Research Article

Handgrip strength as determinant of upper body strength/physical fitness: a comparative study among individuals performing gymnastics (ring athletes) and gymnasium (powerlifters)

Reena Kaur Ruprai, Santosh V Tajpuriya, Neelam Mishra

Department of Physiology, Government Medical College, Nagpur, Maharashtra, India.
Correspondence to: Reena Kaur Ruprai, E-mail: reenakaur.ruprai@rediffmail.com

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Abstract

Background: This study was conducted on two different exercising groups, that is, gymnasium (powerlifters) and gymnastics (ring users). Although the type of physical activity is different, but both of the groups require stamina and coordination of central nervous system and skeletal muscles. In the two groups, the muscle strength of the upper body is remarkable and the handgrip has to be effectual for holding rings (gymnastics) and weights (gymnasium). Also, the time for which the grip can be maintained, which determines the endurance of the individual.

Objective: To find the difference in handgrip strength (HGS) and handgrip endurance (HGE) among the two physically active groups.

Materials and Methods: This study was conducted on a total of 75 subjects, divided into three groups of 25 each, namely, gymnastics, gymnasium, and control, that is, non-exercising group. Anthropometric hand measurements and skinfold thickness, forearm circumference, and forearm muscle were taken with HGS and HGE. Statistical analysis was then done to draw inference.

Result: The study revealed statistically significantly high HGS and HGE in exercising group, in comparison to the control group, also the HGS was maximum in the gymnasium group ($p < 0.0001$). Moreover, the forearm circumference and the forearm muscle area were maximum ($p < 0.0001$) and the skin fold thickness was found to be the least in the gymnasium group. The study revealed positive correlation among HGS and HGE with forearm muscle mass. Thus, the study concluded the positive effect of physical activities on HGS and the weight training of the muscles increases their efficiency due to more acquisition of strength and development.

Conclusion: In view of the fact that our day-to-day activities, a consistent assessment of handgrip forms an integral part of rehabilitation, not only to assess the strength of muscles involved in gripping but also to apply as a tool in rehabilitating patients with variable levels of hand injuries and in many clinical conditions such as diabetes. Can be implemented as a useful parameter by the coach in their fitness and training program.

KEY WORDS: Handgrip strength, handgrip endurance, gymnasium, gymnastics, forearm muscles area

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Introduction

Handgrip strength (HGS) is a good predictor of total muscular strength and endurance. Having strong fingers, hands, and wrist helps you to lift more weight and also to hold the weights for longer time. Many daily functions and sporting events require high activity levels of the flexor musculature of the forearms and hands. These are the muscles involved in gripping strength. From sports, such as wrestling, tennis, football, basketball, and gymnastics, to daily activities, such as carrying laundry, turning a doorknob, and vacuuming, some degree of grip strength is necessary.

Reliable and valid evaluation of hand strength can provide an objective index of upper body strength. The power grip is the result of forceful flexion of all the finger joints with maximum voluntary force that the subject is able to exert under normal biokinectic conditions, also influenced by the synergistic action of flexor and extensor muscles and the interplay of muscle is the key factor in the resulting grip. HGS also varies a function of developmental factors including, nutrition, exercise, and health.[6]

Without adequate grip and forearm strength, sportspersons, gymnastics, as well as gymnasium have the risk of developing lateral epicondylitis, otherwise known as tennis elbow. Often overlooked or taken for granted, the strength of one's grip plays a key role in injury prevention and overall strength development.[4,13]

According to German Sports Scientist Jurgen Weinick, "The characteristic structure of the hand is related to its function as a grasping tool." "Biomechanical measurements such as handgrip dynamometer also allow sports coaches to appreciate the bioenergetics and efficiency of sports movements; training can then aim to achieve a maximal energetic output with minimal expenditure of energy, avoiding at the same time possible fatigue and stress lesions in the locomotory system".[3]

This study was undertaken to determine and compare the HGS and handgrip endurance (HGE) in individuals performing gymnastics with those who are doing gymnasium, that is, weight training exercises. The HGS and HGE have been estimated in many different sports activity, but never a comparison is done among two physical activities. The study made an attempt of quantifying the HGS and HGE in normal non-exercising individuals and comparing it with the exercising individuals and to see how it correlates to physical performance.

