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The Maximum Aerobic Capacity Effects Assessment and the Hand Power Perceived Exertion Rating

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ABSTRACT

Grip and pinch strength are the most important factors affecting the hand's performance. This study was aimed to evaluate the relationship between maximum aerobic capacity (Vo_{2max}) and to rate the perceived exertion (RPE) with grip, pinch strength and endurance and their impact on these factors. This cross-sectional study was performed on 83 male students and office workers through simple random sampling. The Step test, Borg scale, dynamometer, and pinch gauge were used to assess the Vo_{2max}, RPE, grip strength, pinch strength, and endurance, respectively. The findings of this study indicated that there are direct relationships between the Vo_{2max} with grip strength and endurance, and between BMI with pinch strength and endurance. On the other hand, there is an indirect relationship between RPE with grip strength, pinch strength and Vo_{2max}. There was no relationship between RPE with grip and pinch endurance. It was also found that there are direct relationships between BMI with grip and pinch strength, pinch endurance, and Vo_{2max}. Finally, no relationships were observed between the BMI and grip endurance. It was found that Vo_{2max} had no effect on the grip strength, pinch strength, and pinch endurance, but it influenced the grip endurance. In jobs that require high grip, pinch strength, and endurance, individuals with high Vo2max are employed. This will decrease the number of work-related musculoskeletal disorders (WMSDs).

KEYWORDS: *Grip; Pinch Strength; Step Test*

INTRODUCTION

In European countries, the most common work-related musculoskeletal disorders (WMSDs) are related to the upper limb [1). When people act at level beyond their physiological limit, they encounter fatigue [2]. The maximum aerobic capacity (VO_{2max}), as one of the main health-related components, can be assessed via measuring [3]. The more VO_{2max} shows more capacity of performing a physical task. In other words, one would be able to do the heavy task [4].
words, one would be able to do the heavy task [4]. Besides, physiological procedures using mental analysis were applied to assess the difficulty level of a task [5]. In industry, it can be considered as an easier procedure for assessing the difficulty level of a task and VO_{2max} [6]. Therefore, the rating of perceived exertion scale (RPE) has an acceptable error of

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measurement. The main scale introduced by Borg is a 15-point scale which measures the amount of an effort in a range of 6 to 20 [7]. The validity and reliability of the Borg scale have been studied by Skinner et al. and by Stamford (8). A strong grip can potentially results in carpal tunnel syndrome [1]. When the type of grip and amount of force are not proportional, upper limb motions would be affected and it would consequently result in fatigue and muscular tension. Although the hand grip strength threshold is the best way to identify people at risk of limitation of motion, it is not yet fully known [9]. Grip and pinch strength assesses the function of the hand. Grip strength is considered as a sign of general health [10]. Measurement of grip strength provides valuable information on the function and status of the upper limb and the neuromuscular system. Grip strength can also be used as a measurement of the amount of muscular damage or impaired neurological nerves. In addition, grip strength is a good indication of a person's overall physical condition. Assessment of grip strength, compared to other tests, is simple, easy and of high reproducibility [11]. When hands grip strength are measured through standard methods and calibrate equipment, those would be quite reliable, even if various analysts and different dynamometers were used. Some research papers suggested that grip strength screening is a tool for women at the risk of osteoporosis. Studies showed that poor grip strength in men can be used as a predictor of death caused by heart disease and cancer, even when their muscle density and BMI is normal [12]. In grip strength test, the wrist is fixed and the device is kept by all of the fingers [13]. Pinch strength occurs when gripping with each of the fingers or a combination of them [14]. In Palmar pinch, the palm of the first joint of the thumb is placed on the pinch gauge against the index and middle fingers [15]. Therefore, the present study was aimed to evaluate the relationship between maximum aerobic capacity (Vo_{2max}) and ratings of perceived exertion (RPE) with grip, pinch strength and endurance and their impact on these factors.

