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Gender Difference in Hand Grip Strength and Electromyogram (EMG) Changes in Upper Limb.

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ABSTRACT

Hand grip strength is a reliable measurement when standardized methods and calibrated equipment are used. Testing the grip strength is a useful screening tool in managing chronic wrist pain. Grip strength is related to and predictive of other health conditions. An electromyogram (EMG) is a test that is used to record the electrical activity of muscles. When muscles are active, they produce an electrical current. This current is usually proportional to the level of the muscle activity. In this study we attempted to see whether there are any gender differences in hand grip strength and EMG in upper limb. Hand grip strength and EMG were recorded with the help of Grip Force Transducer and surface EMG electrodes. The Maximum Voluntary Contraction (MVC) task consisted of a gradual increase in force from zero to maximum over 3 s, with the maximal force held for 2–3 s. Mean of three trials of grip strength for right hand was calculated. Subjects performed sustained submaximal contractions of handgrip at two different intensities: 30%, and 75% of the pretrial MVC. EMG was sampled in 1-s epochs every 15 s during the contractions and the integrated EMG (IEMG) values were normalized to that of the pretrial MVC by taking the ratios of IEMG at submaximal intensities to that of pretrial MVC. The resultant ratios were expressed in percentage. There was a significant difference in hand grip strength with males (367.97±80.51N) having greater values than females (174.24±55.36N) p<0.05. But women performed consistently longer than men at each of the two intensities [woman vs men; 174.51±82.93 vs157.43±80.31 s for 30% MVC p>0.05 and 50.79±24.33 vs 38.86±11.63s for 75% MVC p<0.05]. Females had greater IEMG (51.65±24.13% at 30% MVC and 92.17±26.44% at 75% MVC) than males (40.00±16.77% at 30% MVC and 71.30±26.89% at 75% MVC) p<0.05. We conclude that males have greater hand grip strength but females have longer time to fatigue and higher IEMG during sustained submaximal contractions owing to the differences in blood supply to the muscle, in type of fibres that constitute the muscle, the central drive and the proportionality of IEMG to the intensity of effort which influences the endurance.

Keywords: Hand Grip Strength, Maximum voluntary contraction, Electromyogram, Time to fatigue.

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INTRODUCTION

Muscular strength can be measured by non-motorized dynamometry (e.g., handgrip dynamometer), motorized dynamometry, or with free weights or exercise machines. Hand grip strength can be quantified by measuring the amount of static force that the hand can squeeze around a dynamometer. Hand grip strength is a reliable measurement when standardized methods and calibrated equipment are used, even with different assessors [1] or with different brands of dynamometers [2]. Testing the grip strength is a useful screening tool in managing chronic wrist pain [3]. Grip strength is related to and predictive of other health conditions, although the relationship is not stated to be causative [4, 5]. Normal hand grip strength is positively related to normal bone mineral density in postmenopausal women [6], with some researchers suggesting that grip strength be a screening tool for women at risk of osteoporosis [7]. Longitudinal studies suggest that poor grip strength is predictive of increased mortality from cardiovascular disease and from cancer in men, even when factors of muscle mass and body mass index are adjusted for [8, 9].

An electromyogram (EMG) is a test that is used to record the electrical activity of muscles. When muscles are active, they produce an electrical current. This current is usually proportional to the level of the muscle activity. An EMG is also referred to as a myogram. EMG can be recorded by two methods; 1) Intramuscular EMG where a needle is inserted through the skin into the muscle. The electrical activity is detected by this needle (which serves as an electrode). The activity is displayed visually on an oscilloscope and may also be detected audibly with a speaker. Since skeletal muscles are often large, several needle electrodes may need to be placed at various locations to obtain an informative EMG. After placement of the electrode(s), the patient may be asked to contract the muscle (for example, to bend the leg). 2) Surface EMG: It is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. The EMG signal generated by the muscle fibers is captured by the surface electrodes, then amplified and filtered by the sensor before being converted to a digital signal by the encoder. In our study we recorded muscle electrical activity by Surface EMG, as it is a non-invasive technique.