A control group that was not performing any type of exercises was also taken for comparison.

Materials and Methods

Written informed consent was obtained from the participants and approval was obtained from institutional ethics committee. This study was undertaken on 25 men performing gymnasium, 25 men performing gymnastics, and another 25 men were taken who were the non-exercising healthy control group for comparison. The age group of the study was between 18 and 30 years; also among the exercising group those who were doing gymnastics or gymnasium for more than 6 months were included. To avoid the confounder of dominance of handedness, only right-handed subjects were included.

The individuals having medical, cardiovascular, or respiratory illnesses; having skeletal muscle disorders; those taking any medications or performing any other physical activity; and left handers were not a part of this study.

Anthropometric measurements included the following:

1. The height was recorded using a stadiometer to the nearest 0.1 cm.
2. The weight was measured by digital standing scales to the nearest 0.1 kg. The body mass index (BMI) was calculated (weight in kilograms divided by square of height in meters).
3. The hand span was measured in dominant hand from the tip of thumb to the tip of small finger with a measuring tape. The accuracy of the measurement was 0.5 cm.
4. The palm length was measured from the distal wrist crease up to the base of the middle finger.[17]
5. The hand length was measured from the distal wrist crease up to the tip of the middle finger.
6. The forearm circumference (FAC) was measured using a measuring tape 4 inches below the olecranon process.
7. The forearm skinfold thickness was measured using skin caliper at the same site as FAC.
   Forearm muscle area (FAMA) was then calculated using Heymsfield formula[8]:
   $FAMA = [FAC - (\pi \times SFT)^2]/4\pi - 10$ (For Men)
8. The HGS of dominant hand was measured using a standard adjustable handgrip dynamometer, at standing position with shoulder adducted and neutrally rotated and elbow in full extension, with maximum force at least for 6 s. After performing three trails, with a rest of 1 min and the best out of three was recorded. Results were recorded in kilograms and the reported precision of the device was 0.1 kg.
9. The HGE was measured by asking the subjects to sustain one-third maximum voluntary contraction as long as he could. Time was noted down in seconds.

Statistical Analysis

The data were expressed as mean and standard deviation. The differences between the three groups were tested using one-way analysis of variance followed by Tukey–Kramer multiple comparison tests. The correlation of HGS and HGE with the various parameters was done by Karl Pearson correlation coefficient, denoted by *r*. After calculating *r*, the test of significance was assessed using the correlation coefficient table of probability.

Result

Table 1 shows the anthropometric measurements and age of the three groups. As can be seen from the table that the three groups are comparable; however, the BMI was slightly more in the control group.

Table 2 clearly shows that the skinfold thickness is least in the gymnasium group. The FAC is found to be significantly higher in the gymnasium group. Also, the FAMA was higher in the same group. This reveals that the weight training results in muscular development.

The HGS and HGE were found to be significantly higher in the gymnasium group.

The three groups were also compared among themselves:

1. HGS: the comparison among the three groups revealed the HGS to be statistically significantly more in the gymnasium group.
2. HGE: the comparison among three groups revealed that the HGE is the least in the control group but same in the gymnasium and gymnastics groups.
3. The FAMA is statistically significantly higher in the gymnasium group, however, not much significant difference is among the control and gymnastic groups.
4. The FAC is maximum in the gymnasium group, revealing significant muscle mass in the group, and not much significant difference in the control and gymnastic groups.
5. Skinfold thickness is found to be least in the gymnasium group.

The study did not find any statistically significant difference in the hand measurements in the three groups [Table 3].

The study also attempted to find a correlation of HGS and HGE, with the study parameters:

1. We found a *positive* correlation of HGS and HGE with FAMA, which was the main aim of this study, to see the effect of muscular strength on HGS and HGE.
2. We also found a *negative* correlation of HGS and HGE with skinfold thickness and BMI. This shows that obesity is related to poor muscular strength.

The observations are also depicted in the form of scatter diagrams [Figures 1–4].