MATERIALS AND METHODS

Participants

In this cross-sectional study, 83 male students and office workers from Isfahan University of medical sciences were selected through simple random sampling. The sample size was calculated by Equation 1. Experiments were performed in an ergonomic laboratory. Participants with a history of arm and hand or wrist surgery at the last three months, the feel of pain, and arthritis in their hands and wrists were excluded {16]. Recent demographic data have been shown in Table 1.

$$n = \frac{(z_1 + z_2)^2(1 - r^2)}{r^2} + 2$$

Z_1: 1.96

Z_2: 84%

r: Correlation coefficient between different variables = 0.3

Equation 1

Procedures

The study was carried out to determine the VO_{2max} using step test based on McArdle or Queen's College method, which is a standard test. To perform this test, one must go up and down on a step with a height of 41.3 cm. The rhythm of going up and down should be steady. Totally, during three minutes, men must go up and down at 72 times and women 66 times. Five seconds after step test, participant's heart rate were accounted at 15 seconds and VO_{2max} was calculated by Equation 2 [17].

Men: VO_{2max} (ml/kg/min)=111.33-0.42 heart rate (bpm) Equation 2

BMI, heart rate, and VO_{2max} were recorded in the forms. RPE was rated by the Borg scale [18]. The scale was from 6 to 20 [19]. In this study, to measure grip strength based on the American Society of Hand Therapists (ASHT), Participants were asked to sit on the chair while their arms were attached to their body and their wrists were placed in an extension of 0-30 degrees and ulnar deviation of 0 to 15 degrees. Then the researchers asked them to use their dominant hand to apply hand grip three times. The average of maximum force to the handle of the dynamometer was recorded as hand their grip strength at kilogram-force (kg f) unit [20]. The test was administered at 8 to 10 A.M. and the rest among the three grips was 60 seconds. Moreover, the participants were asked to apply their hand grips for at least three seconds [21].

At the beginning of the test, the following adjustments were made as follow [16]:

1. Adjusting the dynamometer to zero.
2. Checking the suitability of the dynamometer so that its handle is placed on the middle joint of the "ring finger and index finger".
3. Asking participants to sit on the chair while their arms were attached to their body, and hold the dynamometer (SH 5001 SAEHAN Hydraulic Hand Dynamometer, South Korea) with their dominant hand. The angle of their elbow should be 90 degrees. The other hand was placed on their lap [22].

The participant's grip endurance was specified through the maximum time (in seconds) that one could continue one-third of the maximum voluntary contraction (MVC) [21]. In addition, the participants were instructed to continue their grip as long as they were able. The endurance test was stopped if The participants had no strength and energy to continue and the force was reduced up to ten percent lower than the force exerted at the initial level, at least for five seconds [22]. Then, Palmar pinch test was performed twice with the dominant hand using Pinch Gauge and the maximum force was recorded. The reliability and validity of dynamometer were confirmed for measuring grip strength. A SAEHAN Hydraulic Pinch Gauge, (SH 5005 South Korea**)** was used to measure pinch strength. Studies showed that pinch gauge has high calibration accuracy and precision [23]. In the present study, grip strength, grip endurance, pinch strength, pinch endurance, and RPE were measured before the step test, and those repeated after doing step test and recording the participant's heart rate.

Statistical analysis

Data analysis was carried out using Pearson correlation coefficient, Wilcoxon test, and paired samples t-test in SPSS version 20. The level of meaningful was $P < 0.05$.

