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A COMPARATIVE ELECTROMYOGRAPHICAL INVESTIGATION OF TRICEPS BRACHII AND PECTORALIS MAJOR DURING FOUR DIFFERENT FREEHAND EXERCISES

AMRITASHISH BAGCHI
Lakshmibai National Institute of Physical Education, Gwalior, INDIA.
Email: *amritashishbagchi23@gmail.com*

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ABSTRACT

This study aimed to investigate the effects of different freehand exercises on the electromyographic (EMG) activity of Triceps Brachii (TB) and Pectoralis Major (PM) muscles. Ten healthy men (21.25 ± 2.09 years) performed 1 repetition of four different freehand exercises. The maximum voluntary contraction (MVC) was recorded with the help of biograph infinity software (EMG). Surface ElectroMyoGraphy (SEMG) was used for measuring muscle electrical activity that occurs during muscle contraction. The four different freehand exercises were vertical dips (VD), wider grip vertical dips (WGVD), back dips (BD) and diamond push-ups (DPU). The results of the study shows that in case of the muscles activation in Triceps Brachii, except diamond push-ups (DPU) all the other exercises reveals significant differences with the vertical dips (VD), suggesting that Vertical dips is more effective inactivating the primary mover (Triceps Brachii) as compare to wider grip vertical dips (WGVD) and back dips (BD). When it comes to Pectoralis Major Muscle activationwider grip vertical dips (WGVD) was foundto be more effective, as all the other exercises reveals significant differences with the wider grip vertical dips (WGVD).
Keywords: *Electromyography, muscle activation, freehand exercises, triceps brachii, pectoralis major.*

1. INTRODUCTION

The identification of each movement's peculiarities and its suitability to the training objectives is a task which demands the interaction of many fields of knowledge. A number of exercises can be adopted for the development of a given

Correspondence: Amritashish Bagchi, Research Scholar, Lakshmibai National Institute of Physical Education, Gwalior (M.P), INDIA, Tell: +917415318615, Email: amritashishbagchi23@gmail.com

muscular group; however, an exercise is usually more indicated for each specific situation. The use of machines or free weights may also interfere in the muscular recruitment, once free weight exercises require the control of the implement in three dimensions, which can generate greater activation of the stabilizer muscles (Ferreira, Büll, & Vitti, 2003a; Ferreira, Büll, & Vitti, 2003b; Rocha, Gentil, Oliveira, & Carmo, 2006). Muscle activity is one of the major factors associated with human body movements during sports, exercise, and survival in different daily life tasks (Ronald, Snarr, & Esco, 2013; Ali, Sundaraj, Ahmad, Ahamed, Islam, & Sundaraj 2014). The cause for evolution of different physiological responses is about the different shapes and densities of different muscles. In this very respect, the electromyographic measurements gain great importance (Türker, & Sözen, 2013). Electromyography used in many sports techniques nowadays. Electromyography (EMG) utilizes either surface electrodes that are placed over the muscle or finewire/needle electrodes placed into the muscle (Türker, & Sözen, 2013). In general, surface electromyography (sEMG) is used to measure the activity of superficial muscles and is an essential tool in biomechanical and biomedical assessments. Surface ElectroMyoGraphy (SEMG) is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. As the subject then moves the joint and contracts the muscles, the EMG unit detects the action potentials of the muscles and provides an electronic readout of the contraction intensity and duration. EMG is the most accurate way of detecting the presence and extent of muscle activity (Sousa, Bérzin, Silva, & Negrão-Filho, 2000; Floyd, 2012; Tibold, & Fuglevand, 2015). Triceps brachii is a muscle without whom biceps never looks better. Imagine a well-developed biceps muscles with triceps that never been worked out (Nazário-de-Rezende, Sousa, Haddad, de Oliveira, Medeiros, de Agostini, & Marocolo, 2012). Similarly, when we perform bench press pectoralis activates as the primary muscles with triceps brachii and anterior deltoid acting as secondary muscles. The role of these primary and secondary muscles can also be switch over depending upon the hand spacing while performing the bench press (Rodrigues, Büll, Dias, & Gonçalves, 2003).

The purpose of the study was to determine the effectiveness by comparing the four different freehand exercises with the EMG responses of the selected muscle groups (i.e. Triceps Brachii and Pectoralis Major).

2. METHODS AND MATERIALS

2.1 Subjects

Ten healthy volunteers (age = 21.25 ± 2.09 years, height = 1.71 ± .038 m, weight =69.65 ± 2.92 kg) from Lakshimibai National Institute of Physical Education

(Gwalior, M.P) were included in the study as subjects. Purposive sampling technique was used for the selection of those subjects. They were all experts in weight training, with a minimum of 1 year of practice with the selected exercises. Each participant provided informed consent prior to participation in any testing procedures. As part of the selection criteria, the participants were expected to perform 10 or more proper repetitions of each exercise.