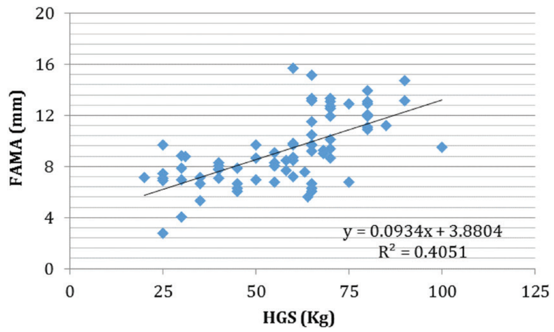

Figure 1: Scatter diagram showing correlation between handgrip strength (HGS) and forearm muscles area (FAMA).

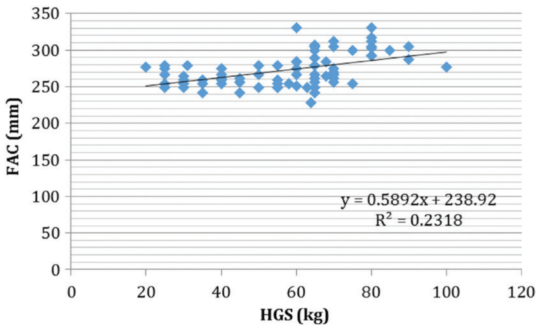

Figure 2: Scatter diagram showing handgrip strength (HGS) versus forearm circumference (FAC).

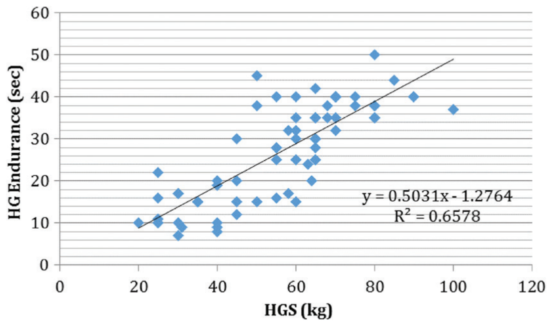

Figure 3: Scatter diagram showing handgrip strength (HGS) versus handgrip endurance (HGE).

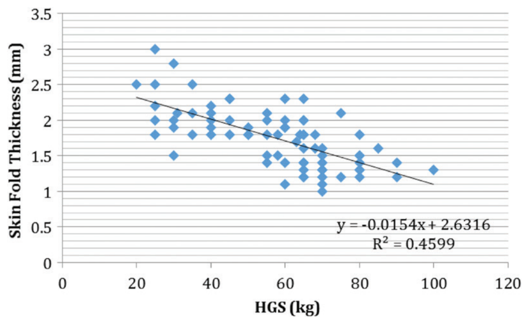

Figure 4: Scatter diagram showing handgrip strength (HGS) versus skinfold thickness.

Discussion

Thus, in summary, this work was carried out on two different exercising groups (gymnasium and gymnastics), which revealed statistically significantly more HGS in the gymnasium group, although the HGE was not statistically different among the two. In comparison, the controls or the non-exercising group had less HGS and HGE.

The FAMA and FAC were found to be highest in the gymnasium group, whereas the skinfold thickness was least.

The hand measurements did not reveal any statistical significant differences among the three groups.

The study found a positive correlation between HGS, HGE, and FAMA.

We also found a negative correlation of skinfold thickness and BMI with HGS and HGE.

However, the study did not come across any significant difference in the hand measurements among the groups.

The HGS appears to be related to an ensemble of masculine-specific characteristics and is believed in men as an indicator of selection during evolutionary history for overall physical strength.

The FAMA was found to be highest in gymnastic group. It could be attributed to the muscle strength, which is determined by muscle size. With routine training the muscle increase in size, the adaptations seen are, increase in the number of

Table 1: Descriptive statistics for study parameters

Parameter	Group					
	Gymnastic		Gymnasium		Control	
	Mean	SD	Mean	SD	Mean	SD
Age (years)	22.04	1.96	22.60	2.96	21.56	2.89
BMI	22.51	2.08	22.77	1.64	24.28	1.95
Hand length (cm)	20.12	0.89	20.42	0.91	20.12	0.82
PL (cm)	10.04	0.53	10.47	0.45	10.29	0.46
HS (cm)	27.76	37.09	21.61	1.13	21.18	0.68
FAC (mm)	261.62	14.07	299.82	18.57	259.49	10.92
Skinfold thickness (mm)	1.78	0.30	1.37	0.22	2.10	0.34
FAMA	8.25	1.32	12.35	1.70	7.08	1.46
Handgrip strength (kg)	61.12	7.18	74.72	9.89	35.96	9.99
Handgrip endurance (s)	32.32	6.92	36.48	6.04	13.80	4.22

