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ORIGINAL ARTICLE

Difference in One-Repetition Maximum and Electromyography between the Dominant and Non-Dominant Arms and Their Relationship to Exercise Onset: An Experimental Study of the Biceps Brachii Muscle

[1]Ibtehal M. Alkhawaldeh*, [2]Moed Altarawneh

[1]Sports Training Department, Sport Sciences Faculty, Mutah University, ALKarak, Jordan. [2]Physical Education Department, Sport Sciences Faculty, Mutah University, ALKarak, Jordan.

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ABSTRACT

Background. The existence of differences between the two arms in terms of strength is considered an original and contemporary issue together, due to the different scientific opinions about the value of the difference, its determinants and causes, and the extent of the impact of the weight-bearing technique on it. **Objectives.** This study aimed to identify the difference in the One-Repetition Maximum (1RM) and Electromyography (EMG) between the dominant and non-dominant arms based on the arm used to start the exercise. **Methods.** The study sample consisted of 16 healthy male beginners in weightlifting and resistance sports with the following averages: (Age = 19.6 years, BMI = 21.65 kg/m2, Mass = 66.23 kg, and Muscle Mass = 21.46). Special tests were performed to determine the EMG and apply the (EPLEYS Equation) to calculate the 1RM and perform the exercise One Dumbbell - Single Arm Bicep Curl. **Results.** The study's results showed a difference in 1RM between the dominant and non-dominant arms regardless of which arm started the exercise, but there were no differences in EMG between the dominant and non-dominant arms. **Conclusion.** The study recommended accustoming individuals to use both arms and performing special harmonic exercises in the non-important arm to compensate for the difference in strength between both arms, due to the importance of muscular strength in our daily lives as one of the elements of physical fitness related to health.

KEYWORDS: ***One-Repetition Maximum, Electromyography, Dominant Arm, Non-dominant Arm.***

INTRODUCTION

The One-Repetition Maximum (1RM) is a measure of the intensity of weight and resistance exercises that indicates the maximum load that the muscle can carry with only one repetition, and thus it constitutes 100% of the muscle's ability to carry weight. Therefore, the intensity for weight and resistance exercises is calculated using 1RM or percentages thereof (1), So all sports training specialists, fitness trainers, and qualified athletes consider that 1RM is the most important reference that determines the amount of force issued by the muscle whether for professionals or beginners and must be noted that each exercise has its weights and 1RM resistances, and it is not a fixed number for all strength and resistance exercises performed by the player himself (2).

When using weights and resistance training programs, it is necessary to train both arms of the body, not just one, and this requires the coach to put weights for the player to carry using his two

*. Corresponding Author:
Ibtehal M Alkhawaldeh, Ph.D.
E-mail: dr.khawaldeh@mutah.edu.jo

arms, either together, such as the BENCH PRESS exercise, or training one arm, then another, as in as some dumbbell exercises, and here it is necessary to specify 1RM to know the intensity (weight) that the player must carry (3).

Some problems arise here, such as whether the two arms can carry the same weight or if they have the same 1RM. This is based on the concept of the dominant and non-dominant arms, which appear at the start of life and appear more in exercise and daily life activities. Whereas (4, 5) showed that the dominant arm is often stronger, more resistant to fatigue, and has higher angular velocities than the non-dominant one. This raises other questions for coaches, the most pressing of which is what weight the player trains with if the player's strength between the two arms differs. Does he continue to train both arms with a single 1RM or does he account for the difference in strength? What, if any, is the cause of this difference? Moreover, what is it worth to the two arms?

To answer these questions about muscular strength, it should be noted that muscular strength comes from two sources: muscles and nerves, whether in the dominant or non-dominant arm. Therefore, when studying the strength differences between the two arms, it was necessary to determine the extent of the nerve signal reaching each arm, especially since the produced force is very much dependent on the nerve signal reaching the muscles rather than the muscles themselves, (6). The nerve electrical signal connected to the muscles, which can be studied and analyzed using electromyography (EMG), provides answers about the nerve source of the force produced in the two arms. Thus, the coach or fitness trainer will have a better understanding of the strength readings in each arm and will be able to develop a training protocol for the player to achieve the desired goal of resistance and weight exercises (7).

The (EMG) examination is a technique that involves recording and analyzing the electrical signals that reach the muscular membrane via the motor nerves, and the responses formed by these signals within the muscle that result in the production of muscle contraction and the associated amount of force. Therefore, (EMG) is an important matter in the sports field, particularly when analyzing sports movements and strength training (8).

