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Original Research

Investigation of Deltoid Muscle Activation From Different Angles in Body Building Athletes

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ABSTRACT

Objectives: It is known that bodybuilders suffer from shoulder injuries frequently. Therefore, it is important to determine the most appropriate form of movement during shoulder exercises. For this reason, this study was carried out to determine the most accurate form of movement by examining the deltoid muscle activation of bodybuilders from different angles.

Methods: The survey model, one of the quantitative research techniques, was used in this study. 53 athletes (44 men, 9 women) with an age of 25.77±9.13 years, height of 177.07±8.40 cm, body weight of 78.06±14.16 kg, and body mass index of 24.78±3.43 kg/m^2 who regularly attended bodybuilding gyms were included in the study. The deltoid activations of the participants was measured, while the glenohumeral joint is at 90°, the cubital joint is in abduction at 180°, 150° and 120°. surface electromyography (sEMG) biofeedback was determined using the Neurotrac Myoplus Pro device. Joint angles were determined with a goniometer. Statistical analyses of the study were performed using the SPSS 25 package program. It was found that the data were normally distributed and the Repeated measures Anova test was applied for comparisons.

Results: As a result of statistical analysis, in male participants, mean deltoid sEMG values and maximum voluntary contraction (MVC [%]) significantly decreased with decreasing angle size ($p<0.05$). In female participants, the average sEMG and MVC (%) values did not change at different angles ($p>0.05$).

Conclusion: According to the research results, shoulder sEMG activations decrease in direct proportion to the angle in bodybuilders. When the glenohumeral joint is 90° and the cubital joint is 180°, the activation of the medial deltoid muscle is highest. It is suggested that bodybuilders should consider the results of our study when performing exercises to hypertrophy the deltoid muscle.

Keywords: Body building, deltoid muscle, electromyography, muscle activation.

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Bodybuilding; It is a branch of sport that generates strength by increasing muscle volume, with and without tools, within a specific training schedule.[1] The popularity of bodybuilding has increased in recent years. It has been reported to have positive sociological effects on individuals in addition to its physiological and physical contribution.[2] However, if this sport is not accompanied by a professional trainer, it can lead to deterioration and loss of function of the human body.[3] Shoulder injuries are one of them.[4] For this reason, exercises for the muscles that

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affect the general biomechanics of the body, such as the deltoid muscle, which allows the movement of the shoulder joint in many planes and axes, should be carefully selected.

When studying the biomechanics of the shoulder, it is seen that the deltoid muscle allows anatomical movements in different planes and axes.[5] The deltoid muscle is the muscle that originates from the spina scapula and extends to the humerus, controlling the abduction of the shoulder and aiding in flexion and extension of the shoulder. This muscle is the broadest muscle of the shoulder and consists of three parts, the anterior, middle, and posterior deltoids.[6,7] The deltoid muscle closes the proximal part of the humerus and is attached to the lateral side of the humerus with a thick tendon.[8] Since its strongest part is the middle deltoid muscle, it acts as an agonist during shoulder abduction.[9] However for the full activation of the deltoid muscle, the glenohumeral joint and the cubital joint must be kept in the correct form. Bunun için farklı çalışmalarda farklı sonuçlar elde edilmiştir.

In the study conducted by Muething et al.,[10] comparing the surface electromyography (sEMG) results of individuals with a previous deltoid muscle injury and healthy individuals, it was found that anterior deltoid activation was significantly lower in individuals with a deltoid muscle injury.

In reviewing the literature, it was found that sEMG activation of many movements has been studied to produce a maximal hypertrophic response during concentric or eccentric exercises for bodybuilding athletes. However, we did not find any studies on the position of the forearm during activation of the deltoid muscle. Therefore, the aim of this study is to examine the activation of the deltoid muscle during shoulder abduction, the glenohumeral joint in the lateral plane and at 90°, and the cubital joint at 180°, 150°, and 120° of extension.