BMI, body mass index; HS, Hand span; PL, Palm length; HS, Highly significant; NS Non significant FAC, forearm circumference; FAMA, forearm muscles area; SD, standard deviation.

Table 2: Comparison of different study parameters among three study groups

	One-way Analysis				
			Multiple comparison by Tukey's Test		
	F	*p*	Gymnastic vs control	Gymnasium vs control	Gymnastic vs gymnasium
BMI	6.33	0.0029	1.77 (0.005)	1.51 (0.019)	0.25 (1.000)
Hand length	1.01	0.3679, NS	0 (1.000)	0.30 (0.664)	0.30 (0.664)
PL	5.23	0.0079, HS	0.25 (0.196)	0.18 (0.548)	0.44 (0.006)
HS	0.74	0.4823, NS	6.57 (0.845)	0.42 (1.000)	6.15 (0.942)
FAC	58.37	<0.0001, HS	2.13 (1.000)	40.33 (<0.0001)	38.209 (<0.0001)
Skinfold thickness	39.68	<0.0001, HS	0.32 (0.001)	0.74 (<0.0001)	0.42 (<0.0001)
FAMA	85.00	<0.0001, HS	1.16 (0.023)	5.26 (<0.0001)	4.10 (<0.0001)
Handgrip strength	116.39	<0.0001, HS	25.16 (<0.0001)	38.76 (<0.0001)	13.6 (<0.0001)
Handgrip endurance	107.03	<0.0001, HS	18.52 (<0.001)	22.68 (<0.001)	4.16 (0.042)

BMI, body mass index; HS, Hand span; PL, Palm length; HS, Highly significant; NS Non significant; FAC, forearm circumference; FAMA, forearm muscles area.

Table 3: Correlation of forearm muscles area (FAMA), handgrip strength (HGS), and handgrip endurance (HGE) with the study parameters

	FAMA		HGS		HGE	
	r	*p*	*r*	*p*	*r*	*p*
BMI	–0.1621	0.1647	–0.3623	0.0014	–0.3774	0.0008
Hand length	0.1170	0.3176	0.1028	0.3802	0.0503	0.6681
PL	0.1274	0.2761	0.0830	0.4792	0.0130	0.9122
HS	–0.0383	0.7446	–0.0128	0.9129	–0.0291	0.8045
FAC	0.9186	<0.0001	0.4784	<0.0001	0.4517	<0.0001
Skinfold thickness	–0.8240	<0.0001	–0.6781	<0.0001	–0.5507	<0.0001
HGS	0.6365	<0.0001	—	—	—	—
HGE	0.5621	<0.0001	0.8110	<0.0001	—	—

BMI, body mass index; HS, Hand span; PL, Palm length; HS, Highly significant; NS Non significant FAC, forearm circumference.

contractile proteins (actin and myosin) in connective tissue with increase in enzymes and stored nutrients.[18]

Muscle strength is the ability to exert a maximal amount of force for a short period, and muscle endurance is the ability to do something for an extended period. In the study, the endurance is also increased that is also directing toward efficiency of the muscle.

The loss of muscle mass is a contributor to many of age-related changes such as weight gain, back pain arthritis, osteoporosis, diabetes, and even heart attack.

Weight lifting is known to prevent muscle loss that is associated with aging. Increase in the muscle tissue also results in increase in metabolic rate, decrease in fat percentage, decrease in heart rate, decrease in cholesterol and lung function in addition to increase in the flexibility and cardiovascular circulation exercise also improves individual's self confidence.

