EFFECT OF TEST (BODY) POSITIONS ON ELBOW FLEXOR MUSCLE STRENGTH AMONG HEALTHY SUBJECTS

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ABSTRACT

Background: Strength is a muscle‘s capacity to exert maximal effort or resist maximal opposing force. Muscle strength has been a subject of measurement for many investigators including physiotherapists with diverse techniques employed. The primary aim of this study was to find the relationship between test positions (trunk position) and the elbow flexor muscle strength. *Methods:* A total of 300 subjects (males=195, females=105) voluntarily participated in the study. The elbow flexor muscle strength was measured using cable tensiometre while the comfort level perceived in each position was evaluated using the modified Borg scale. *Results:* The result revealed that subjects had a significantly greater ($p<0.001$) elbow flexor strength when the trunk-hip angle position was 120^0 in both adult male and female subjects. Significantly positive association ($r = 0.87$, $p = 0.01$) was found between the muscle strength produced and the comfort intensity level perceived at different body position. *Conclusion:* The major finding of the study indicated relationship exists between elbow flexor muscle strength and different test (body) positions. It also exists between elbow flexor muscle strength and the perceived comfort level at different test positions. The findings are valuable in evaluation and rehabilitation training of arm/fore-arm injured athletes or patients. It is recommended that during muscle strength testing or strengthening programme, significant consideration should be given to the test (body) position and the degree of comfort derived by the subject or patient.

Keywords: Muscle strength, elbow flexor, comfort intensity level, test positions, rehabilitation.

INTRODUCTION

Muscular strength (force) has been a subject of measurement for many investigators including physiotherapists with diverse techniques employed. Muscular strength is one of the essential components of synchronized human movement (Smith, 1976). Benders and Kaplan (1968) defined muscular strength as the force exerted by a muscle or a muscle group at a point which may be at the extreme of any position within the range of motion. Strength is a muscle‘s capacity to exert maximal effort or resist maximal opposing force (De, Sengupta, Maity, Pal, and Dhara, 2011). It is also the capacity of a muscle or muscle group to produce tension necessary for maintaining posture, initiating movement, or controlling movement during condition of loading on the musculo-skeletal system (Smidt and Roger, 1982).

Various factors have been said to contribute to the determination of muscular strength. Round, Honour, Jones, and Neril (1996), Morehouse and Miller (1971), Astrand (1970), Jensen and Schultz (1970) concluded that muscular strength is related to person’s sex and age. Also, Brunnstrom (1976), Walmsley and Swann (1976) reported that the initial length of a muscle is a dominant factor in determining the force available for contraction and tension developed. Body weight has been found to be good predictor of muscular strength (Olaogun and Ifesanya, 1997; Balogun and Onigbinde, 1991; Brookwater, 1950). Lamphier and Montoye (1976) found negative correlation between body fat and muscle strength. Garry and Mark (1982), Scruddler (1976), Moffroid, Whipple and Hokfost (1969) found that as the velocity of shortening increased, the muscular tension reduces. Merton (1956) found that the range of muscular contraction diminished with fatigue.

Test position of the body during exertion of muscular strength contributes to variation in muscular strength (Amell, Kumar, Narayan, and Gil, 2000; Smidt and Roger, 1982). Body position during assessment of muscle strength is one of the variables that must be controlled to ensure the validity and reliability of isokinetic dynamometer (Abdel-aziem, Mosaad, and Abdelraouf, 2013; Worrell, Perrin, and Denegar, 1989; Currier, 1977). Garry and Mark (1982) in their study recommended that consideration should be given to the test or body position during muscle testing or strengthening programmes.

Standardized grip strength testing procedures have been recommended to provide even greater objectivity of measurement. In a clinical setting, however, there are a number of reasons why it may be impossible to follow standardized testing procedures, such as patient’s inability to tolerate an upright position or the presence of contractures in upper extremity joints (Parvatikar and Mukkannavar, 2009). At the same time, it is important to carry out muscle testing or training in the position where maximum outcome would be obtained. Richards, Okon, Palmiter–Thomas, (1996) said alternative testing position may be useful, however, in identifying positions, which maximize biomechanical abilities and may assist in the design of environment and tools.

