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The Impact of Leg Width on Muscle Activation and Performance during Push-Up Exercise

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Abstract Push-up is an effective bodyweight exercise that can help improve the muscular endurance and strength of the upper limb muscles from health risks. Additionally, there are many ways to perform push-up, and it might cause several changes to its effectiveness. This includes changing the leg conditions such as legs open wide, legs open to shoulder-width, and narrow legs. The study aimed to investigate the effect of leg width during push-ups on muscle activity and performance. A total of 30 trained men (22.36 ± 2.17 years old) participated in the study. Participants were required to perform push-ups in three conditions; i) leg open wide, ii) leg open to shoulder width, and iii) narrow leg. The electromyography (EMG) was used to evaluate the activity of the anterior deltoid (AD), pectoralis major (PM), and triceps brachii (TB) muscles in all conditions. Performance on push-ups was also assessed by the number of repetitions for each condition in this study. The results of one-way repeated measure ANOVA demonstrated that there was a significant difference in the TB during the push-ups between the leg conditions, $p < .05$. TB was found to be more activated during narrow leg compared to the other two positions. However, there was no significant difference in the PM and AD during the push-ups between the leg conditions, $p > .05$. Findings also showed that the number of repetitions was significantly lesser while performing with narrow legs. The study concluded that in terms of performance, performing push-ups with a wider leg and a shoulder-width leg will be more advantageous instead of employing a narrow leg position. However, narrow legs would be prescribed if more challenges want to be given to TB.

Keywords Push-Up, Leg Width, Muscle Activation, Sports Performance, Strength and Conditioning

1. Introduction

Strengthening the torso or upper body is often accomplished through push-up exercises [1], [2]. Specifically, push-ups target the upper body muscles like the anterior deltoid [3], triceps brachii [4] and pectoralis major [5]. To perform a regular push-up, individuals

usually need to spread their legs to shoulder width with their knees extended and put their hands below the humeral joint [6]. After the elbows have flexed to 90 degrees, the body is lowered to the ground before returning to the starting position [2].

According to Hoffman [7], there was also a different push-up protocol based on gender. Females do the push-up in the modified posture with the knees acting as the pivot point (bent-knee push-up), whereas males utilize the normal position with the toes acting as the pivot point (full-body push-up) [8],[9]. This modified version has facilitated females since it is difficult for them to perform full-body push-ups [8]. Additionally, low-strength females who struggled to perform push-ups at a 90-degree angle were more successful with bent-knee push-ups [10].

Muscle force or strength output rises in response to increases in the electromyography (EMG) signal [11], [12]. It is believed that greater benefits will result from exercises that create larger EMG signal amplitudes [13], [14]. The basic push-up can be performed in various ways, but the most frequent changes to the exercise include the angles of the joints [15],[16], the body's position [1],[17] and the stability of the surrounding space [18], all of which have influenced muscle activity.

Despite the standard protocols of push-up, it seems there are many variations that could be performed and many claims of the benefits of performing the different variations exist without any proof through scientific studies. A common but often neglected is how manipulating leg width during the push-up will impact muscle activation and performance. The bigger the leg is, the more stable it would be for the individual and this might increase the potential to perform better. However, there seems to be no study that had clarified this and thus, it is the aim of this study to determine and compare the effects of narrow, shoulder, and wide leg width during push-up exercises on muscle activation and performance. The finding of this study will help coaches and athletes to select the types of variations that they need to perform for their own needs.

2. Materials and Methods

2.1. Participants

A total of 30 trained men aged between 20 to 25 years old were involved in the study. They are all physically active and have experience with push-up exercises as one of their physical fitness training. As a way to minimize other factors influencing the results, only participants that can perform more than 36 repetitions in one minute will be recruited as participants. This is based on the percentile norms found by Baumgartner et al. [19] in which 36 is equal to 90% of the percentile norm. For the participant's inclusion criteria, they must be free from injury to join the study. Participants would be excluded from the study if they had injuries and cannot perform the correct movement of push-up for 36 repetitions in one minute. Participants received a brief explanation of the objectives of the study, the steps to be taken, and the benefits and disadvantages of taking part before the intervention. Next, they were required to fill out the consent form and complete the physical activity readiness (PAR-Q). Participants were made aware that they were free to leave the research at any moment without giving any reason. This study was approved by Sultan Idris Education University's Human Research Ethics Committee.

2.2. Procedure

In the first session, participants' demographic data, including their age, height, and mass, was collected. The participants were then given a briefing and instructed on how to properly do a push-up until they could do it on their own during the familiarization session. Participants underwent a maximum voluntary contraction (MVC) test two days following the familiarization session to measure the muscles' maximum contraction (i.e., pectoralis major, anterior deltoid, and triceps brachii).