Methods

Sample

In the study conducted by Coratella et al.,[11] deltoid muscle activation in the Lateral Raise movement was examined in different grip styles and 10 competitive bodybuilders participated in this research. When type I error (α) was analyzed as 0.05 and power (1-β) as 0.80 and Actual power as 0.813 and effect size as 0.7 in the power analysis conducted to determine the research sample, it was determined that at least 8 participants should participate in the research for each group (male, female).[12] In this regard, bodybuilding athletes who (a) regularly (at least 2 days/week) attend a bodybuilding gym and (b) voluntarily participate in the study were included in our study. Participants who (a) a cardiovascular problem, (b) a chronic respiratory problem, (c) shoulder joint surgery, (d) spine surgery, (e) acute shoulder pain, (f) an active infection, (h) steroids excluded from the study. Participants using similar performance-enhancing drugs were not included. Participants who (a) had shoulder pain, (b) could not fully follow instructions, and (c) had a body mass index greater than 30 were excluded from the study. In this regard, participants with active infection (1) and shoulder pain with exercise (2) were not included in the study. Thus, 53 bodybuilding athletes (44 men, 9 women) aged 16–51 years participated in our study. Demographic information of the participants is given in Table 1.

Table 1. Descriptive ınformation of participants

Parameters	Men (n=44) $\bar{X}$±SD	Women (n=9) $\bar{X}$±SD
Age (year)	23.88±7.88	35.00±9.66
Height (cm)	179.34±6.54	166.00±7.87
Wight (kg)	80.53±12.74	66.00±15.29
BMI (kg/m^2)	24.97±3.14	23.87±4.71
Sport age (year)	2.20±1.06	1.66±0.1.00
Cardio training time (sec)	1.34±0.52	3.22±1.30
Weekly exercise time (day)	4.79±0.90	3.88±1.90
1-RM	11.67±3.61	5.83±1.76

1-RM: 1 Repeat maximum; BMI: Body mass index.

Data Collection

Several methods are used to determine muscle activation.[13] One of these is needle EMG. Because needle EMG is both a costly and invasive procedure, it may not be preferred for use in athletes.[14] In subsequent years, muscle activation has been evaluated in less time, at a lower cost, and on a larger scale with technologies such as sEMG.[15] Therefore, in our study, sEMG measurements were performed using a dual-channel Neuro Trac Myoplus Pro device (Verity Medical, UK). Before the evaluation, the joint range of motion (ROM) of all participants was evaluated. ROM values of all participants were within the normal limits. Shoulder impingement test was also performed. No pathological condition was detected in the test results.

After general demographic data were collected from all participants in the study, muscle activations were measured after 8 min of warm-up and 5 min of stretching. The sEMG device was connected to the computer and Neuro Trac ETS 4.00 software. The connection between the other devices and the computer was disconnected so that the connection between the device and the computer would not be interrupted. The graphical results of the measurements were displayed on the computer screen. sEMG activations were determined using self-adhesive silver chloride surface electrodes. The diameter of these electrodes was 3.2 cm. Before attaching the electrodes, the test surface was cleaned with alcohol, and hair was removed to reduce skin impedance.[16] The surface electrodes were placed parallel to the medial deltoid muscle and 1/3 proximal according to the SENIAM protocol.[17,18] Before participants' sEMG measurements, 1-repetition maximum values (1- RM) were determined according to the Brzycki formula (1- RM = (lifted weight/(1.0278–(0.0278 × number of repetitions)).[19] After participants' 1-RMs were determined, electrodes were placed at the designated sites. When the shoulder joint (art. humeri) is fully adducted, the elbow joint (art.cubiti) is at 180°, 150°, and 120°, while the weights are in their hands, they are asked to abduct the shoulder joint by 90° in the sagittal axis in the lateral plane.[20] During this movement, the hand was in pronation. The angles of the elbow joint were determined using a goniometer. Measurements were taken at all angles without removing the electrodes. Between each measurement, participants were allowed 1 min of rest. The device recorded the minimum, maximum, mean, standard deviation, percentage of maximum voluntary contraction (MVC), contraction initiation times, and relaxations of the participants. EMG activities were recorded as microvolts (μV) and percent (%).

Ethical Dimension of Research

For the research, the "Voluntary Consent Form" was signed by the participants. A "Voluntary Consent Form" was signed by the families of participants under the age of 18. The research was conducted within the framework of the rules set forth in the Declaration of Helsinki. The Ethics Committee of the Institute of Health Sciences approved the study under registration number 2022/163. Participants were informed about the tests that were to be performed as part of the study. Necessary explanations about the purpose and significance of the study were given to the participants.