Many works have been done locally and international on muscular strength, however to the best of my knowledge most of the work done established how the various arthro-kinetic positions affect the muscle length and thus influence the tension generated. Also correlations between anthropometric measures and muscular strength were often sought. Furthermore most of these work focused on the lower limbs muscle / muscle groups. Since upper limbs muscle / muscle groups are also commonly rehabilitated when injured or pares, this study was designed to examine the effect of test (trunk) positions on upper limbs muscular strength, essentially the elbow flexor group. It was equally considered useful to conduct further study into other factor that could affect muscle strength. The primary aim of this study therefore was to find the relationship between test (trunk) positions and the elbow flexor muscle strength.

METHODS

A total of 300 subjects (males=195, females=105) voluntarily participated in the study. They were male and female students of Obafemi Awolowo University, Ile-Ife, Nigeria. There ages range from 16-30 years. Subjects signed informed consent forms after being provided with a brief description of the study. The present study was approved by the Human Ethical Committee of the institution, and the experiment was performed in accordance with the Helsinki Declaration. The exclusion criteria for this study included any previous history of upper extremity abnormalities, inflammatory joint diseases, neurological disorder or injury to upper limb and other health conditions.

The study was carried out at the gymnasium of the department of Medical Rehabilitation, Obafemi Awolowo University, OAU, Ile-Ife, Osun State Nigeria. The following instruments were used for the study: body weighing balance, standiometre, a tape measure, fore-arm cuff, goniometre, cable tensiometre, and a trunk adjustable couch.

Procedure

The aim and objectives were briefly explained; the procedure was explained and demonstrated to the subject prior to data collection. All the subjects reported themselves to be in good health. Majority of subjects were right hand dominant. Each subject's name, gender, and age were documented. Measurement of these indices: body weight and height, were taking in erect standing on a weighing balance and standiometre respectively.

Prior to the commencement of data collection, a practice trial was given to familiarize the subjects with the tensiometer. Before testing, the examiner demonstrated how to hold the handle of the tensiometer. The same instructions were given for each trial. For the actual test, each subject sat on a plinth and place their back on the adjustable part of the plinth. The arm was kept in alignment with themed-lateral side of the body (trunk), with a padded material placed under the arm. The elbow was kept at 55^o for all the subjects based on the recommendation from previous studies that maximum muscular strength is obtained when contraction (exertion) takes place in about 20% increased muscle length (stretch), from its resting position (Yang, Lee, Lee et al, 2014; Kendal and McCreary, 1983).

After the subject was positioned with the tensiometer, the examiner instructed the subject to "pull as hard as possible … harder … harder. Relax". The highest tensiometer reading was noted. The subjects were asked to relax and rest for 2 minutes before next pull to control for the effects of fatigue. With the dominant hand used, three trials were performed in each position. Mean of 3 trials were recorded for calculation purpose. The same procedure was carried out 4 times with the trunk-hip angle kept at 90^o, 120^o, 145^o and 180^o. The starting angle was randomized by balloting to distribute the possible effect of resultant fatigue (from successive contraction), in addition to the resting time.

The perceived comfort for each position was graded using comfort intensity level scale (A Modified Borg devised category rating scale- Borg, 1982). The scale ranges from 1-10 with the perceived comfort level increasing in that order.

Descriptive and inferential statistics were used for the analysis of the collected data using. The data analysis was done using Statistical Package for Social Sciences (SPSS version 16). Data were computed for the mean and standard deviation and also computed with single factor analysis of variance procedure (ANOVA) followed by use of the Newman Keul"s post hoc test. In addition, t-test was used to compare the effects between genders. In the above statistical analysis, a value equal to or less than 0.05 was considered evidence of statistically significant finding.

RESULTS

The sample contained 300subjects, male (n=195) and female (n=105) with ages ranging from 16-30 years with the mean age of 21.65 ±2.51 years. The height ranged from 1.52 – 1.92m, with the mean height of 1.6 ± 0.07m. The weight ranged from 40.0 – 84.0kg with the mean weight of 60.52± 7.89kg.

