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Cross-Sectional study

The influence of physical workload on different grip strengths in healthy adults

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Abstract

Background: Prehensile and precision hand grip strength are important indicators of overall muscular function and can significantly influence the worker's capability while carrying out the physical activities at work. In this study the effect of physical workload encountered in various occupational settings on the strength of the hand grip as well as strength of different precision grips was investigated.

Materials and Methods: A cross-sectional study was performed on 150 healthy adult subjects from different occupational backgrounds. The strength of gripping was measured using Baseline hydraulic hand dynamometer (Baseline®, Irvington, NY 10533, USA) while strength of different precision grips were measured by a Baseline HiRes hydraulic pinch gauge (Baseline®, Irvington, NY 10533, USA).

Results: one-way MANOVA test declared the significant difference in grip strengths when compared between work categories ($F = 10.9$, $p < 0.001$, Wilk's $\Lambda = 0.175$, partial $\eta 2 = 0.44$). Participants in high physical load occupations demonstrated higher grip strength compared to those in low physical load occupations.

Conclusions:
Grip strength is affected by the amount of physical load and the time of maintaining posture for physical work in a positive way. Higher physical load occupation demonstrates higher grip strength. These results underscore the need for targeted strength assessments and interventions in occupational health to optimize worker performance and reduce injury risk.

Keywords: Hand grip; precision grip; Strength; Physical workload.

Introduction:

Grip strength (GS) is one of the most important indicators that predicts whether a person is productive and obtains a good health, muscular strength, endurance and dexterity. GS is noted to be normally variable following the age, the sex and the dominance of the hand. Clinically, the GS varies enormously according to diseases or injuries of the hand. Though it is crucial to establish the properties and measures to evaluate performance-based tests before the clinical application **(1)**.

In any framework that encounters sports medicine or any clinical condition, hand grip strength is one of the basic measurements that indicates the overall muscle performance, as it is a good indicator of the gross strength and the general hand performance, its endurance as well as the isometric and dynamic strengths. GS is steadily associated with physical activities, anthropometric measures such as age, gender, dominance, and body mass index. Where, males typically obtain stronger hands than females. Asymmetry between dominant and non-dominant hands regarding the grip strength is frequent and mostly favors the dominant hand as it gains more strength from manipulating objects and endurance from tolerating long lasting position. Thus, the dominant hand exceeds the non-dominant by average of 10% **(2)**.

Recently, evident findings declared a strong relation between musculoskeletal dysfunctions and risk factors at the workplace such as muscle pain, muscle weakness or fatigue during or after work hours. The strength of hand gripping should be evaluated to indicate hand power, which is optimally measured by using the dynamometer, which depends on exerting maximum isokinetic or isometric resistance **(3)**.

In some occupations the workers need to exert forces with their hands that might exceed the grip strength, resulting in various injuries of the hand. The hand prehensile movement - which is the way people prehend, grasp or manipulate objects- is mainly either power or precision. Power grip is described as using the palm as an end of a clipper and the fingers as the other end, whereas precision involves fine opposition of the four digits with the thumb, creating different types of grips as key grasp, tip to tip pincer grasp (also referred to as pad-to-pad) and tripod (also referred to as palmer) grasp **(4)**.

In Tip-to-tip precision, tension is generated between pads of the thumb and that of the fingers with no contact with the palm. Tip-to-tip is particularly interesting as this grip is usually used in high-precision tasks **(5)**. Generally, the pinch grip denotes the power of the thumb and the four digits, and the strength of the extrinsic muscles within the forearm **(6)**.

Hand muscles exert force in different prehensile movements. The determinants of different occupations imply the type of gripping activities. In heavy job determinants, it usually imposes tremendous strain on the muscles of the hands, because of one of two situations; first is the great forces exerted by the muscles as it is capturing, holding or seizing objects within the hand compass and second, because of high demands on the muscles due to continuously repetitive or prolonged sustained contraction **(7)**.

