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Efficacy of Push-Ups on a Fitness Structure Compared to that on the Ground on Upper Body Muscular Activation in Healthy Indian Males – A Comparative Study

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ABSTRACT

Introduction: Conventional push-ups on the ground are recognized for fairly improving shoulder strength. A fitness structure has been developed for push up for improved muscle activation.

Objective: The present study aimed to compare the activity of the shoulder and trunk muscles in two push-up positions: push-ups on the fitness structure vs standard push-ups on the ground.

Methods: The study was a comparative study conducted among physically fit adult males in which 18 volunteers were recruited from physical training organization. Participants received instructions on proper push-up position and technique. Participants did 10 push-ups each and Electromyography (EMG) measures were recorded on biceps, triceps, deltoid anterior and pectoralis major muscle. These participants were asked to initially complete push-ups on the fitness structure followed by push up on the ground. The recordings of push-ups under the two conditions were analysed and compared using an unpaired t-test.

Results: The mean age of the study participants was 26.94 ± 1.259. The activity of shoulder and trunk muscles was better in the case of push-ups on the structure than on the ground. The difference in mean EMG readings of biceps muscle (11.133 ± 0.871 vs 7.346 ± 1.121) ($p<0.001$), triceps muscle (4.992 ± 0.881 vs 3.228 ± 0.438) ($p<0.001$), deltoid muscle (5.328 ± 1.373 vs 3.257 ± 1.103) ($p<0.001$) and pectoralis muscle (5.631 ± 1.290 vs 3.2906 ± 0.94875) ($p<0.001$) was statistically significant.

Conclusion: These results indicate that the designed structure could be a promising tool to those who perform rigorous physical activity. Future studies must include randomized trials to further validate our study results.

Key Words: Electromyography, Push-up exercise, Muscle activation, Upper body workout, Upper body activation, Fitness structure

INTRODUCTION

Physical fitness is a state of well-being with a low risk of premature health problems and the energy to participate in a variety of physical activities.[1] The conventional push-up is a fairly popular technique for improving muscle performance and assessing an individual's muscular endurance.[2] Push-ups are admired for being simple to learn with the involvement of very little or no equipment.[3] It is known to strengthen the upper body muscles, shoulder, arm and trunk to be precise.[2] The other advantages being rehabilitating the shoulder, stabilization training of dynamic joints, and improving proprioceptive feedback mechanisms.[4] Using Electromyographic (EMG) procedures, investigators have documented push-up as an effective method for activating muscles of the upper body.[5] However, ground push-ups are also known to place much resistance on the trunk muscles, which can place a huge load on the lumbar vertebrae causing lower back pain.[6] Changing the push-up position can affect the abdominal and vertebral muscles and lumbar angle and load.[7] Also, it's been suggested that instead of the standard push-up, using different devices for push-ups can better improve upper extremity and core muscles of the body.[8,9] It is valuable for athletes where strength training is essential, especially army professionals, bodybuilders and for many other individuals who are either recouping from any type of injury or wish to attain a certain level of fitness.[10]

A fitness structure was designed to activate different upper body muscles.[10] The fitness structure was designed to make it economical, simple to use and manufacture, and ideal for high strength training. However, the muscle activation and

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performance were not evaluated using the apparatus. Hence, the study was conducted to compare the activity of the upper body muscles in two push-up positions: push-ups on the fitness structure (experimental) vs standard push-ups on the ground (control).

MATERIALS AND METHODS

This was a comparative study conducted for a period of 2 months from June 2020- July 2020. Eighteen (18) Healthy males in the age range of 25 - 30 years who were physically fit with no upper extremity pathology within the past year were included in the study. Additionally, participants were required to engage in upper extremity resistance training including conventional push-ups at least twice a week for the past 3 months. The participants were excluded if they had upper back or upper extremity pain or if they had any recent surgeries. The study protocol was approved by the institutional ethical and review board before the commencement of the study.