Comparison of the muscular strength obtained from the four (4) different test positions

Presented in table 1 and 2 were the results of analysis of variance ANOVA and post-hoc to compare the muscle strength of the subjects obtained at the different test positions. Significant difference was found. The result showed that a significant difference existed among values obtained at four test positions ($p<0.05$). The result of post hoc test (multiple comparisons) showed that both significant and non-significant difference existed for MS of different position pairing.

Table 1: ANOVA Comparison of the elbow flexor muscular strength at different test (trunk) positions (N=300)

Variable	*Test Positions,* TP TP1	TP2	TP3	TP4	F-value	P-value
Muscle strength (*M* ±SD)	*34.70* *±10.27*	*35.25* *±9.85*	24.55 ±8.06	24.54 ±9.20	123.90	0.0001

Level of significance = 0.05

Table 2: Post-Hoc Multiple Comparison of the elbow flexor muscle strength at different test positions

Test positions TP *TP -- TP*	Mean Difference	P value
1 -- 2	-0.55	0.20
1 -- 3	10.16	0.0001
1 -- 4	10.17	0.0001
2 -- 1	0.55	0.20
2 -- 3	10.70	0.0001
2 -- 4	10.17	1.00
3 -- 1	-10.16	0.0001
3 -- 2	-10.70	0.0001
3 -- 4	1.00E-02	1.00

4 -- 1	-10.17	0.001
4 -- 2	-10.71	0.001
4 -- 3	-1.00E-02	1.00

Level of significance = 0.05

Comparison of the comfort intensity level obtained from the four (4) different test positions

Presented in table 3 and 4 were the results of analysis of variance ANOVA and post-hoc to compare the comfort intensity level of the subject obtained at the different test positions. Significant difference was found. The result of post hoc test (multiple comparisons) showed that significant difference existed for comfort intensity level of different positions pairing.

Table 3: ANOVA Comparison of the comfort intensity level (CIL) at different test Positions (N = 300)

Variable	*Test Positions, TP*				F-value	P-value
	TP1	TP2	TP3	TP4		
Comfort Intensity Level CIL) (M ±SD)	*6.46 ±2.33*	*7.82 ±1.73*	5.59 ±1.76	6.05 ±2.39	123.90	0.0001

Level of significance = 0.05

Table 4: Post-hoc multiple comparison of the comfort intensity level at different test positions

Test positions TP TP -- TP	Mean Difference	P value
1 -- 2	-1.37	0.0001
1 -- 3	-0.87	0.0001
1 -- 4	2.12	0.0001
2 -- 1	1.37	0.0001
2 -- 3	2.23	0.0001
2 -- 4	3.49	0.0001
3 -- 1	-0.87	0.0001
3 -- 2	-2.23	0.0001
3 -- 4	1.25	0.0001
4 -- 1	-2.12	0.0001
4 -- 2	-3.49	0.0001
4 -- 3	-1.25	0.0001

Level of significance = 0.05

Relationship between muscular strength (MS) and the perceived comfort intensity (CIL)

The result of the Pearson moment correlation between Muscle Strength and Comfort Intensity Level of the subjects showed that there was a strong positive correlation between the MS and the CIL for the different test (body) positions ($r = 0.87$, $p < 0.01$).

Comparison of the muscular strength obtained from the four (4) different test positions between male and female subjects

Presented in table 5 is the result of t-test comparison between the variables of age, muscle strength, and comfort intensity level of male and female subjects. There was significant difference between the muscle strength of both male and female subjects, despite the lack of significant difference in age and comfort intensity levels.

Table 5: Comparison of muscle strength and comfort intensity level of male and female subjects

Variables	*Test Positions, TP*	*Subjects* *Male* (n=105)	*female(n=105)*	*t-value*	*p- value*
Age (Years)		21.55±2.22	20.85±2.41	2.32	0.22
Muscle Strength (KgF)	TP1	37.80±8.57	29.30±7.60	7.70	0.0001
	TP2	37.55±7.81	29.64±7.06	8.00	0.0001
	TP3	26.35±5.90	20.83±5.28	7.72	0.0001
	TP4	27.11±6.96	20.18±6.37	8.33	0.0001
Comfort Intensity Level	TP1	6.26±2.59	6.55±2.07	-0.93	0.36
	TP2	7.77±1.83	7.90±1.72	--0.49	0.62
	TP3	5.61±1.75	5.61±1.88	0.00	1.00
	TP4	4.29±2.26	4.49±2.55	-0.61	0.54

Level of significance = 0.05

DISCUSSION

The primary objective of this study was to find out the effect of test position (trunk) on elbow flexor muscular strength. The study also measured the perceived level of comfort in each position and the relationship this has with the elbow flexor muscle strength. Measurement of elbow flexor muscle strength is an important component of upper limb essential in muscle training, treatment and rehabilitation.