For the second, third and fourth sessions, participants performed push-ups exercise using three different leg widths; i) leg open narrow (Figure 1a), ii) leg open to shoulder width (Figure 1b, and iii) leg open wide (Figure 1c). Given that the study used a repeated measure design, order effects (e.g., fatigue effect or practice effect) might affect the participants. Thus, the counterbalancing approach has been utilized to address the problem [20]. Participants performed push-ups in one position per day to avoid tiredness. Figure 1 showed the difference of leg width conditions during push-up.

Figure 1(a). Narrow width

Figure 1(b). Shoulder width

Figure 1(c). Wide width

2.3. Protocol

Standard push-ups were executed with the hands that was shoulder-width apart, fingers pointing front, on a level, sturdy surface. The participants began the push-ups with their arms extended (up), forearms and wrists pronated, feet at shoulder-width intervals, and fingers flexed. The elbow was flexed 90 degrees and the shoulder was abducted 45 degrees while the forearm and wrists remained pronated. Participants were asked to lower their bodies until their chests were only two inches off the ground. Each participant needs to perform ten consecutive repetitions in all positions. The participants will need to repeat the trial if they fail to perform the push-up correctly. Participants were required to repeat these protocols in each leg position. The rate of push-up repetition was one every two seconds. A metronome was used to measure the timing. Last but not least, participants were required to complete as many push-ups as they could in each position. The number of repetitions for each position was recorded.

2.4. EMG Marker Placement

Muscle activation was measured using an EMG instrument and wireless electrodes (Trigno, Delsys, USA) following the SENIAM recommendations. For muscle identification, the surface EMG for non-invasive assessment of muscles (SENIAM) was used. Participants were given 10 minutes to warm up before utilizing the EMG. After that, the participants' skin was cleansed with an alcohol swab before the electrodes were applied. On both sides of the participants, the electrodes were located on the pectoralis major (PM), triceps brachii (TB), and anterior deltoid (AD). Participants were advised to wear minimal, comfortable clothing (tight-fitting attire) during the test session to improve the accuracy of the EMG reading. The mean value of muscle activation level in PM, TB, and AD during the exercise was measured and reported in the form of a percentage from maximal voluntary contraction (MVC).

2.5. Statistical Analysis

The Statistical Package of Social Science (SPSS) version 22.0 was used to analyze the data. The Shapiro-Wilk test was employed to determine if the data were normally distributed, and the result supported this. Means and standard deviations (SD) were calculated as descriptive analyses for the muscle activation in PM, TB, and AD and push-up performance for each situation. One-way repeated measure analysis of variances (ANOVA) was utilized to examine the muscular activation and push-up repetitions during the execution of push-ups with the three varied leg widths. The statistical significance level was set to a value of $p < 0.05$.

3. Results

3.1. Physical Characteristics

Table 1 showed the physical characteristics of the participants.

Table 1. Physical characteristics of participants.

Variables	Mean ± SD
Age (years)	22.36 ± 2.17
Height (m)	1.67 ± 0.07
Body mass (kg)	68.52 ± 5.73

3.2. EMG during Push-ups in all Positions

Table 2 showed the muscle activation data through the EMG readings.

Table 2. Leg width and EMG readings

Leg width/EMG	PM mean (% MVC)	AD mean (% MVC)	TB mean (% MVC)
Leg open wide	57.10 ± 1.30	46.51 ± 2.34	42.45 ± 2.46*
Leg open to shoulder width	56.64 ± 1.30	44.84 ± 2.30	46.53 ± 2.50
Narrow leg	56.71 ± 1.19	45.13 ± 2.01	48.26 ± 2.55*

*significant difference, $p<0.05$

3.2.1. Pectoralis Major (PM)

The findings revealed that there was no significant difference in the pectoralis major (PM) during the push-ups between the three leg conditions, $F (1, 29) = 271.812$, $p > .05$. The descriptive analysis in Table 2 demonstrates that push-ups performed with the leg extended wide (57.10 ± 1.30%) have a slightly greater muscle activation rate in PM than those performed on a narrow leg (56.71 ± 1.19%) and leg open to shoulder width (56.64 ± 1.30%).