Surface electromyography is widely used in many applications, such as: Physical Rehabilitation (physical therapy/physiotherapy and orthopedics), Urology (treatment of incontinence), Biomechanics (sport training, motion analysis, and research), and Ergonomics (studies in the workplace, job risk analysis, product design and certification).

Published normative data for hand grip strength are available from many countries. Analysis of grip strength by gender shows higher grip by males at all ages, and analysis by age group demonstrates a peak of grip strength in the fourth decade and then a gradual decline in grip strength for both genders [10, 11]. This trend is always present even though some studies divide participants by age gender, and then by right and left hand, while a small number of studies divide participants by age gender and then dominant and non-dominant hand [11]. Even some of the Indian studies show that handgrip strength and endurance is significantly higher in males compared to females. But there are few previous studies which show that women either have similar or longer time to task failure (time to fatigue) compared to strength matched men [12, 13]. Endurance time during sustained submaximal isometric handgrip exercise is dependent up on the intensity of the effort. This intensity of effort in turn depends on the IEMG [14]. In India most of the studies compare the absolute hand grip strength and time to fatigue, but EMG changes in response to sustained hand grip strength have not been studied [15, 16]. That’s why in this study we attempted to see whether there are any gender differences in hand grip strength and EMG in upper limb.

METHODS

This was a cross sectional observational study which included 30 male and 30 female healthy medical students with age (mean ±SD) 18.73±1.08 years and 18.58±0.73 years respectively as subjects. The study protocol was approved by the Institute’s Ethical Committee and each subject signed an informed consent statement prior to participation and could withdraw without prejudice at any time. Subjects with any joint problems of hand, wrist and elbow, history of fracture, neurological condition, and any deformities of upper limb were excluded from the study. Clinical examinations were conducted to rule out any systemic illness.

Body Mass Index (BMI) in Kg/m^2, forearm circumference of dominant hand in cm, blood pressure in mm of Hg and Heart rate in beats per minute were recorded in all subjects.

Hand grip strength and Electromyogram were recorded with the help of Grip Force Transducer and EMG electrodes by using Power lab 8/30 series with dual bioamplifier (AD Instruments Australia, model No. ML870). Hand grip strength of dominant hand was measured using a computerized Hand Dynamometer with participants seated with their elbow by their side, flexed to right angle and a neutral wrist position.

The Maximum Voluntary Contraction (MVC) task consisted of a gradual increase in force from zero to maximum over 3 s, with the maximal force held for 2–3 s. Mean of three trials of grip strength for right hand was calculated. Subjects performed sustained submaximal contractions of handgrip at two different intensities: 30%, and 75% of the pretrial MVC.

For the recording of EMG, silver chloride (AgCl) surface electrodes were placed, 3 cm distal to the cubital fossa, over the flexor digitorum profundus. EMG was sampled in 1-s epochs every 15 s during the contractions and the integrated EMG (IEMG) values were normalized to that of the pretrial MVC by taking the ratios of IEMG at submaximal intensities to that of pretrial MVC. The resultant ratios were expressed in percentage [14].

Statistics

Descriptive statistical analysis has been used in the present study. Results on continuous measurements were expressed as Mean±SD (Min-Max). Significance was assessed at 5 % level of significance. Student't' test (two tailed, independent) was used to find the significance of study parameters between two groups.

Statistical software

The Statistical software namely SPSS 17.0, was used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

There was no significant difference in mean BMI between males and females P>0.05. There was a statistically significant difference in forearm circumference between males and females P<0.05. (Table 1)

There was a significant difference in hand grip strength with males (367.97±80.51N) having greater values than females (174.24±55.36N) p<0.05. (Table 2)

Table 1: Comparison of study characteristics between two groups

STUDY CHARACTERISTICS	MALES	FEMALES	P VALUE
Number	**30**	**30**	
Age in years	18.73±1.08	18.58±0.73	>0.05
Forearm circumference in cm	22.06±1.91	18.82±1.73	<0.05
BMI (kg/m^2)	21.25±3.08	21.24±3.76	>0.05