Grip strength is measured by the maximum voluntary force exerted by an individual under normal kinetic and ergonomical state. Upper limb muscle strength is directly proportional to the power of the hand, concerning the quality of gripping, therefore, hand anthropometric measurements and dimensions, as palm length and width, hand length and the circumference, are directly related to the strength of gripping too, indicating stronger and more powerful and precise hand performance and productive work outcomes **(8)**.

The grip muscles performance is influenced by social and economic status including the individual's income, level of education, health care and occupational category. Occupational category could be related to occupational physical activity, which in turn is related to muscle strength **(9)**.

Some studies reported that stronger gripping strength is correlated to higher subjection to heavy workloads that increases the strength of gripping performance in consequence to demands of certain loads, specifically in manual workers, engaging in tasks with their upper limb and hand that needs exerting increased forces in their occupational activities in the workplace **(10)**.

Previous studies relating occupational characteristics and GS have suggested that low productivity is possibly the result of poor hand strength due to continuous exposure to repetitive physical work. Manual, heavy workers who are subjected to higher demands than their muscular abilities are at risk of strength decline in comparison with non-manual workers, regardless of the demographic and socioeconomic, health and general circumstances related to work **(9)**.

This study demonstrates the need for grip strengths assessments and interventions in occupational health to optimize worker performance and reduce injury risk.

Materials and Methods:

This study was conducted at the faculty of physical therapy, Badr University in Cairo. Ethical approval for the study was obtained from the Scientific Research Ethical Committee of Faculty of Physical Therapy, Badr University in Cairo (NO: IRB00014233-14).

Sample size calculation:

G*Power3.1.9.7 was used to determine the sample size using the following statistical parameters: power (1-β) = 0.95, α error probability = 0.05, and effect size f = 0.0625. Thus, the total sample size was found to be 144.

Subjects:

This study was conducted among 150 healthy subjects of both genders. All subjects were clinically and medically free of any diseases. They had no impairments of sensation or other neurological or physiological problems. Subjects were excluded from the study if they had any deficits, Significant tightness, any neurological disorders that affect balance or mentality and finally any pathological causes of obesity (endocrinal, genetic syndromes). Subjects were distributed in four categories in accordance to their occupational jobs that is based on expected physical load.

• Category 1: no physical load (teacher, bank teller)
• Category 2: long-lasting postures with repeated motion (engineer, dentist)
• Category 3: heavy physical load (nurse, housekeepers)
• Category 4: both heavy physical load and long-lasting postures with repeated motions (electrician, construction builder, mechanic) **(11)**.

Procedures:

Hand grip strength was measured using Baseline hydraulic hand dynamometer (Baseline®, Irvington, NY 10533, USA) and the strength of different precision grips were measured using a Baseline Hi-Res hydraulic pinch gauge (Baseline®, Irvington, NY 10533, USA), **(6,12).**

In order to evaluate their hand grip, the participants squeezed the dynamometer's handle, which was set to the second handle position, as hard as they could for three consecutive trials. They rested for one minute after each trial, and the mean of the three records was documented **(13).**

The grip and pinch strengths were measured according to the recommendations of the American Society of Hand Therapists (ASHT), where the participants sat with erect back on a chair with the shoulder in a neutral position, arm parallel to their torso, 90º elbow flexion and the wrist in a neutral position **(6).**

The pinch gauge was positioned and supported by the researcher to measure the other three precision grips (key grasp, tip-to-tip pincer grasp, and tripod grasp), allowing the subject to concentrate on exerting the maximum force. In three consecutive trials, subjects were told to apply and hold their maximum grip force on the pinch gauge for three seconds, with a one-minute rest interval after each trial, the rest of the fingers were completely flexed **(13).**

The testing position of the digits were managed as follow:

- Between the thumb pad and the lateral aspect of the middle phalanx of the index finger for the key precision grip.
- Between the thumb pad and the pad of the index for the tip-to-tip pinch grasp.
- Between the thumb pad at one side and the pads of the index and middle fingers together at the other side for measuring the tripod (palmer) grasp **(13).**

A full demonstration was presented by the researcher, appropriate verbal instructions were given along with encouragement to enhance exerting maximum effort during each attempt, with the average of the three trials recorded **(8)**.