The finding showed a significant difference in the muscle strength values recorded at the different test (trunk) positions (trunk -.hip angles). Also there was a significant difference between the comfort intensity levels perceived at the different test positions. Furthermore, a strong positive correlation was found between the muscle strength and the comfort intensity level obtained at the different test positions (TP).

Smidt and Rogers in their study of factors contributing to the regulation and assessment of muscular strength found body position as a factor that influences muscle strength. Previous studies showed significant relationship between muscle length and the strength of the muscle. Most of the studies concluded that maximum muscle strength is obtained when muscle length is stretched by about 20% from its resting position before force exertion (Parvatikar and Mukkannavar, 2009; Brunnstrom, 1976; Walmsley and Swann, 1976). Varying the muscle length produced varying muscle strength or tension. However, in this present study, the muscle length was kept constant for all the subjects but only the trunk position (trunk -hip angle) was varied. This variation in the trunk-hip angle produced varying muscular strength. Also the level of comfort perceived varied with each position and the muscle strength testing. It may be suggested that the variation in strength obtained in the study was due to variation in the level of comfort perceived by the subject. The comfort – tension relationship showed that more force is generated when the comfort level is high. This finding supported the recommendation of Garry and Mark that consideration should be given to the test or body position during muscle testing or strengthening.

It is important to note that there was no significant difference in the level of comfort perceived by both male and female subjects, though significant difference existed in their elbow flexor muscle strength. Since no significant difference was found comparing the age of male subjects to the females, it then suggest that other factors such as anthropometric factors might be responsible for this significant difference in male and female muscle strength. Further study is needful to confirm this. Balogun, Akomolafe, Amusa (1991) in their study of grip strength attributed the differences in strength between the genders to their physical characteristics rather than to the biological differences.

According to the finding of this study, during general muscle testing/study, training or rehabilitation of the elbow flexor muscles, trunk position should be kept between 90^0 and 120^0, which happened to be the range of highest comfort which also produced the maximum elbow flexor muscular strength. However position of maximum comfort could be identified for individual client during elbow flexor muscle training or rehabilitation. This kind of alternative positions as been suggested in the study from rigid or standardized positions may be useful in identifying positions which maximize biomechanical abilities and may assist in the design of environments and tools. With this knowledge, an individualized treatment program can be designed to train the athlete or patient in the specific body positioning for upper extremity training, to provide the greatest efficiency and to minimize the incidence of overuse disorders.

The use of convenience sample limits the generalization of the results of this study to the population at large. Our study was limited to asymptomatic subjects as well as non-ambidextrous people. In our study majority of subjects were right-handed. These norms should be used with caution for left handed persons.

CONCLUSION AND RECOMMENDATION

The major finding of the study indicated relationship exists between elbow flexor muscle strength and different test (body) positions. It also exists between elbow flexor muscle strength and the perceived comfort level at different test positions. Test positions (body) affect the outcome of muscle testing or strengthening. It is vital that when measuring elbow muscle strength, one understands how changes in body position can result in altered elbow muscle strength. Hence the findings are valuable in evaluation and rehabilitation training of arm/fore-arm injured athletes or patients

It is recommended that during muscle strength testing or strengthening programme, significant consideration should be given to the test (body) position and the degree of comfort derived by the subject or patient. In view of this, treatment and / or training chair, plinth /couch should be made of adjustable part e.g. back rest.

Further study is recommended using other muscle group. Also further studies are needed to find out how individual variables such as ambidexterity, work characteristics and as well as anthropometric measurements of subjects can influence elbow flexor muscle strength.

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