3.2.2. Anterior Deltoid (AD)

The findings revealed that there was no significant difference in the anterior deltoid (AD) during the push-ups between the three leg conditions, $F (1, 29) = 395.791$, $p > .05$. The descriptive analysis in Table 2 shows that push-ups with the leg wide open (46.51 ± 2.34%) activate

the AD muscle more than push-ups with the narrow leg (44.84 ± 2.30%) and open to shoulder width (45.13 ± 2.01%).

3.2.3. Triceps Brachii (TB)

The findings revealed that there was a significant difference in the triceps brachii (TB) during the push-ups between the three leg conditions, $F(1, 29) = 436.826$, $p < .05$. The descriptive analysis in Table 2 depicts that push-ups with a narrow leg (48.26 ± 2.55%) activate the TB muscle more than push-ups with the leg open to shoulder width (46.53 ± 2.50%) or a leg open wide (42.45 ± 2.46%). The pairwise comparison also indicated that there was a significant difference between a leg open wide and a narrow leg during the push-ups, $p < .05$.

3.3. Number of Repetitions

Analysis of the number of push-up repetitions in Table 3 demonstrated that there was no significant difference between the three leg positions, $F(1, 29) = 12.541$, $p > .05$. Based on the pairwise comparison, it showed that there was a significant difference between the leg open wide and a narrow leg, $p = 0.005$, and the leg open to shoulder width and narrow leg, $p = 0.015$. Nevertheless, there was no significant difference between the leg open wide and the leg open to shoulder width, $p > .05$.

Table 3. The number of push-up repetitions using three positions

Positions	Leg open wide	Leg open to shoulder width	Narrow leg
Number of repetitions	49.24±2.98*	48.80±2.19*	44.26±2.13*

*significant difference, $p<0.05$

4. Discussion

The purpose of this study was to compare the muscle activation of the PM, AD, and TB using three different leg conditions during push-ups (i.e., leg open wide, leg open to shoulder width, and narrow leg). The research's main findings revealed that the leg condition during push-ups did not yield significant changes in the muscle activation of PM and AD. Nevertheless, the finding showed that employing three different leg conditions while performing push-ups caused a significant difference in the TB muscle. Executing the push-ups using a narrow leg has produced higher muscle activation on TB than a leg open to shoulder width and wide open leg.

Based on the EMG results, only triceps brachii has shown a muscle activation change between the three leg positions during the push-ups. As a result of leg width changes, TB that act as assistance during this movement were affected. Only TB was found to be affected but not the other two muscles. This clearly showed that assistance muscles play a big role during movement. When the leg becomes narrow, the body is not in a stable position, thus assistance muscle needs to work more in order to help the agonist muscle to do its work compared to PM and AD, TB is more distal and is nearer to the hands that are landed on the ground to stabilize and push the body. Thus, this would also become the justification for why only TB is affected.

Additionally, the number of repetitions for a push-up performance is much greater with a wide and shoulder-width leg position than with a narrow leg position. As a result, the study demonstrates that using a wide leg and a shoulder-width leg can improve push-up effectiveness.

Furthermore, the study also suggests that people can use a variety of leg conditions when executing push-ups based on the comfortability and stability of their bodies. Previous studies have shown that body stability played a vital role in push-up exercise [21], [18], [22], [23]. When performing push-ups on an unstable surface, such as a stability ball or wobble board, more muscles in the upper body, including the PM, TB, and AD, are activated than when doing push-ups on a stable surface (like on the floor or stable surface) [6].

The limitations of this study are that it did not take into account the core muscles activation, and did not look at the core strength of participants involved that might affect the results. However, the requirement to perform the minimum number of repetitions in order to become a participant during the screening process should be able to counter the limitations.

The results of the current study expand our understanding of how individuals' muscle activation and performance are impacted by altering strategies used in push-up exercises [1], [24], [6], [25]. As this study only used one gender, future studies may try to compare the leg positions used during push-ups on muscle activation between males and females. The result might add some new findings as the previous study has shown that the push-up performance between genders has differed [8], [9].

5. Conclusions

This study concluded that performing push-ups with the leg open wide and shoulder width is more effective compared to narrow width. This finding was accompanied by the results that showed more TB muscles activation during narrow leg stance, reflecting instability while performing the movement, which causes the assistance muscle to work more during the movement. However, with whatever methods of push up been performed, it is essential to perform the push-ups with proper form and gradually increase intensity as strength improves. It is also wise to consult with a healthcare professional or fitness expert, especially if the individuals have any related health risks. Additionally, a well-rounded exercise routine that includes a variety of exercises and activities can provide more comprehensive health benefits.

Data Availability

The original contributions presented in the study are included in the article; further inquiries can be directed to the author: ali.nadzalan@fsskj.upsi.edu.my.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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