Statistical analysis:

For statistical analysis, Version 26 of the Statistical Package for the Social Sciences (SPSS) was chosen to analyze the gathered data. The Tukey post hoc test and One Way MANOVA were utilized to compare between work categories.

Results:

One hundred and fifty subjects [category 1 (40), category 2 (37), category 3 (37), and category 4 (36)] were included in the current study. Their mean value of ages was 36.26 ± 12.8 years, and body mass index (BMI) was 27.15 ± 4.47 Kg/m^2.

Generally, one-way MANOVA test showed that there was significant difference in grip strengths when compared between work categories ($F = 10.9$, $p < 0.001$, Wilk's $\Lambda = 0.175$, partial $\eta2 = 0.44$).

Concerning hand grip strength (HGS), there was a statistically significant difference between different work categories by one-way MANOVA. For right hand, F (3,146) was 191.5, P value was < 0.001 and partial η2 was .797. for left hand, F (3,146) was 128.8, P value was < 0.001and partial η2 was 0.726. Tukey post hoc test showed significant difference (for right and left hands) between category 2 and category 1 (p-value < 0.001), category 3 and category 1 (p-value < 0.001), category 4 and category 1 (p-value < 0.001), category 3 and category 2 (p-value < 0.001), category 4 and category 2 (p-value < 0.001), category 4 and category 3 (p-value < 0.001). Figure 1 shows difference in HGS between different work categories for right and left hands and table 1 shows mean values ± standard deviation of different grip strengths in different work categories.

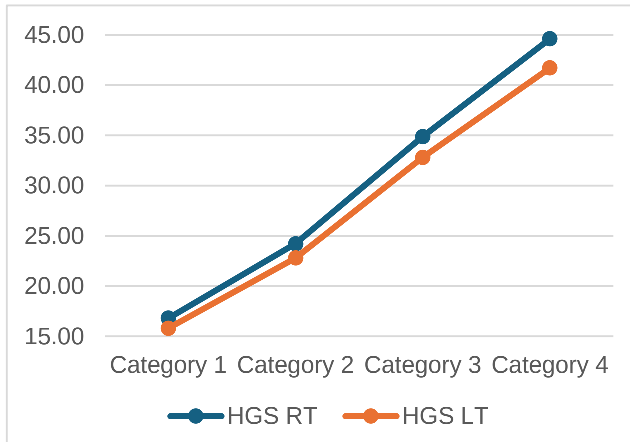

Figure 1. Difference in HGS between different work categories for right and left hands.

Concerning key pinch grip strength, there was a statistically significant difference between different work categories by one-way MANOVA. for right hand, F (3,146) was 6.6, P value was < 0.001 and partial η2 was 0.120. for left hand, F (3,146) was 10.2, P value was < 0.001 and partial η2 was 0.173. for right hand, Tukey post hoc test showed significant difference between category 3 and category 1 (p-value = 0.004), category 4 and category 1 (p-value = 0.003), category 3 and category 2 (p-value = 0.038), category 4 and category 2 (p-value = 0.031). but there was no statistically significant difference between category 2 and category 1 (p-value = 0.902), category 4 and category 3 (p-value = 1). For left hand, there was significant difference between category 3 and category 1 (p-value = 0.003), category 4 and category 1 (p-value < 0.001), category 3 and category 2 (p-value = 0.011), category 4 and category 2 (p-value < 0.001). but there was no statistically significant difference between category 2 and category 1 (p-value = 0.982), category 4 and category 3 (p-value = 756). **(Figure 2 and Table 1)**.