Values are Mean±SD (Min-Max). BMI: Body Mass Index in kg/m^2

Table 2: Comparison of Hand Grip Strength, Time to fatigue and IEMG

STUDY CHARACTERISTICS	MALES	FEMALES	P VALUE
Hand Grip Strength (MVC in N)	367.97±80.51	174.24±55.36	<0.05
Time to fatigue in seconds at 30% of MVC	157.43±80.31	174.51±82.93	>0.05
Time to fatigue in seconds at 75% of MVC	38.86±11.63	50.79±24.33	<0.05
Normalized IEMG in percentage at 30% of MVC	40.00±16.77	51.65±24.13	<0.05
Normalized IEMG in percentage at 75% of MVC	71.30±26.89	92.17±26.44	<0.05

Values are Mean±SD (Min-Max). MVC: Maximum Voluntary Contraction, IEMG: Integrated Electromyogram.

But women performed consistently longer than men at each of the two intensities [woman vs men; 174.51±82.93 vs157.43±80.31 s for 30% MVC p>0.05 and 50.79±24.33 vs 38.86±11.63s for 75% MVC p<0.05]. The results were statistically significant for 75% MVC. (Table 2)

Females had greater IEMG (51.65±24.13% at 30% MVC and 92.17±26.44% at 75% MVC) than males (40.00±16.77% at 30% MVC and 71.30±26.89% at 75% MVC) p<0.05. (Table 2)

DISCUSSION

As reflected in this study males have significantly higher hand grip strength than females. This is in accordance to previous studies [10-15]. This finding can be explained by the following reasons:

- Increased bone mineral density in males when compared to females.
- Increased muscle mass in males when compared to females

In our study we found that time to fatigue in females during sustained submaximal contraction at 30% of MVC was higher than males but the values were statistically insignificant. On the other hand at 75% of MVC there were statistically significant higher values in females.

These findings are similar to the previous studies involving both sustained and intermittent submaximal contractions [12, 14].

The difference in time to fatigue favouring easy fatigability in males when compared to females contributes to the accumulating evidence that women can sustain continuous, as well as intermittent, muscle contractions at low to moderate intensities better than men [12, 17&18]. There are many possible causes for this phenomenon and, broadly, they can be summarized as:

Differences in blood supply to the working muscles

The possibility that has received most attention concerns the fact that during a contraction the blood supply to the working muscle will be occluded to some degree, and the extent of this will depend on the forces developed within the muscle [19, 20]. Thus stronger men experience greater occlusion of blood flow during the more forceful contractions, leading to a greater accumulation of metabolites, less oxygen supply, and briefer contractions.

Differences in the composition and fatigue characteristics of the fibres making up the muscle

Compared with type II fibres, type I fibres have a slower speed of contraction and consequently a slower rate of energy utilization because of which the two types of fibres fatigue at different rates, and this can be seen in the fatigue characteristics of human muscle [21]. The logic of this argument is that female muscle should contain more type I slow fibres than male muscle. The available evidence tends to show a larger percentage (5%) of type I fibres in premenopausal women than men [22, 23].

Differences in motivation and the ability to sustain central drive [12, 17, 18].

In our study at the endurance limit, IEMG was greatest in the 75% of MVC in both males and females. When compared between males and females, the IEMG was greater in females at both 30% and 75% of MVC. Our findings are similar to studies done abroad [14]. The increase in IEMG is proportional to the intensity of effort. The time to fatigue depends on this intensity of effort.

CONCLUSION

In conclusion, we can confirm that though males have greater hand grip strength, females have longer time to fatigue and higher IEMG during sustained submaximal contractions. Intrinsic sex related differences in skeletal muscle properties, such as contractile speed and rate of energy utilization, probably play a key role in the sex-related differences in fatigue. These findings can be evaluated by doing further studies on larger sample sizes, as there are no studies involving IEMG available in the literature on Indian population. Grip strength and relative endurance may both contribute to the risk of work-related accidents and cumulative musculoskeletal injury.

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