Volunteers were recruited through convenience sampling technique from physical training organization till the sample of 18 was reached. Written informed consent was taken from all the participants before the commencement of the study. The participants attended two programmes separated by a minimum of 48 hours. An orientation was held to educate the participants about the purpose of the investigation. The study participants signed informed consent before the start of the study. They received instructions on proper push-up position and technique. Once assured that the subjects could correctly perform the muscle tests and exercises, the sites for electrode placement were prepared by abrading the skin with fine sandpaper and cleansing the area with 70% isopropyl alcohol. Shaving of hair was performed if necessary. Initially, the participants performed push up on the fitness structure followed by standard push-ups on the ground.

Data recording

A surface electrode was used to determine the activation of muscles. The electrodes were applied unilaterally with no preference for left or right sides. Electromyography (EMG) data were collected using a NeuroScan EMG/NCV/EP (Innotech Medical (P) Ltd., Punjab, India). All EMG signals were amplified, band-pass filtered (20–450 Hz), and sampled at 1,000 Hz. The position of placement of electrode is mentioned in Table 1 and Figure 1.

Fitness structure

The structure used in the study was an inverted U-shaped structure, 40′ long and 5′ high is grouted on a cement concrete prepared bed. This structure is supported by seven vertical supports made of the same material, again grouted on the concrete surface. Another 40′ long galvanized iron pipe is welded to this structure 2′ above the concrete surface. All joints are welded firmly on all sides. Located 2.5′ away from this axis are 24 inverted U-shaped hand supports, placed at repetitive intervals of 1.5′ -1.0′ -1.5′ from each other. These hand supports are 1.5′ long and 2′ high. They are made of steel and are 2′ ′ thick.[10] (Figures 2 and 3)

Procedure

To standardize hand and leg placement between exercises, a point was marked, where participants placed their hands and legs both on the ground and the fitness structure. While exercising the participants were asked to keep the spine straight, and shoulders flexed 90° relative to the trunk's longitudinal axis and elbows flexed 90°. The investigator placed the Electrode first on the biceps muscle (one muscle at one time). The exercise began in the "up" position with the arms extended, forearms and wrists in the neutral position. After 1st round of 10 push-ups, EMG reading on biceps muscle was recorded. Next, the patient was asked to stand up and the electrode was attached to the triceps muscle. 10 push-ups were repeated on the structure and EMG values were noted down. The same procedure was again repeated for deltoid muscle and pectoralis muscles (Figures 2 and 3).

Statistical analysis

Descriptive and inferential statistical analyses were carried out in the present study. Results on continuous measurements were presented on Mean ± SD and results on categorical measurement were presented in number (%). The level of significance was fixed at p=0.05 and any value less than or equal to 0.05 was considered to be statistically significant. Student t-tests (two-tailed, unpaired) was used to find the significance of study parameters on a continuous scale between two groups. The Statistical software IBM SPSS statistics 20.0 (IBM Corporation, Armonk, NY, USA) was used for the analyses of the data and Microsoft Word and Excel were used to generate graphs, tables etc**.** The ethical clearance was obtained from the institutional review board (no: TNPESU/R4/Ph.D./Feb-2017/08)

RESULTS

The Mean age of the study participants was 26.94 ± 1.259 years. The Mean height of the study participants was 173.11 ± 4.764 and the mean weight was 70.06 ± 7.696 (Table 2). The activity of shoulder and trunk muscles was better in the case of push-ups on the structure than on the ground. The difference in mean Electromyography readings of biceps muscle (11.133 ± 0.8714 vs 7.346 ± 1.1210) (P<0.001), triceps muscle (4.992 ± 0.8819 vs 3.228 ± 0.4383) (P<0.001), deltoid muscle (5.328 ± 1.3736 vs 3.257 ± 1.1039) (P<0.001) and pectoralis muscle (5.631 ± 1.2909 vs 3.290 ± 0.9487) (P<0.001) was statistically significant (Table 3).