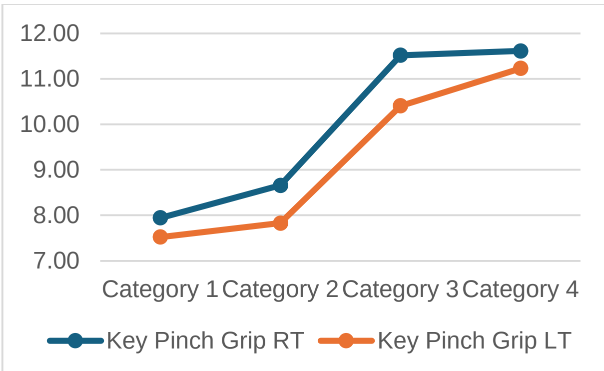

Figure 2. Difference in key pinch grip strength between different work categories for right and left hands.

Regarding tip-to-tip grip, there was also a statistically significant difference between different work categories by one-way MANOVA. For right hand, F (3,146) was 22.79, P value was < 0.001 and partial η2 was 0.319. for left hand, F (3,146) was 17.8, P value was < 0.001and partial η2 was 0.268. for right hand, Tukey post hoc test showed significant difference between category 2 and category 1 (p-value = 0.027), category 3 and category 1 (p-value < 0.001), category 4 and category 1 (p-value < 0.001), category 3 and category 2 (p-value = 0.049), category 4 and category 2 (p-value < 0.001). but there was no statistically significant difference between category 4 and category 3 (p-value = 0.095). For left hand, there was significant difference between category 2 and category 1 (p-value = 0.009), category 3 and category 1 (p-value < 0.001), category 4 and category 1 (p-value < 0.001), category 4 and category 2 (p-value = 0.001), category 4 and category 3 (p-value = 034). but there was no statistically significant difference between category 3 and category 2 (p-value = 0.635). **(Figure 3 and Table 1)**.

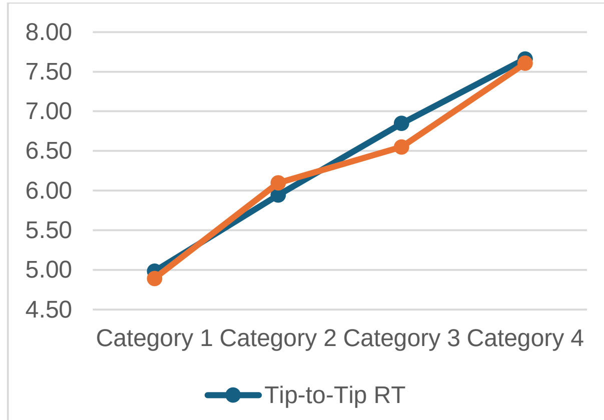

Figure 3. Difference in tip-to-tip grip strength between different work categories for right and left hands.

Concerning tripod grip strength, there was a statistically significant difference between different work categories by one-way MANOVA. For right hand, F (3,146) was 45.77, P value was < 0.001 and partial η2 was 0.485. for left hand, F (3,146) was 40.15, P value was < 0.001 and partial η2 was 0.452. for right hand, Tukey post hoc test showed significant difference between category 2 and category 1 (p-value = 0.015), category 3 and category 1 (p-value < 0.001), category 4 and category 1 (p-value < 0.001), category 3 and category 2 (p-value < 0.001), category 4 and category 2 (p-value < 0.001). but there was no statistically significant difference between category 4 and category 3 (p-value = 0.137). For left hand, there was significant difference between category 2 and category 1 (p-value = 0.025), category 3 and category 1 (p-value < 0.001), category 4 and category 1 (p-value < 0.001), category 3 and category 2 (p-value < 0.001), category 4 and category 2 (p-value < 0.001). but there was no statistically significant difference between category 4 and category 3 (p-value = 0.258). **(Figure 4 and Table 1)**.