RESULTS

Pearson correlation coefficient showed that there were direct relationships between V_{o2max} with grip strength, grip endurance, pinch strength, pinch endurance, and BMI ($P < 0.05$) and it had highest correlation with grip strength ($r = 0.871$) and lowest correlation with pinch endurance ($r = 0.213$). There were direct relationships between BMI with grip strength, pinch strength, and endurance, and Vo_{2max}. However, there was no significant relationship between BMI and grip strength ($P > 0.05$). BMI had the highest correlation coefficient with pinch endurance ($r = 0.305$) and the lowest correlation coefficient with grip endurance ($r = 0.026$). Moreover, there were direct relationships between age of participants with his grip strength, pinch strength, endurance, and Vo_{2max} ($P < 0.05$). The Spearman correlation coefficient showed that there were inverse relationships between the RPE with grip strength, pinch strength, and Vo_{2max}, while there were no relationships between RPE with grip and pinch endurance ($P > 0.05$). The RPE had highest correlation with grip and pinch strength ($r = -0.028$) and lowest correlation with the grip endurance ($r = -0.052$). As well as, the Pearson correlation coefficient showed that the participant's height had direct relationships with grip strength, pinch strength, and Vo_{2max} and the highest correlation coefficient ($r = 0.546$) with grip strength. However, there was no relationship between the endurance of grip and pinch. The related data are available in Table 2. In this study, the mean, standard deviation, and range values of grip strength, grip endurance, pinch strength, pinch endurance, and Vo_{2max} of the participants were computed. The results have been presented in Table 3. In the present study, the rating of perceived exertion was also studied before and after the step test. Wilcoxon test showed that the RPE after the step test was significantly higher than that before the step test ($P \leq 0.001$). The results have been reported in Table 4. The paired t-test showed that the average grip strength, grip endurance, pinch strength, and pinch endurance did not differ before and after the step test. In other words, the participant's Vo_{2max} affected the grip endurance ($P=0.04$) but it did not affect other parameters mentioned above. The results have been shown in Table 5.

Table 1. The demographic information of the participants

Variable	Minimum	Maximum	Mean ±SD
Age (Year)	19	62	30.15±10.29
Height(cm)	145	182	167.73±6.57
Weight(kg)	44	97	64.40±10.06
BMI(Kg/m2)	16.85	29.94	22.82±2.76

Table 2. The relationships between grip strength, grip endurance, pinch strength, pinch endurance, BMI, Vo_{2max}, RPE, age, and height

Variable	Vo2max		RPE		BMI		Age		Height	
	r	P value	r	P value	r	P value	r	P value	r	P value
Grip strength	0.871	≤ 0.001	-0.275	0.012	0.260	0.018	0.649	≤ 0.001	0.546	≤ 0.001
Grip endurance	0.399	≤ 0.001	-0.052	0.64	0.026	0.816	0.418	≤ 0.001	0.096	0.386
Pinch strength	0.543	≤ 0.001	-0.280	0.010	0.287	0.009	0.376	≤ 0.001	0.398	≤ 0.001
Pinch endurance	0.213	0.027	-0.081	0.468	0.305	0.005	0.287	0.009	≤ 0.001	0.998
BMI	0.309	0.004	-0.311	0.004	-	-	-	-	-	-
Vo2max	-	-	-0.251	0.022	0.309	0.004	0.811	≤ 0.001	0.535	≤ 0.001

Table 3. The mean and standard deviation of grip strength, grip endurance, pinch strength, and pinch endurance, and Vo_{2max} in participants

Variable	Minimum	Maximum	Mean ±SD
grip strength	13	55	29.94±10.68
grip endurance	5	91	34.32±21.34
pinch strength	4	12	1.96±7.49
pinch endurance	3	120	33.50±22.31
Vo2max	57.13	101.25	78.75±1.51
RPE	6	13	10.42±1. 51

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Table 4. Statistical distribution of ratings of perceived exertion before and after the step test

Degree RPE	Description of degree	Before step test	After step test	P value
		Frequency (Percent) N (%)	Frequency (Percent) N (%)	
6	Do not apply any pressure	3(3.6)	0	
7-8	Ultra-light	6(7.2)	0	
9-10	Very light	16(19.3)	1(1.2)	
11	light	48(57.8)	5(6)	
12-13	A little hard	10(12)	35(42.2)	≤0.001
14-15	hard	0	26(31.3)	
16-17	very difficult	0	12(14.4)	
18-19	Super hard	0()	3(3.6)	
20	Maximum pressure	0()	1(1.2)	

Table 5. The mean grip strength, grip endurance, pinch strength, and pinch endurance before and after step test

Variable	Before step test	After step test	P value
	Mean ±SD	Mean ±SD	
Grip strength	29.94±10.68	29.4±10.5	0.46
Grip endurance	34.32±21.34	30.8±21.6	0.04
Pinch strength	1.96±7.49	7.2±2	0.11
Pinch endurance	33.50±22.31	33.52±23.4	0.99