Analysis of the Data

IBM SPSS (California, USA) package 25 was used for the statistical analysis of the study. Normality analysis of the data was determined using the values for kurtosis and skewness (+1.5/–1.5). It was found that the data were normally distributed. Paired Measures Anova test was performed to compare muscle activations from different angles. The Bonferroni test was applied to determine the effectiveness between variables. The Mauchly test was used for homogeneity of variances. The Greenhouse–Geisser verification was used to validate the variances. The effect size of the study was calculated according to Cohen's d formula 0.2 small, 0.5 medium, and 0.8 large effects were calculated.[21] The significance level in the study was set at 0.05.

Results

Looking at Fig. 1, we see that males at 180° (259.14±105.45 μV), 150° (232.95±88.07 μV), 120° (220.06±77.71 μV), and females at 180° (199.23±68.59 μV), 150° (208.47±83.95.) μV), sEMG mean values at 120° (180.36±49.20 μV) were examined. A significant difference was found between the sEMG mean values of males (p=0.001, F=10.751). Accordingly, it was observed that the average of activation decreased as the angle narrowed (180° >150° >120°). However, the women's sEMG mean values did not differ in various aspects (p=0.327, F=1.201).

When Fig. 2 is examined, it is seen that 180° (25.87±5.55%), 150° (25.53±4.43%), 120° (23.1±4.57%) in men and 180° (23.37±3.86%), 150° (22.90±3.02%) in women. and 120° (23.07±4.79%) were the mean MVC. A significant difference was found between the mean MVC (%) of males (p=0.018, F=4.219) Accordingly, it was observed that the average of activation decreased as the angle narrowed (180° >150° >120°). However, the mean MVC (%) of women did not differ in different aspects (p=0.945, F=0.057).

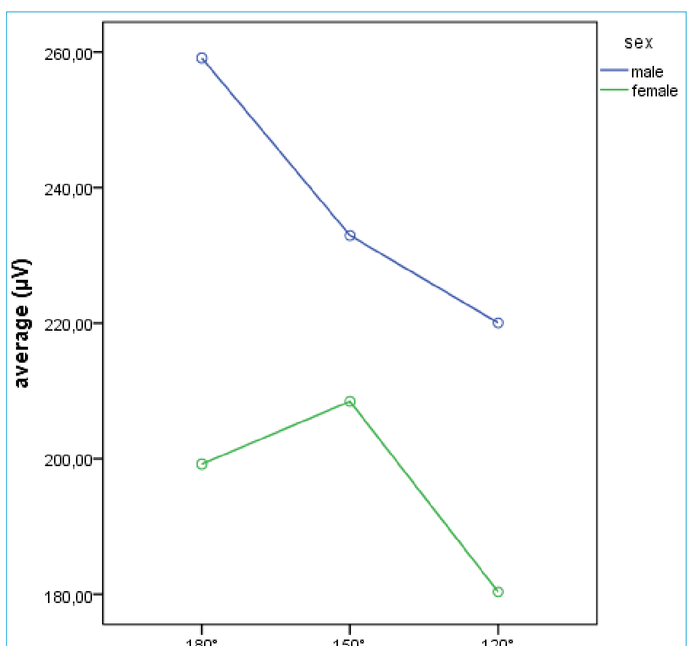

Figure 1. Comparison of surface electromyography means by gender.

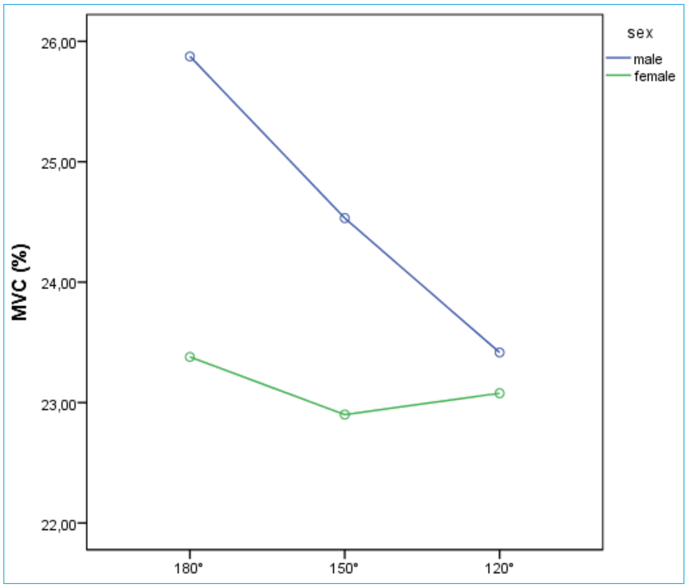

Figure 2. Comparison of maximum voluntary contraction (MVC) (%) percentages by gender.

