, 1988; Imrhan, 1996; Mandahawi 2008). In order to enhance this interaction knowledge about human body dimensions, physical strength, limitations, as well as capabilities are required. Grip strength is an important aspect that must be considered when designing tools and equipments which people use in their daily life due to the fact that grip are critical to many daily activities.

Repetitiveness and forceful exertions are the two major occupational risk factors that lead to Cumulative Trauma Disorder (CTDs) in upper extremities (National Institute for Occupational Safety and Health (NIOSH), 1997). Silverstein et al., (1986) have proved that high force and high repetitiveness are positively associated with hand wrist CTDs. The combination of high force and high repetitiveness increases the magnitude of association more than either factor alone. Since gripping objects and tools are components of many industrial operations, it is very important to determine the grip force exerted by operators. This information is important not only for quantifying exposure, but also for assessing effectiveness of job or tool design interventions (McGorry R. et al., 2010). Thus when designing a job; it is highly recommended to take into consideration the forceful exertion required to perform the job in order to decrease the probability of CTDs occurrences and to use an effective exposure assessment method to quantify the gripping force.

Many studies pointed that if hand tools have poor ergonomics, then workers' hands and forearms become increasingly subject to a variety of work related musculoskeletal disorders from cumulative trauma, such as: tendonitis, strained muscles, carpal tunnel syndrome, nerve impingement, and many others (Kelly et al., 1995; Kattel et al., 1996; Wells and Keir, 1999; Sande et al., 2001; Mirka et al., 2002; Boyles et al., 2003). Therefore, evaluation of grip strength in the workplace may help in three main aspects which are: to identify individuals at risk for work related musculoskeletal disorders of the hands and forearms, to determine the improvement made over the process of treatment and rehabilitation (Boissey et al., 1999; Greeves et al., 1999; Abbott et al., 2001; Peolsson et al., 2001), and to assess feigned injury (Tredgett and Davis, 2000; Westbrook et al., 2002).

On the other hand, in Jordanian industry, tools and equipments are used widely for various types of operations. However, most of these tools are imported from countries which do not take into account the gripping force for Jordanians populations. Because grip force for Jordanians are lacking, one cannot determine the suitability of these tools and equipments for Jordanians, except to say that anecdotal evidence indicates that improvements may be necessary for comfort, health and safety. Furthermore, Many researchers reported that almost all studies on handgrip strength have tested one-handed contraction (usually the preferred hand at a single fixed grip width), however many industrial tasks and activities are performed using both the hands with muscular forces applied simultaneously with each (Imrhan and Mandahawi 2010; Imrahn 2003; Imrhan 1999). Therefore, in this research papers two hands grip strength will be measured taking into considerations three types of pinches at two different grip widths.

## 2. Methods

### 2.1. Subjects

Thirty-three healthy male college students participated voluntarily in this study. They were willing to participate in their own request; no subject had any history of musculoskeletal problems to our knowledge. Permission was obtained from the Hashemite University to conduct the strength tests and gather demographic and anthropometric information from the subjects.

### 2.2. Apparatus

A special two hand strength tool have been designed to collect the two hand strength data, it is consist of a custom-designed handle attached to a Dillon digital push-pull force gauge which measures the force in 500 N x 0.02 N, which is the highest available capacity in the GL Force Gauge Series. Dillon GL Force gauges are affordable digital force measurement devices which include a full set of handy accessories that assist in compression testing applications. Also, they measure the tension, compression, weight, and force. Dillon's digital force gauges provide 120% overload protection and a rugged metal die cast enclosure, backlit LCD display, and serial output. Furthermore, a special designed handles have been combined with the Dillon's digital force gauges which consists of two oval Teflon plates: long axis = 12.7 cm; short axis = 10.2 cm; and thickness = 1 cm. The force gauge is connected to the lower galvanized beam so that it has highly sensitivity. The distance between the oval plates could be varied manually over a wide range, thus yielding different grip widths. The handle and force gauge were attached to a sturdy adjustable tripod stand as shown in Figure (1) which allowed the experimenter to make adjustments to the height of the handle to deal with different statures of subjects for similar body

postures, the orientation of the handle such that the forearms were kept in their natural mid-orientation and the angle of the handle with respect to the vertical so that the wrist was not appreciably bent during the MVC contractions. Furthermore, the height of the handle (measured from mid-distance between the Teflon plate pair) was set at 5.1-10.2 cm below subjects' standing elbow height, which is close to the recommended work surface height for tasks requiring significant hand forces (Ayoub, 1973).