The studies carried out by Ravisankar et al.[10] revealed that HGS is a simple index of skeletal muscle mass and functional index of nutritional status. HGS is also influenced by personal effort and cardiorespiratory fitness. Poor performance and early fatigue (less HGE) are seen in chronically energy-deficient people also. HGS is less in underweight people. Study carried out by the author, where a comparison was made between BMI and HGS, revealed that the HGS is less in persons who are either underweight or overweight. These findings are similar to those of our study, as the present work also found a negative correlation of HGS and HGE with BMI.

The study carried out by Saha[14] revealed that the HGS was found to be more in people engaged in physical activity. In another study by Saha[15] revealed a positive correlation between grip strength and muscle girth% and skeletal muscle mass. The study by the author is also comparable with the present work because it is equivalent with the findings of our effort, wherein the HGS and HGE were more in the exercising groups in comparison to those who were not engaged in physical activity. Another similarity is positive correlation of the muscle mass with HGS and HGE as we also revealed the same in our work. Physical activity is often recommended as a strategy for maintaining active lifestyle; it should be an integral part of every one's life. Sedentary lifestyle itself is the most important health risk factor.

Regular physical activities help to develop and maintain skeletal health, endurance, flexibility and even bone health, and definitely decrease in diseases.[11]

The study carried out by Bonitch-Gongora et al.[6] found that the HGS and HGE are more in young judo athletes. This work is supportive of our work.

The study carried out by Nicolay and Walker[7] also concluded the correlation between BMI and HGS showing low HGS in underweight as well as overweight individuals. The work carried out by them has parallel findings as of our study, reflecting the importance and positive effect of physical fitness.

The study carried out by Koley and Yadav[12] also revealed that the HGS was more in cricketers and can be used indicator for the excellent performance in cricket as well as a useful selection criterion for this sport. This work also shows the implication of fitness on physique and goes hand in hand with our work.

HGS is a strong indicator of health status, based on the incidence of disability, morbidity, and mortality in adult population; elderly men with good HGS are on an average at a lesser risk for disability and joint impairment. It was also found that the mortality rate is also less in people with good HGS, as studies carried out by Rantanen et al.[9] The study by them could be of value in following up and performing a prospective study.

In a study carried out by Shah et al.[16] revealed that patients with chronic obstructive pulmonary disease (COPD) have significantly lower HGS, concluding that patients with COPD have reduced upper limb muscle strength and muscle endurance affected more than muscle strength. Thus, the study of Shah et al. is beneficial in captivating the importance of HGS not only in normal healthy individuals but also in disease-affected individuals. A similar study carried out by Cetinus et al.[3] found HGS in patients with type 2 diabetes and concluded that the patients with diabetes have lesser HGS. These studies have captured the significance of HGS in the disease conditions also, which further enhances the utility of HGS in evaluating the muscle power.

Thus, the study has effectively narrated the importance of estimation of HGS and HGE, which is a simple and reliable method to determine the muscle strength. The HGS and HGE can be useful predictors of muscular weakness in healthy, sports personnel, as well as diseased individuals. Also, it can measure the improvement and future of the performance (when done on regular basis). In addition, it can also foretell the success of training program, and improvement by itself is a strong motivator of the participant.

However, the handgrip dynamometer used in the study gives an overall idea of the muscular strength of upper extremity, more sophisticated instruments such as pinch dynamometer that provides information about individual muscles can make the study more superior. Moreover, the work was limited to healthy exercising and non-exercising participants, which limited our findings. Further studies should be conducted on various clinical disease conditions (diabetes, nerve injuries), which would also be beneficial in practical application of handgrip dynamometers in clinics.

Additional potential studies can also be planned to see the HGS and HGE in various sport activities as well as to further correlate HGS, overall strength, and overtraining or fatigue status.

Conclusion

We conclude that exercises must be incorporated as an important part of life. Since HGS is a simple maneuver to determine the upper body strength, coaches should include conditioning programs for both maximal isometric HGS and the ability to resist successive isometric contractions to maximize performance. Clinical application of handgrip dynamometer to evaluate the muscular strength in relevant patients should also be given a thought on.

In conclusion, the simple method of handgrip dynamometry has been found to reveal more than an individual's HGS. From nutritional status to physical functioning, this method of assessment can provide a cost-effective, noninvasive screening tool to evaluate well-being and competence.

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