Discussion

In this study, conducted to determine the activation of the deltoid muscle at 180°, 150°, and 120° in bodybuilders, the activation of the deltoid muscle was tested by abducting the shoulder joint to 90°.[22] According to the research results, it was found that the activation level of the medial deltoid muscle decreased as the angle of the elbow joint decreased. The activation of the medial deltoid muscle was highest when the cubital joint was 180°. While a statistically significant difference in sEMG values was found at all angles in male athletes, we did not find a significant difference in female athletes.

Bodybuilders are often expected to perform static contractions in addition to voluntary contractions. Although there is no strong evidence to support this, it is believed that elite bodybuilders can control the activation levels of their muscles and activate almost all of their muscles by moving the muscles together.[23] Muething et al.[10] found that athletes who had a previous shoulder injury had lower sEMG activations. Pope et al.[24] argued that the action potential and motor response of the hypertrophic response, which occurs in muscle length and strength, also increase. When the results of our research are evaluated together with the studies of Muething et al. and Pope et al. the muscle activation in the deltoid muscle, which varies according to the angle, can be related to muscle strength.[10, 24] In our study, the decrease in sEMG values due to the decrease in angle in the deltoid abduction of the athletes may be due to the absence of action potentials. This may be the cause of postural deformities in the upper glenohumeral joint[25] and shoulder injuries.[26]

Bodybuilding exercises involve continuous movements of the appendicular skeleton and musculature in various contractions and angles. Muscle weakness anywhere can lead to decreased endurance and joint injury.[27] For this reason, it is important to know the anatomical structure of the muscle and in which state it is more active, especially in sports such as bodybuilding where muscles are specifically developed.[28]

In the study of Cortella et al.,[11] which investigated EMG activity of shoulder abduction in elite bodybuilding athletes, the activation of the deltoid muscle was analyzed during different grip types (internal rotation, external rotation, flexion of the elbow joint, and extension of the elbow joint). The medial deltoid muscle showed lower activation when the elbow joint was flexed and higher when it was in full extension (180°). Therefore, they suggested that practitioners should select exercises according to the deltoid muscle they wish to activate. When evaluated in this context; the results of our research show similarities with the study of Cortella et al.[11]

In their study, Park et al.[29] investigated the activation of the deltoid muscle during shoulder abduction in athletes participating in active upper extremity sports and found that the activation of the posterior deltoid muscle was lower than that of the medial and anterior deltoids. Accordingly, they suggested that different eccentric muscle activity patterns may be required for shoulder joint stabilization. In our study, sEMG activation in male bodybuilders decreased with decreasing joint angle, whereas sEMG activation did not change in female athletes; this could be because female athletes include functional training methods in their training program in addition to eccentric and concentric exercises.

Study Limitations

This research was applied on amateur bodybuilders. There is a need for detailed research on competitive bodybuilders. Another limitation of our study is that the test was performed only in one plane and with the wrist in pronation. It is thought that there is a need for further research on different positions of the wrist. Although the results of the power analysis showed a sufficient number of female participants, it was difficult to reach the sample group of women who had done resistance exercises for a certain period. Therefore, there is a numerical difference between male and female participants.

Conclusion

According to the results of our investigation, during the abduction movement of the medial deltoid muscle, the highest angle of activation is such that the glenohumeral joint is a maximum of 90° parallel to the frontal plane and the cubital joint is 180°. According to the results of our study, it is recommended to investigate the reasons for the decrease in activation due to the narrowing of the elbow angle in people who practice bodybuilding sports on a long-term basis. At the same time, the results of our investigation will serve bodybuilders and trainers as a basis for exercises to develop the deltoid muscle.

Disclosures

Ethics Committee Approval: The study was approved by the Ethics Committee of Health Sciences of Bandirma Onyedi Eylul University (No: 2022/163, dated 16.11.2022).

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

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