Palmar pressure distribution during push-up exercise

Chuckpaiwong B, Harnroongroj T

ABSTRACT

Introduction: Doing repetitive push-ups is among the most common exercise for the upper body and shoulder stabiliser muscle strength training. However, adverse effects such as neck pain, back pain, palmar pain and wrist pain have been reported. To date, to our knowledge, palmar pressure when performing push-ups has not been previously reported. We hypothesised that various hand positions during push-ups may provide different palmar pressures.

Methods: Bilateral palmar pressures were recorded in ten individual volunteers. All the subjects were set up for doing push-ups in five positions of the hand. Peak palmar pressure was recorded by Emed pressure platform system (Novel GmBH, Munich, Germany). The palm was divided into the following five anatomic regions, viz. thenar, lunate, hypothenar, metacarpals and fingers. Statistical comparison between the five positions of the hand was analysed using the analysis of variance test.

Results: A distribution of the mean peak pressure of the lunate and hypothenar areas were relatively higher than the other areas in both standby and full-elbow flexion positions. At the palmar position 30 cm wider than the shoulder width, the palmar pressure revealed significantly higher peak pressure in the lunate area in the standby and fully-flexed elbow positions (p-value is less than 0.05). At the palmar position 10 cm narrower than the shoulder width, palmar pressure showed significantly higher peak pressure in the hypothenar area only in the fully-flexed elbow position.

Conclusion: The information regarding palmar pressures while performing push-ups in different hand positions may be used as a guideline for exercise modification, especially in injured athletes.

Keywords: exercise complication, palmar pain, palmar pressure, push-up exercise, sports injury, wrist pain

Singapore Med J 2009; 50(7): 702-704

INTRODUCTION

The push-up is a popular exercise among both young athletes and the general population. The advantages are its simplicity; no equipment or cost is involved, and it can be used for many different purposes. Shoulder, back and upper arm strengthening are among the main purposes of this exercise. In addition, it also trains neuromuscular coordination.[1,2] Various techniques of push-ups have been proposed,[3-5] each claiming different advantages. Using different hand positions is one of the modifications that provide a significant difference in muscle activation.[6-8] Cogley et al reviewed the benefits of a narrow-base hand position over the tricep brachii and the benefits of a wide-base hand position over the pectoralis major.[6] Freeman et al reported the benefit of more shoulder muscle activation with the dynamic push-up (push-up with the hands on a wobbly surface).[4]

However, despite the many advantages of this exercise, it may also cause some adverse outcomes, such as neck pain,[9] back pain[4] and palm and wrist pain.[10] Specific high pressure in the palm can cause discomfort and pain in athletes, especially in patients with previous hand and wrist injuries. We hypothesised that various hand positions during push-ups may provide different palmar pressures, and this may be used as a guideline to modify hand positions for push-ups in people requiring shoulder strengthening, but who have hand and wrist pain.

METHODS

A total of ten healthy, active male adults (20 hands) were recruited from the university and surrounding community. The average age (and standard deviation) of the subjects was 22.10 ± 0.7 years, and the average height and weight were 1.73 ± 5.6 m and 65.80 ± 7.5 kg, respectively. Measurements included arm span, shoulder width (tip of the acromion on one side to the other side) and arm length (greater tuberosity of the humeros to the styloid process of the radius of the same side). All subjects were tested bilaterally during this study. None had a history of upper extremity, shoulders and back injuries within the past

Orthopaedic Surgery Department, Siriraj Hospital, Mahidol University, 2 Prannok Street, Bangkok 10600, Thailand

Chuckpaiwong B, MD
Assistant Professor

Harnroongroj T, MD
Professor

Correspondence to:
Dr Bavornrit Chuckpaiwong
Tel: (66) 2 419 7968
Fax: (66) 2 412 8172
Email: chuck003@gmail.com