2.2 Experimental Approach to the Problem

To compare the EMG response between different freehand techniques, subjects performed 1 repetition of 4 freehand techniques of the exercise, with surface electrodes positioned over the 2 muscle bellies (Triceps Brachii and Pectoralis Major). A familiarization session was carried out 1 week before testing. During this session, the set up for all the freehand exercises and the participant's technique for performing those exercises were designed. The four different freehand exercises were vertical dips (VD), wider grip vertical dips (WGVD), back dips (BD) and diamond push-ups (DPU). Surface Electro Myo Graphy (SEMG) is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. The SEMG signal generated by the muscle fibers is captured by the electrodes, then amplified and filtered by the sensor before being converted to a digital signal by the encoder. It is then sent to the computer to be processed, displayed and recorded by the Infiniti software. The MyoScan-Pro sensor's active range is from 20 to 500 Hz. It can record SEMG signals of up to 1600 microvolts (μV), RMS. A/D Converter (Encoder; ProComp Infiniti) has 2 channels (C and D) sampling at 256 samples per second.

2.3 Data Collection

The participants performed 1 repetition of four exercises one by one. Sufficient recovery time was provided to the participants after completing each exercise. As mentioned earlier that the exercise were of freehand in nature, body weight was used for the dips and diamond push-ups.

On the testing day, maximum muscle activation was recorded with the help of Biograph infinity version 5.0 (Electromyography Software). After shaving and applying the abrasive cream to the electrodes, the EMG electrodes were placed parallel to the muscle fiber on two locations (i.e. channel C for Triceps Brachii and channel D for Pectoralis Major). Raw EMG signals were recorded using a 15 foot optic fiber wire that is directly connected to A/C encoder. A 20 mega pixels extended video camera was synchronized with the EMG software (Biograph infinity version 5.0), to find out the maximum voluntary contractions

(MVCs) of the selected muscles at the time of performing the exercises. Myoscan-pro sensor with triode electrode was used.

2.4 Statistics Analysis

The descriptive statistics (mean, standard deviation, skewness, kurtosis etc.) and Shapiro-Wilk's test was used for testing the assumption of normality and to know the nature of data. All data are presented as mean with standard deviations. A repeated measure analysis of variance (ANOVA) was used to detect the mean differences between each four different freehand exercises. For this purpose Statistical Package for Social Science (SPSS) version 20.0 was used. The level of significance was set at 0.05.

3. RESULTS

Table 1: Descriptive statistics and test of normality

	Vertical dips		Wider grip vertical dips		Back dips		Diamond push ups	
	T.B	**P.M**	**T.B**	**P.M**	**T.B**	**P.M**	**T.B**	**P.M**
Mean	1053.6	654.5	845.8	937.0	721.5	434.9	829.0	618.6
Std. Error of Mean	61.25	39.35	60.96	83.36	33.63	44.62	53.25	48.08
Std. Deviation	193.7	124.4	192.77	263.6	106.37	141.1	168.4	152.0
Skewness	0.59	-0.20	1.17	1.32	-0.51	0.11	0.40	1.34
Std. Error of Skewness	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
Kurtosis	0.86	-0.52	2.12	1.64	.40	-1.65	-.37	2.14
Std. Error of Kurtosis	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33
Shapiro – Wilk (p-vaule)	0.92	0.59	0.22	0.14	0.67	0.37	0.83	0.15

As a guideline, a skewness value more than twice its standard error indicates a departure from symmetry. Since none of the variables skewness is greater than twice its standard error, hence all the variables are symmetrically distributed. Similarly, the value of kurtosis for the data to be normal of any of the variable is not more than twice its standard error of kurtosis hence none of the kurtosis values are significant. In other words the distribution of all the variables is meso-kurtic.

Further for testing the normality Shapiro-Wilks test was used. It compares the scores in the sample to a normally distributed set of scores with the same mean and standard deviation. If the test is non-significant (p>.05) it tells that the distribution of the sample is not significantly different from a normal distribution (i.e. it is probably normal) and vice-versa. Here from table 1 we can see that none of the variables p value is less than .05, hence the data is normally distributed.