**Figure 1**: Custom-Designed Apparatus for Measuring Snap-Type Two-Handed Grip Strength

### 2.3. Procedure

Subjects, in small groups, were given demonstrations of the different pinch grip types, then allowed to perform simulated gripping tests to familiarize themselves with the apparatus, and finally tested individually. They were required to stand comfortably and pinch grip the Teflon plates with both hands, and squeeze as hard as they could with maximal voluntary effort (MVC), without jerking. The height of the instrument was adjusted according to the stature of subjects to insure the proper standing and performing of pinching where the subjects were asked to stand still and not use their upper weight by bending the shoulders, thus depending only on the strengths of fingers.

The apparatus was settled to display the peak value of the MVC of pinch grip. Three different types of pinch grip were used: Chuck, Lateral, and Pulp-2 at two pinch grip widths of 3.8 and 6.8 cm respectively as shown in Figure 2. The maximum value was taken upon two trails performed by subjects for each pinch type with a proper amount of time for resting between the two trials to help prevent muscular fatigue. The experiment was conducted in two sessions with a gap of one week between each session. Each subject performed six MVC contractions for the three pinch types at a particular pinch width in each session for a total of 12 contractions in the two sessions covering the two widths. The following figures demonstrate the different types of pinches that were used during the experiment. Anthropometric data were taken for all subjects that include:

age, stature, hand Length, inner hand breadth and hand thickness similar to what was taken by Mandahawi et al., (2008) and Imrahn (2003) in his study.