Studies, on the other hand, show that performing high-intensity exercises with weights and resistances causes a rapid response in the central nervous system and the peripheral nervous system from the cerebral cortex, through the spinal cord, to the peripheral motor nerves, implying that repetitive muscular work at high load intensity standards leads to a deficiency in the force generated during each iteration (9). This means that training at 1RM intensity causes central and peripheral nerve fatigue, particularly in the cerebral cortex, above the spinal cord, and in the spinal cord, limiting the possibility of repeating the load of 1RM more than once (10).

Whereas previous studies, such as Ames and Churchland (2019), revealed a 10% difference in 1RM between the dominant and non-dominant arm in the Bicep Curl exercise, The current study attempts to determine the percentage of the difference and link it to the amount of (EMG), which shows the amount of nerve signal connecting the muscles when contracting and thus attempts to explain the presence or absence of the difference by inferring the amount of (EMG) (11).

So, when attempting to connect ideas, another question appears here. Does performing an exercise with weights and resistances of 100% of 1 RM on one arm affect the strength of the other arm when performing the same exercise? Also, is it better to begin with the dominant arm to reduce strength differences between the two arms, or is it preferable to begin with the non-dominant arm to use all of the motor neuron capacity of this arm to compensate for the lack of strength that it has when compared to the dominant arm? From this arose the concept for this study, which was applied to the biceps brachii muscle, in which the player carries a weight equal to 1 RM with one arm and then repeats the load with the other arm using dumbbells, using the One Dumbbell - Single Arm Bicep Curl exercise from a sitting position. This is to determine if there are any differences in strength between the dominant and non-dominant arms, as well as to see if there are any differences in signal connected to each arm when performing the exercise.

So this study sought to detect the difference between the dominant and non-dominant arms when performing the One Dumbbell - Single Arm Bicep Curl exercise, using the arm used to start the exercise and in favor of the dominant one, It also aimed to detect the difference in EMG between the dominant and non-dominant arms when performing the One Dumbbell - Single Arm Bicep Curl exercise, using the arm used to start the exercise and in favor of the dominant one.

MATERIALS AND METHODS

Participants. The study sample consisted of 16 healthy males (New beginners) in weightlifting and resistance sports with the following averages: (Age = 19.67 years, BMI = 21.56 kg/m2, Mass = 66.23 kg, Muscle Mass = 21.46), and all respondents' dominant arm is their right arm. Also, when tested in the INBODY test, they all scored Normal in the Skeletal Muscle Mass (SMM) test.

All respondents were fully informed about the study procedures, and before they were subjected to all of the study tests, they were examined by specialized doctors to determine the extent of any health issues they had during all of the study tests and to demonstrate their complete safety. Table 1 depicts the homogeneity of the study sample members:

The table displays the mean and standard deviations of age, weight, Body Mass Index (BMI), and Skeletal Muscle Mass (SMM) measurements. By displaying the coefficient of variation values in the table's last column, it is clear that the largest value of this coefficient was (8.86%), which is related to the Body Mass Index (BMI) variable, as this value is the largest among the coefficients of different values, but it did not exceed the limit (50.0%). Thus, we can conclude from this data that the respondents are homogeneous in these measurements.

Table 1. The homogeneity of the respondents' age, weight, Body Mass Index (BMI), and Skeletal Muscle Mass (SMM) measurements.

Measurements	Mean	Standard Deviation	Coefficient of Variation
Body Mass Index (BMI) (kg/m^2)	21.65	1.91	8.86
Weight (kg)	66.23	0.04	2.41
Skeletal Muscle Mass (SMM)	21.46	0.89	4.15
Age (Year)	19.6	0.56	2.85

Study Protocol. To achieve the objectives of the study, its protocol included the following procedures:

1- Calculate the 1RM by Applying the EPLEYS Equation for both arms.

2- Test the right arm to confirm the 1RM given in the equation, and then test the left arm after 24 hours.

3- Conduct the 1RM experiment on the One Dumbbell - Single Arm Bicep Curl exercise, with the right (dominant) arm first, followed by the left (non-dominant) arm, with recording the EMG value of the working arm. Repeat the test after 48 hours, but this time start with the left arm (non-dominant) and then with the right arm (dominant) while recording the EMG value of the working arm.