DISCUSSION

In the present study, there were direct relationships between Vo_{2max} and factors including grip strength and endurance, pinch strength and endurance, and BMI. Ranjana et al. carried out a study in 2015 and compared the grip strength and endurance between two groups of obese young subjects of 20 to 35 year-olds (BMI>30kg/ m^2) and none-obese young subjects (18.5<BMI <25 kg / m^2). There were a seven percent increase in grip strength, 32% decrease in endurance period, and 34% decrease in the rate of power-loss in young-obese subjects in compared to the none-obese young subjects. There was also an increase in RPE. However, the mentioned results in elderly-obese (over 50 years) were not observed [22]. Cavuoto and Nussbaum carried out a study in 2013 and proved that there was a direct relationship between BMI and hand grip strength in the young [24]. Although, in 2004, Rolland et al. observed no difference between the hand grip strength of obese-elderly and non-obese elderly people [25]. In 2011, Eksioglu reported an inverse relationship between BMI and grip endurance [26]. Habibi et al., in 2013, were shown that pinch and grip strength in the dominant hand was more than other hand. Moreover, a significant relationship was

reported between BMI with dominant and non-dominant grip and pinch strength [27]. However, in this study, BMI was found to be directly related to pinch and grip strength, and pinch endurance. Increased muscle strength in people with high BMI can increase pinch and grip strength, and pinch endurance. However, it had no relationship with grip endurance. In 2008, Madanmohan *et al*. cconcluded that six-week yoga exercises did not increase grip strength because those were performed in the short-term. However, a significant increase in women's grip endurance was observed but there was no significant increase in men [21]. In the present study grip and pinch strength and their endurance were not significantly different before and after the Step test. It can be due to the lack of involvement of upper body muscles in this test. Rantanen et al. focused their study on 50-68 years men and observed that the average maximum grip strength was equal to 36.65 kg [28]. In a study performed by Shandir Ramlagan et al., in 2014, 3840 men and women aged 50 years and higher were tested in South Africa. The average grip strength was 37.9 kg at men with a mean age of 61 years and 31.5 kg at women with an average age of 62 years. Moreover, in their study, grip strength was found that had a meaningful relationship with height [16]. The results of Hairi et al. also support these findings [29]. The present study also was found a significant relationship between height and pinch grip strength. However, there were no significant relationships between the height of participants with their grip and pinch endurance. In a study carried out by Victoria and coworkers, in 2015, on 741 boys and 767 girls aged 6 to 19 years, it was observed that gender and age influenced on the hand strength. Based on the findings, hand grip strength raised with increase of the age of participants. There seems to be a direct relationship between hand grip strength and age of participants. Moreover, hand grip strength of boys was higher than that of girls. However, the dominant hand showed no significant effect [23]. Habibi et la. in their study found no significant relationships between age with grip and pinch strength [27]. However, in the present study, it was observed that there were direct relationships between age and parameters such as grip strength, pinch strength, grip endurance, and pinch endurance. Mathiowetz and Ager reported that gender, as an important factor, affect hand strength. Butterfield stated that gender is an important factor only at children over 12 years [30- 31]. As he has confirmed that hand power depends on both gender and age [32]. In the study carried out by Nicola et al., the weakest grip strength was related to individuals with high BMI who were either under 30 or over 70 years, while the highest grip strength was related to those with high BMI who were between 30-70 years [12].

CONCLUSION

Vo_{2max} is known as an effective factor influencing on grip endurance. Also, Vo_{2max} seems to have a direct relationship with grip strength and endurance, pinch strength and endurance, and BMI. Therefore, in jobs that require high grip, pinch strength, and endurance, individuals with high Vo_{2max} are employed. This will decrease the number of work-related musculoskeletal disorders (WMSDs). The present study only was included male students and office workers. Therefore, it is highly recommended to study female and industrial workers through consideration kind of work and overall physical activity. Moreover, it was suggested that other methods be used to assess Vo_{2max} and examine simultaneously the influence of age, obesity, and height on Vo_{2max}, grip strength, and grip endurance, pinch strength, and pinch endurance.

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CONFLICT OF INTEREST

There is no conflict of interest for any of the authors.

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