Figure 1: Mean value of muscles activation (triceps brachii and pectoralis major) in four different freehand exercises

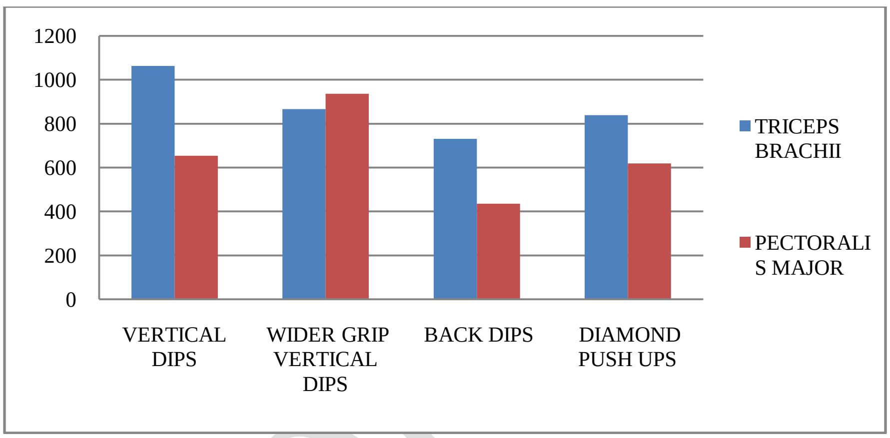

Figure 1 shows that in vertical dips the muscles activation of Triceps Brachii is more than the other three freehand exercises. And in case of back dips the EMG response of Triceps Brachii muscle is lower than the other three freehand exercises. Similarly, the Pectoralis major muscle shows higher muscle activation in wider grip vertical dips and lower muscle activation in case of back dips.

Table 2: Mauchly's test of Sphericity and corrections

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	Df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Triceps Brachii	0.31	8.98	5	0.11	0.56	0.68	0.33
Pectoralis Major	0.51	5.06	5	0.41	0.72	0.96	0.33

To test the equality of variances of the differences between the treatment levels, Mauchly's Test of Sphericity was used. Repeated measures ANOVAs (within-subject factors) are particularly susceptible to the violation of the assumption of sphericity, as violation causes the test to become too liberal (i.e., an increase in the Type I error rate). Therefore, determining whether sphericity has been violated is very vital. Mauchly's Test of Sphericity tests the null hypothesis that the variances of the differences are equal. Thus, if Mauchly's Test of Sphericity is statistically significant ($p<0.05$), we can reject the null hypothesis and accept the alternative hypothesis that the variances of the differences are not equal (i.e., sphericity has been violated). The results of Table 2 show that the assumption of sphericity has not been violated as mauchly's test was not significant.

Table 3: A summary of the within group repeated measure analysis of variance in the four different exercises with regards to muscles activation in pectoralis major and triceps brachii

Muscles	Groups	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Triceps Brachii	Sphericity Assumed	578013.47	3	192671.15	11.89	.000
	Sphericity Assumed	437525.77	27	16204.65		
Pectoralis Major	Sphericity Assumed	1291369.70	3	430456.56	19.50	.000
	Sphericity Assumed	596005.30	27	22074.27		

In the above table, for both the cases *p*-value is less than 0.05. Hence the *F*-ratio for Triceps Brachii and Pectoralis Major is significant at 5% level. In this case the null hypothesis is rejected; therefore at least one of the means will be different.

4. DISCUSSION

The repeated measure ANOVA table shows that statistical differences was observed when comparing the muscle activation or the EMG responses of Triceps Brachii and Pectoralis Major muscles with the 4 different freehand exercises. It means the EMG responses of the TB and PM muscles in various selected freehand exercises were not similar. Since ANOVA does not tell us where the difference lies; Bonferroni's post hoc test was used to get the clear picture. The result of Bonferroni's post hoc test shows that, in case of the muscles activation in Triceps Brachii, except diamond push-ups (DPU) all the other exercises reveals significant differences with the vertical dips (VD).This difference is may be due to the nature of exercise as the back dips and diamond push – ups are closed chain exercises whereas vertical dips and wider grip vertical dips are open chain exercises. In back dips and diamond push-ups the body weight is distributed to four points and in case of vertical dips and wider grip vertical dips the whole body weight is only on two points that increases the load. When it comes to pectoralis major muscle activation all the exercises reveals significant differences with the wider grip vertical dips (WGVD). With respect to variation in hand spacing, it has been noted that a wider grip requires more activity in pectoralis major muscles while a narrow grip activates the triceps brachii (Barnett, Kippers, & Turner, 1995). Vertical dips (VD) also show significant differences with back dips (BD). Again it may due to the nature of exercise as the wider grip vertical dips and vertical dips are almost similar except the width of the bar.

5. CONCLUSIONS

This study compared the muscle activity of triceps brachii and pectoralis major between four different freehand exercises. Vertical dips (VD) produced the maximum voluntary contraction and maximum muscles activation in triceps brachiias compared to other three exercises. Except diamond push-ups (DPU) all the other exercises reveals significant differences with the vertical dips (VD), suggesting that Vertical dips is more effective in activating the primary mover (Triceps Brachii) as compare to wider grip vertical dips (WGVD) and back dips (BD) Similarly, wider grip vertical dips (WGVD) produced a greater level of muscle activity in pectoralis majoras compared to other three exercises. Here significant differences were found suggesting that by increasing the width in vertical dips the muscles activation in pectoralis major get enhanced and it acts as a primary mover while performing the wider grip vertical dips.

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