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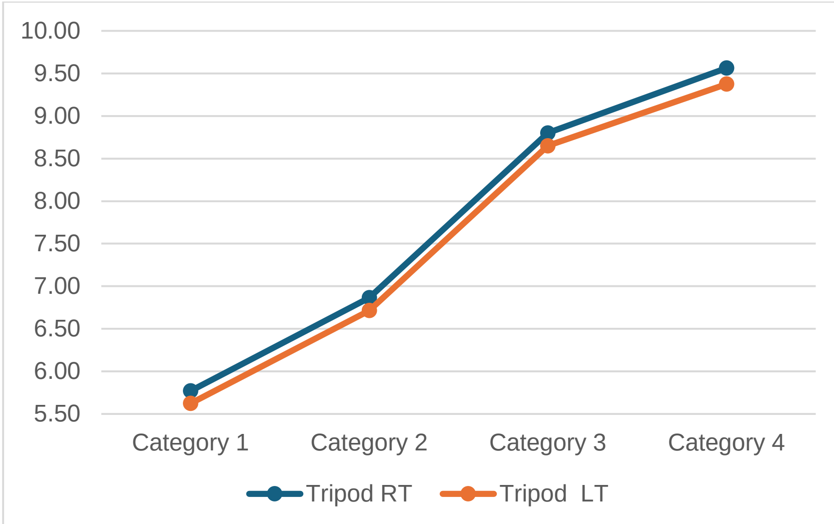

Figure 4. Difference in tripod grip strength between different work categories for right and left hands.

Table 1. Mean values (±standard deviation) for different grip strengths in different work categories

Work Category	Hand grip		Key Pinch		Tip-to tip		Tripod	
	RT	LT	RT	LT	RT	LT	RT	LT
Category 1	16.8 (±4.7)	15.8 (±4.2)	7.9 (±6.5)	7.5 (±6.3)	5 (±1.5)	4.9 (±1.2)	5.8 (±1.3)	5.6 (±1.3)
Category 2	24.2 (±4.4)	22.8 (±4.8)	8.7 (±2.2)	7.8 (±1.6)	5.9 (±1.4)	6.09 (±2.2)	6.9 (±1.5)	6.7 (±1.7)
Category 3	34.9 (±5.7)	32.8 (±7.9)	11.5 (±5.4)	10.4 (±1.7)	6.8 (±1.1)	6.6 (±1.2)	8.8 (±1.7)	8.7 (±1.9)
Category 4	44.6 (±6.6)	41.7 (±7.1)	11.6 (±1.9)	11.2 (±1.5)	7.7 (±1.9)	7.6 (±1.9)	9.6 (±1.9)	9.4 (±1.8)

Discussion:

This study aimed to investigate the effect of physical workload encountered in various occupational settings on the strength of the hand grip as well as strength of different precision grips. The effect of workloads on both hands being it the dominant or the non- dominant regarding the grip strength, key pinch, tip to tip, and tripod. The results showed a statistically significant difference between different work categories for different grip strengths for right, and left hands. Findings of this study compared the occupational categories (groups) Category 1: no physical load, category 2: long-lasting postures with repeated motion, category 3: heavy physical load, category 4: both heavy physical load and long-lasting postures with repeated motions.

According to our results, the dominant hand's grip and pinch strength was greater than the hand with less dominance across all workloads. It's possible that this is because the hand with more dominance is used more often to complete everyday tasks, which strengthens the muscles in the dominant hand and increases its grip and pinch strength relative to the non-dominant hand.

The findings of this study are consistent with several investigations that discovered that the hand with more dominance had a stronger pinch grip than that with less dominance **(14-16)**, which suggests that this may be the result of frequent and continuous use of one hand compared to the other -according to dominance- while carrying out daily duties, which subsequently leads to increased muscle strength and gripping power.