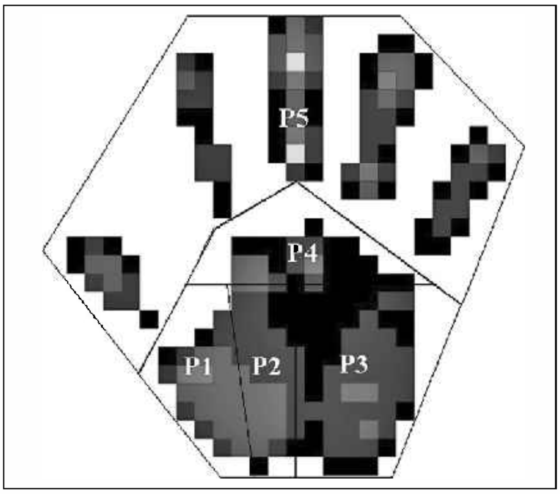

Fig. 1 Diagram shows the five designated areas of the palm. P1: thenar area; P2: lunate area; P3: hypothenar area; P4: metacarpalare; P5: finger area

year and no history of upper extremity, shoulder or back surgery. All subjects read and signed an informed consent approved by the institutional review board. All subjects were set up for push-up exercises in the five positions of the hand interval, viz. hand interval equal to shoulder width (0); hand interval 10 cm narrower than the shoulder width on each side (–10); hand interval 10 cm wider than the shoulder width on each side (+10); hand interval 20 cm wider than the shoulder width on each side (+20); and hand interval 30 cm wider than the shoulder width on each side (+30). All subjects were asked to place one hand in the centre of an Emed® pressure platform system (Novel GmBH, Munich, Germany).

The palm was divided into the following five anatomic regions, viz. the thenar, lunate, hypothenar, metacarpals and fingers (Fig. 1). Within each of these palmar regions, the following variables were analysed: peak pressure, total pressure, mean pressure and contact area. All data was simultaneously recorded in both the starting and full-elbow flexion positions. The measured peak pressure was the primary outcome data. Five trials in each subject were performed. Statistical comparison between the five hand positions was analysed using the analysis of variance (ANOVA) test with an alpha-level of 0.05. The Statistical Package for Social Sciences version 12 (SPSS Inc, Chicago, IL, USA.) was used to calculate all the data.

RESULTS

The average (and standard deviation) arm span was 177.55 ± 6.1 cm, shoulder width was 38.3 ± 2.8 cm, and arm length was 60.0 ± 9.6 cm. A distribution of the mean peak pressure of the lunate and hypothenar areas were relatively higher than the other areas in both standby and full-elbow flexion positions. The mean peak pressure of the metacarpal and finger areas had very little peak pressure. Comparing the peak pressure in each area between the five different hand positions, it was observed that the +20 and +30 positions showed significantly higher peak pressure in the lunate area in the standby position ($p < 0.05$). The +30 position also showed significantly higher peak pressure in the lunate area in the full-elbow flexion position ($p < 0.05$). The –10 position showed significantly higher peak pressure in the hypothenar area in the full-elbow flexion position. The detailed findings are shown in Table I.

DISCUSSION

This study showed the various peak pressure distributions in the palm while performing push-ups. A wider hand position significantly generated a higher peak pressure in the lunate area. On the other hand, a narrower hand position significantly generated a higher peak pressure in the hypothenar area. Many studies were concerned with the advantages of muscle activation during push-ups.[6-8] and improvisations to strengthen specific muscles around the shoulder with minor modifications.[5,11] However, none of these studies mentioned the palmar pressure when performing this exercise. From the biomechanics standpoint, our study revealed that a wider hand position generated a higher peak pressure in the medial side of the palm, and a narrower hand position generated a higher peak pressure in the lateral side of the palm. The palmar pressure in the metacarpal and finger areas was not significantly changed by the hand positions. Our results may help us to understand push-up-induced palmar pain by its biomechanical adaptation. The specific hand position and its modification may guide the athlete to avoid palmar pain problems. This study recommends a wider hand position for athletes who have hypothenar pain and a narrower hand position for athletes who have thenar or lunate pain. Furthermore, this information may be used as a guideline to develop a new technique or an assisting device to decrease palmar pain when performing this exercise.

The force plate was originally used to measure plantar pressure in gait analysis studies. Our study modified the original software and pilot-tested it for the accuracy of palmar pressure measurement. This is an instance where instrument modification can improve and widen the usage of an expensive experimental instrument. Although our study has a limited subject population, the results are still significant enough to support a statistical difference. Our study subjects are representative of the major population affected by this form of injury/pain, i.e. young, active male athletes.

To date, several modifications of push-ups have been

Table I. Mean palmar peak pressure in each area during push-up in full-elbow extension (standby position) and full-elbow flexion positions.