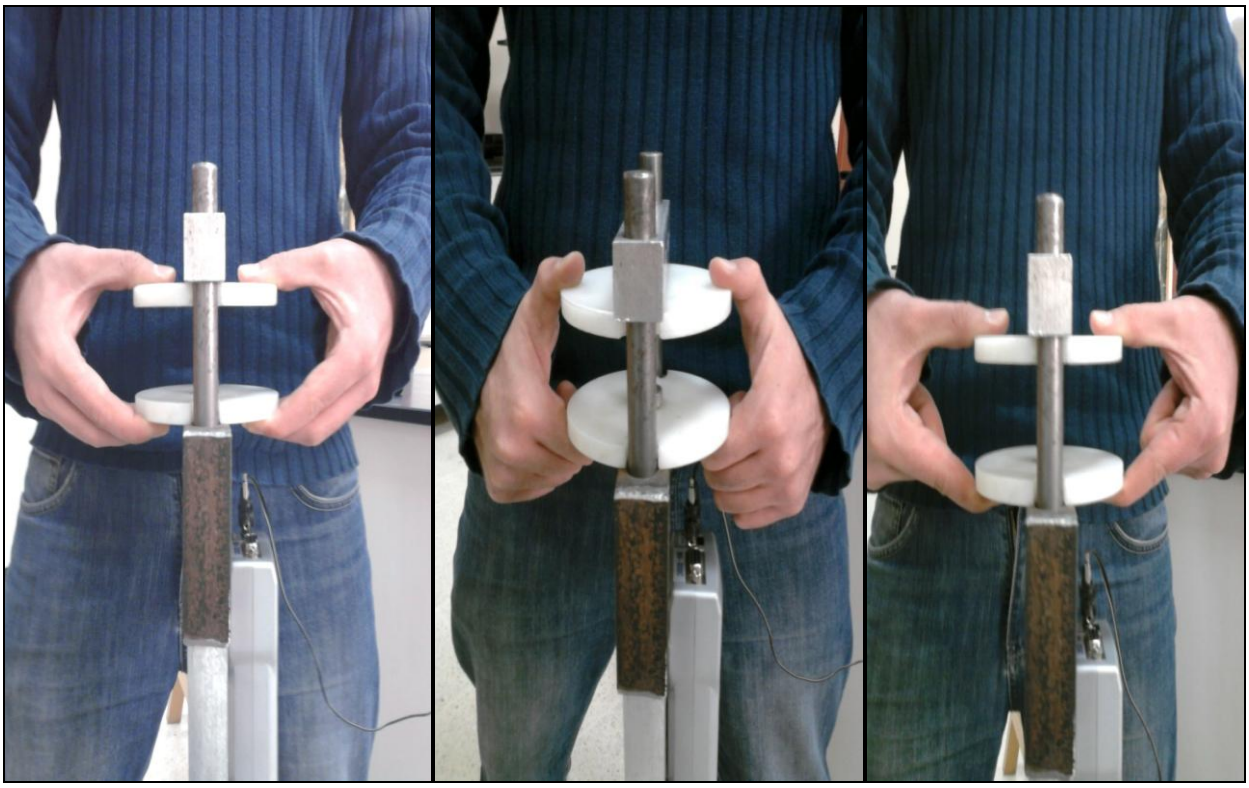

Figure 2: Three Different Types of Pinch Grip Chuck Pinch, Lateral Pinch and Pulp-2 Pinch from Left to Right Respectively

## 3. Results and Discussion

Anthropometric dimensions for subjects are summarized in Table (1), average stature and hand size compare well with those of the Jordanian civilian adults, published in Mandahawi et al., (2008).

Table 1: Summary of Anthropometric Characteristics

| Variable | Mean | Standard deviation | Range |
|---|---|---|---|
| Age (yr) | 21.44 | 1.92 | 17-26 |
| Stature (cm) | 177.84 | 6.24 | 167-190 |
| Body weight (kgf) | 78.16 | 18.38 | 50-126 |
| Hand length (cm) | 18.59 | 0.66 | 17-19.6 |
| Inner hand breadth (cm) | 8.35 | 0.41 | 7.3-9.1 |
| Hand thickness (cm) | 3.78 | 0.40 | 3.1-5.2 |

The pinch strength values for the Jordanian males have been summarized in Table (2). It was noticed that the minimum MVC were from the pulp-2 pinch, although lateral pinch was larger than chuck pinch at 3.8 cm, it become lower at 7 cm this proves with what was mentioned in

Imrahn and Rahman study (1995) where the increased pinch grip width would make the lateral pinch more difficult to be performed. Furthermore, the trends in pinch strength of two hands against pinch width are slightly different from what was found by Imrahn and Rahman (1995) for one hand and Imrahn (1999; 2003) but it similar to the study results of Dempsey and Ayoub (1996) where they also found a decreasing trend in the one-hand pinch while increasing the width.

Table 2: Summarized Data for Pinch Strengths (N) at Various Widths

| Pinch width (cm) | Statistics | Chuck pinch | Lateral pinch | Pulp-2 pinch |
|---|---|---|---|---|
| 3.8 cm | Mean | 90.70 | 99.16 | 23.81 |
| | Standard deviation | 49.51 | 43.87 | 17.10 |
| 6.8 cm | Mean | 139.92 | 136.07 | 59.24 |
| | Standard deviation | 59.61 | 41.45 | 46.55 |

ANOVA analysis indicated that both pinch width and pinch type were significant to the pinch strength at ($p < 0.001$) but there was no significant interaction between the two variables. The regression model showed no strong relationships between the anthropometry variables and the pinch strengths which is similar to the result in Imrahn (1999; 2003). Means of ratios between pairs of the different pinches were computed in Table (3).

Table 3: Means of Ratios Between Pairs of Different Pinches

| Pinch Ratio | Pinch Width (cm) | |
|---|---|---|
| | 3.8 | 7 |
| Chuck/Lateral | 0.91 | 1.03 |
| Lateral/Pulp-2 | 4.16 | 2.30 |
| Chuck/Pulp-2 | 3.91 | 2.36 |

## 4. Conclusion

An experiment was conducted to measure two hand grip strength for thirty three male Jordanian subjects at three different pinch grips (Chuck Pinch, Lateral Pinch and Pulp-2 Pinch) and two different widths using a customized designed two hand grip strength tool. It was found that the minimum MVC were at the pulp-2 pinch and lateral pinch was larger than chuck pinch at 3.8 cm and it become lower at 7 cm. Furthermore, the analysis show that both pinch width and pinch type were significant to the pinch strength but there was no significant interaction between the two variables. The results show that strong relationships between the anthropometry variables and the pinch strengths, these results are relatively similar to the results found by Imrahn (1999; 2003). The results of this study are not conclusive nor exhaustive; future studies on other types of pinch widths for a wider range with more types of pinches like to study the pulp to pulp pinch for each finger opposing the thumb and with subject samples from both genders are necessary to gather information on strength–width relationships as a function of gender and a wide range of grip width.

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