1RM Calculate. The (EPLEYS Equation) was used to calculate the 1RM, which had previously been used in many previous studies, such as Reynolds et al. (2006), and the amount of 1RM obtained from the equation was then confirmed in a real weight-bearing experiment to ensure confirmation and validation of the value of 1RM for the study sample (2).

EPLEYS Equation =1RM = (WEIGHT LIFTED × REPS × 0.0333) + WEIGHT LIFTED

The equation was applied to both arms but at the same time and 1RM was calculated for each arm to ensure that the dominant and non-dominant arms did not affect the arm strength sequence.

Electromyography (EMG) test. After shaving the hair and cleaning the area with alcohol, the (ANR-M40) device was made in the USA used to ensure that no effect changes the reading of the sensors (Surface Electrodes), which were placed over the middle and the apex of the previously identified arm's biceps brachii muscle. The values displayed on the screen are then recorded after performing the One Dumbbell - Single Arm Bicep Cur test (8).

One Dumbbell - Single Arm Bicep Curl Exercise. The athlete stands shoulder-width apart, feet shoulder-width apart, and holds a 1RM weight with the test arm attached to the EMG electrodes. Then, with one repetition, he makes a bending movement of the elbow to bring the forearm closer to the hummers while keeping the chest straight and with no inward rotation of the shoulders.

Statistical Analysis. The raw data was processed through the statistical processors of the SPSS software version 27 at a $P \leq 0.05$, where the mean, standard deviation, and Coefficient of Variation were used to determine the homogeneity of the sample, A Paired t-test was also performed to determine the degree of differences in 1 RM and EMG between the dominant and non-dominant arms depending on whether the exercise started with the dominant or non-dominant arm in favor of the dominant one.

Ethical Considerations. The Scientific Research Ethics Committee at Mutah University obtained the ethical approval of the study, and all participants were briefed on the study's tests and presented to a specialist doctor to ensure that they were not affected by any of the study's tests.

RESULTS

The following are the study's results:

Table 2 shows the results of the T-Test used to compare the 1RM of the dominant and non-dominant arms when performing the One Dumbbell - Single Arm Bicep Curl exercise. By displaying the values of the level of significance calculated to compare the dominant arm with the non-dominant one when performing the exercise starting with the dominant arm, it was discovered that it amounted to (0.002), which is a statistically significant value as it is less than 0.05. When comparing the dominant and non-dominant arms when starting the exercise with the non-significant arm first, it reaches (0.000), which is a statistically significant value as it is less than 0.05. That is, whether the training started with the dominant or non-dominant arm, there is a statistically significant difference in the value of 1RM between the dominant and non-dominant arm in favor of the dominant one in all cases, indicating acceptance of the hypothesis.

Table 2. The T-Test to compare 1RM between dominant and non-dominant arms when performing the One Dumbbell - Single Arm Bicep Curl exercise with the dominant or non-dominant arm in favor of the dominant arm.

Exercise Start Arm	Preferred Arm	Arithmetic Mean	Standard Deviation	Difference of 2 Means	T Value	Significance Level	Result
Dominant	Right	5.10 kg	0.67	1.10	3.13	0.002	Significant Difference
	Left	4.00 kg	0.64				
Non-dominant	Right	5.09 kg	0.80	1.04	53.2	0.000	Significant Difference
	Left	4.05 kg	0.77				

Table 3 Shows T-Test results comparing EMG between dominant and non-dominant arms during the One Dumbbell - Single Arm Bicep Curl exercise. By displaying the values of the level of significance calculated to compare the dominant arm with the non-dominant one at the start of the exercise with the dominant arm, it was discovered that it amounted to (0.454), which is a non-statistically significant value as it is greater than 0.05. When comparing the dominant and non-dominant arms when starting the exercise with the non-significant arm first, it reaches (0.352), which is not statistically significant as it is less than 0.05. That is, regardless of whether the training began with the dominant or non-dominant arm, there is no statistically significant difference in EMG value between the dominant and non-dominant arms in favor of the dominant arm in all cases. This means rejecting the study's hypothesis and accepting the alternative hypothesis, which states that there is no statistically significant difference in EMG between the dominant and non-dominant arms when performing the One Dumbbell - Single Arm Bicep Curl exercise, whether starting with the dominant or non-dominant arm.

Table 3. The T-Test compares EMG between dominant and non-dominant arms during the One Dumbbell - Single Arm Bicep Curl exercise, whether starting with the dominant or non-dominant arm in favor of the dominant one.