Mean palmar peak pressure	−10	0	10	20	30
Standby areas					
Thenar	7.9 ± 0.2	8.2 ± 0.1	8.0 ± 0.3	8.3 ± 0.1	7.7 ± 0.2
Lunate	13.0 ± 0.0	14.0 ± 0.1	17.0 ± 0.3	20.0 ± 0.5*	21.0 ± 0.6*
Hypothenar	15.0 ± 0.1	15.0 ± 0.0	14.0 ± 0.2	14.0 ± 0.2	16.0 ± 0.3
Metacarpal	0.0 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
Finger	1.4 ± 0.0	1.5 ± 0.0	1.9 ± 0.0	1.5 ± 0.0	2.4 ± 0.0
Full-elbow flexion areas					
Thenar	5.2 ± 0.1	6.8 ± 0.1	6.8 ± 0.2	9.6 ± 0.2	13.0 ± 0.6
Lunate	8.3 ± 0.1	13.0 ± 0.2	13.0 ± 0.5	15.0 ± 0.5	18 ± 0.6*
Hypothenar	25.0 ± 0.3*	24.0 ± 0.7*	21.0 ± 0.4	17 ± 0.3	13 ± 0.7
Metacarpal	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Finger	3.2 ± 0.1	2.7 ± 0.0	3.3 ± 0.1	3.6 ± 0.0	4.1 ± 0.0

*$p < 0.05$

reported, including wall push-up, chair push-up, and push-up plus (scapular stabiliser training). Each modification provides a different palmar pressure derived from many factors, including the hand position, surface of the placing palm, percentage of body weight transfer to the palm, and number of muscle activation. Our study was designed to control the optimum environment for this exercise. The final outcome of palmar pressure distribution was calibrated to apply to a standard push-up. Our results may apply to both injured and non-injured cases which require basic exercises such as the push-up. Further investigation of specific modifications that can further improve the performance of this exercise may be needed.

In conclusion, information regarding palmar pressure while performing push-ups in different hand positions may be used as a guideline for exercise modifications, especially in injured athletes. A wider hand position is appropriate for the athlete who has hypothenar pain, while a narrower hand position is appropriate for the athlete or patient who has thenar or lunate pain.

REFERENCES

1. An KN, Korinek SL, Kilpela T, Edis S. Kinematic and kinetic analysis of push-up exercise. Biomed Sci Instrum 1990; 26:53-7.
2. Ludewig PM, Hoff MS, Osowski EE, Meschke SA, Rundquist PJ. Relative balance of serratus anterior and upper trapezius muscle activity during push-up exercise. Am J Sports Med 2004; 32:484-93.
3. Kotani Y, Tokuhiro A. Kinesiological study of the push-up motion in spinal cord injury patients: involving measurement of hand pressure applied to a force plate. Acta Med Okayama 2002; 56:75-82.
4. Freeman S, Karpowicz A, Gray J, McGill S. Quantifying muscle patterns and spine load during various forms of the push-up. Med Sci Sports Exerc 2006; 38:570-7.
5. Lehman GJ, Macmillan B, Macintyre I, Chivers M, Fluter M. Shoulder muscle EMG activity during push up variations on and off a Swiss ball. Dyn Med 2006; 5:7.
6. Cogley RM, Archambault TA, Fibeger JF, et al. Comparison of muscle activation using various hand positions during the push-up exercise. J Strength Cond Res 2005; 19:628-33.
7. Welsch EA, Bird M, Mayhew JL. Electromyographic activity of the pectoralis major and anterior deltoid muscles during three upper-body lifts. J Strength Cond Res 2005; 19:449-52.
8. Gouvali MK, Boudolos K. Dynamic and electromyographical analysis in variants of push-up exercise. J Strength Cond Res 2005; 19:146-151.
9. Mikawa Y, Watanabe R, Fuse K. Quadriplegia caused by push-up exercise. Arch Orthop Trauma Surg 1994; 113:174-5.
10. Lester B, Halbrecht J, Levy IM, Gaudinez R. "Press test" for office diagnosis of triangular fibrocartilage complex tears of the wrist. Ann Plast Surg 1995; 35:41-5.
11. Moseley JB Jr, Jobe FW, Pink M, Perry J, Tibone J. EMG analysis of the scapular muscles during a shoulder rehabilitation program. Am J Sports Med 1992; 20:128-34.