Incel et al. also agreed with our results as they stated that the grip and pinch strength of the dominant hand is significantly different from that of the non-dominant hand. The dominant hand's grip and pinch strength is higher than the non-dominant hand's **(17)**. And **Ertem et al.** too found that in left-handed individuals, the dominant hand's grip and pinch strength is nearly 10% higher than the non-dominant hand, but in other individuals, the two hands' grip and pinch strengths are equal **(18)**.

Concerning the hand grip, key pinch, tip to tip, and tripod strength, we found that people had higher values in category 4 (where there is both heavy physical load, sustained postures and repeated motions) compared with the other categories which contradicted with **Habibi et al.** who showed that in moderate and heavy work intensities people recorded lower grip and pinch strength in comparison with demands that is less intense **(14)**.

The strength of different gripping styles is affected relating to many variables including decreased muscle performance and low functional activity in elderly people. Additionally, it may be linked to general weakness, malnutrition, a lack of physical activity, muscle impairments, dependence in daily activities, a decline in cognitive functions, and all-caused mortality problems **(19).**

Jain et al. studied 182 individual of both sex who have manual dependent jobs, they were categorized into three levels of work experience. And their results demonstrated that the strength of their grasp, whether it be prehensile or precise, is significantly influenced by upper limb muscle activity and the usage of tools for particular manual tasks. An individual's occupational job plays a significant role in determining their mental and physical abilities, which in turn affects their overall muscle strength along with the grip strength exerted. They further observed that professional workers, who take a neutral approach typically put out more effort in response to demands exerted at work **(20)**.

Saremi et al. examined the connections between dentists' occupation and hand function specifically, hand grip strength and anthropometric hand size. They discovered it was highly related to occupation and HGS. 720 dentists both females and males participated in the study, and the findings showed a strong correlation between the clinical experience and task specialization and the hand function **(21)**.

In accordance **Tokarski et al.** examined fifty-two female workers and distributed them into three categories according to their age: 20-25, 45-50 and 55-65 years. They concluded that the forces exerted in manual tasks by older females are nearly decreased by 20% than that exerted by younger females. But when it came to the engagement of smaller hand and forearm muscles resembled in manual works that included hand interaction, older females showed equivalent force abilities as younger females, which again agrees with our outcomes that heaver work increases the precision grip capabilities, as well as the hand grip **(22)**.

Chandra et al. examined the grip strength of 45 workers, distributed according to their work category, the subjects worked as safety guards, industrial workers and technicians, and found significantly lower grip strength value in industrial workers compared to safety guards. And they interpreted the results explaining that stressors inherent of the job might be the reason for the differences, especially those involved in repeated manual movements and sub-optimal work conditions **(23)**.

While **Walker-Bone et al.** examined the strength of hand gripping using a dynamometer, and found that men who performed heavy lifting, extended and sustained tasks like walking or standing still, and even strenuous activities prolonged periods of their working lives had decreased grip strength abilities than men who performed fewer of these activities **(24)**.

Lee k. indicated that people who performed manual tasks, salespersons, and service workers were more likely than non-manual workers to have weak hand muscles, regardless considering social and demographical issues like age and income, or considering work demands, as working hours per day, or either health factors like engaging in an exercise routine or leisure time **(9)**.

This agrees too with **Moller et al.** who proposed that the diversity in hand grip strength is only partially explained by physical exposures over the course of working years **(25)**.

In another study where grip strength was examined in elder population aged 80 years or more found that strength was less in those who performed manual work in comparison with those who performed non-manual tasks when both types were performed for a prolonged time. Furthermore, there was a higher correlation between manual labor and increased physical stress **(26).**

Conclusion:

Grip strength is affected by the amount of physical load and the time of maintaining posture for physical work in a positive way. Higher physical load occupation demonstrates higher grip strength.

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Conflicts of interest: The authors state no conflict of interest.

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