Exercise Start Arm	Preferred Arm	Arithmetic Mean	Standard Deviation	Difference of 2 Means	T Value	Significance Level	Result
Dominant	Right	2.89 V	2.67	0.07	2.78	454.0	No Significant Difference
	Left	2.81 V	2.64				
Non-dominant	Right	2.87 V	1.80	0.05	2.51	0.352	No Significant Difference
	Left	2.82 V	1.77				

DISCUSSION

The current study attempted to find a weight-bearing technique based on the exercise's starting arm to reduce the difference in the force produced between the dominant and non-dominant arms. However, this did not appear in the study's results, which confirmed the existence of differences in

1RM between the dominant and non-dominant arms, favoring the dominant arm regardless of which arm started the exercise. This means that starting to carry the weight with a specific arm does not reflect the resultant force produced in each arm, nor does it work to eliminate the difference in 1RM. Where the dominant arm regained its strength as a result of repeated daily use, increasing the number of motor units responding to nervous commands within it at the same level as the neuromuscular signal connecting it or the non-dominant arm. In other words, because of the daily extra activation, the motor units responding to the same nerve command are greater in the dominant arm than in the non-dominant arm (12).

Despite the 1 RM difference between the two arms, there was no difference in the nerve signal connecting each arm. This means that the difference in strength when carrying the maximum possible weight is due to muscular rather than nerve causes, even though the source of nervous force equals 80% compared to 20% from a muscular source (13). The number of motor units affected by the nerve signal is one of these muscular reasons, as is the synergy and coordination of the work of the muscles supporting performance, as well as the inhibition of the work of opposing motor units, all of which are more efficient in the dominant arm than the non-dominant arm (14).

The dynamic distribution of force, on the other hand (the distribution of workforce over time) has been always more in the dominant arm, which has a greater ability to adjust the motor path to lift the weight. This indicates that the dominant arm outperforms the non-dominant one. The disruption of the motor path in the non-dominant arm definitively means the dispersion of some of the productive force distributed to the angles of the weight-bearing joints, which reduces the angular work torque in this non-dominant arm in the mobile muscle contraction, especially when the intensity of work is equal to 1 RM (15). This also implies that there are mechanical differences in load between the dominant and non-dominant arms, which affect peak performance strength.

In fact, and the fact that muscular strength arises from two sources, muscles, and nerves, and since the nerve signal connecting the muscles in both the dominant and non-dominant arms has no difference, we conclude that the difference in strength at its maximum level in the opposing muscles in the arms is due to the difference in strength from the muscular source, so this must be treated The imbalance in strength is muscular in origin through training programs aimed at reducing or eliminating the difference in the level of strength between the dominant hand and the non-dominant hand.

The results of this study agreed with the results of the study Krzysztofik et al. (2012). In terms of the existence of differences in strength and performance between the dominant and non-dominant sides of the body, noting that the study did not study the arms only (16).

The results of this study also agreed with the results of the study Jee and Park (2019), Where results of their study indicated that there were differences in the angles of the performance when approaching and distancing between the dominant and non-dominant parties (17).

CONCLUSION

In resistance exercises and weight bearing, the difference in the force produced by the dominant and non-dominant arms remains at 1RM intensity, regardless of which arm started with weight bearing. Furthermore, the difference in productive force is not due to neurological differences, but rather to muscular and mechanical differences, which increase the strength of the dominant arm more than the non-dominant one as a result of its frequent daily use. Therefore, it is preferable for individuals to become accustomed to using both arms or to perform special harmonic exercises in the unimportant arm to compensate for the difference in strength between the arms, as muscle strength is crucial in our daily lives and is one of the fitness elements related to health.

The study limitations are EPLEYS Equation, (ANR-M40) device, One Dumbbell - Single Arm Bicep Curl Exercise, study sample.

APPLICABLE REMARKS

- It necessitates that trainers develop training programs that compensate for the lack of strength based on synergy and muscular compatibility to reduce the difference in muscle strength between the arms.

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AUTHORS' CONTRIBUTIONS

The idea, protocol, study design, and funding: Ibtehal M. Alkhawaledh. Applying the study, collecting theoretical literature, data analysis, and discussing the results; Ibtehal M. Alkhawaledh and Moed Altarawneh.

CONFLICT OF INTEREST

There is no conflict of interest for any of the parties in this study.

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