DISCUSSION

The push-up exercises are very popular in upper body strengthening programs. They are closed kinetic chain exercises, for which pectoralis major and triceps brachii are the principles acting muscles.[11] Different variants of the exercise have been suggested in the past, either using different postures[12], altering the position of hands and feet[13], or compared to the movable-load bench press exercise[14], stable or unstable surfaces[15] or sling-and ground-based push-up exercise.[16] Therefore, we compared the activity of the shoulder and trunk muscles between push-ups on the fitness structure and standard push-ups on the ground.

A total of 18 volunteers participated in the study. The study findings suggested that the push-ups on fitness structure showed better activation compared to push-ups on the ground. Calatayud et al.[8] used a suspended push-up with a pulley system showed greater activation compared to standard push-ups on the floor. They suggested that suspended push helped increase core muscle activation. These findings were also comparable to the study conducted by Snarr et al.[17] which also supported this evidence. The Perfect Pushup™, a rotating handgrip device was found to be superior for activating the pectoralis major and posterior deltoid compared to conventional push-ups in the study by Allen et al.[9] and Youdas et al.[2] Sandhu et al.[18] suggested that the addition of a simple Swiss ball to your push up is capable of improving shoulder muscle activity. Kim et al.[19] suggested that the push-ups performed with the 50% palmar width resulted in greater activation of pectoralis minor, triceps brachii, and infraspinatus muscle activities. Borreani et al.[20] suggested that any unstable surface such as wobble board, stability disc, fitness dome, and Suspension Trainer improves muscle activation. All these studies showed that modification of conventional push-up technique may yield positive results in terms of better muscle activation.

The study results showed that fitness structure is a decent alternative for ground push-ups providing better muscular activation. The structure used is cost-effective. However, we did not conduct an in-depth analysis of the push-ups on the patients. The other limitations were that the convenience sampling technique was employed for the study which does not truly represent the general population. This study was a simple comparative study with a limited sample size; thus, the observed association cannot be interpreted as causal inferences. However, this was the first study that contributed significantly to the literature by introducing a new apparatus in fitness training. In future, it's recommended to conduct a multicentric large scale randomized trial on a wider population (including females, different ethnicity, people from different geographical location etc.) to further validate the study results.

CONCLUSION

The study results showed that fitness structure is a cost-effective and good alternative for ground push-ups providing better muscular activation. This study was one of the very first studies that developed and studied the modified push-ups on an apparatus. This apparatus could be deemed useful in already fit individuals like army personal, bodybuilders and many other fitness enthusiasts.

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Authors contributions:

1. Vikas Malik: concept, design, literature search, data acquisition, the definition of intellectual content, manuscript editing and manuscript review.
2. Dr. R. Ramakrishnan: concept, data analysis, statistical analysis, the definition of intellectual content, manuscript editing and manuscript review.

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Table 1: Position of electrode placement

S no	Muscle name	Position of EMG electrode	Muscle activation
1	Biceps brachii	Placed in the middle of the forearm just anterior to the radius.	Flexing the distal phalanx of the thumb activates the muscle
2	Triceps	Placed posterior to deltoid tubercle, for long head 6-8 cm (4 fingerbreadths) distal to the posterior axillary fold	Activated during push up on fitness structure
3	Deltoid Anterior	Placed 4-5 cm below the anterior margin of the acromion	Activated by forwarding elevation of the arm
4	Pectoralis Major	Placed on the anterior axillary fold	Measured during exercise

Table 2: Descriptive statistics (N=18)

Variable	Mean	Standard Deviation
Age	26.94	1.259
Height	173.11	4.764
Weight	70.06	7.696

Table 3: Comparison of the Electromyography readings of push-ups on structure and on ground using unpaired t-test (N=18)

Muscles	Structure	Ground	t value	P-value
Biceps	11.133 ± 0.8714	7.346 ± 1.1210	11.316	<0.001**
Triceps	4.992 ± 0.8819	3.228 ± 0.4383	7.601	<0.001**
Deltoid	5.328 ± 1.3736	3.257 ± 1.1039	4.986	<0.001**
Pectoralis	5.631 ± 1.2909	3.290 ± 0.9487	6.198	<0.001**

Figure 1: Position of electrode placement.

Figure 2: Push-up on structure.

Figure 3: Push-up on the ground.