

The effect of medial arch support over the plantar pressure and triceps surae muscle strength after prolonged standing

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ABSTRAK

Latar belakang: Aktivitas dengan posisi berdiri dalam waktu yang lama merupakan salah satu penyebab kelainan pada tungkai bawah dan kaki. Penelitian ini bertujuan melihat pengaruh penyangga lengkung medial terhadap distribusi tekanan plantar dan kekuatan otot triceps surae saat berdiri dan berjalan setelah berdiri dalam waktu yang lama.

Metode: Penelitian ini merupakan penelitian eksperimental dengan desain pre dan pasca. Pengukuran distribusi tekanan plantar menggunakan alat Mat-scan dengan variabel yang diukur adalah daerah kontak dan puncak tekanan. Pengukuran dilakukan pada saat berdiri dan berjalan. Pengukuran kekuatan otot triceps surae menggunakan hand held dynamometer. Pengukuran dilakukan sebelum dan sesudah bekerja dalam posisi berdiri dalam waktu yang lama dengan menggunakan penyangga lengkung medial pada sepatu. Data hasil penelitian dianalisis menggunakan uji T berpasangan.

Hasil: Terdapat penurunan puncak tekanan antara berdiri ($p = 0,041$) dan berjalan ($p = 0,001$). Terdapat penurunan luas daerah kontak saat berdiri ($104,12 \pm 12,42$ vs $99,08 \pm 10,21$; $p = 0,023$). Tidak terdapat perbedaan yang bermakna pada pengukuran kekuatan otot triceps surae sebelum dan sesudah berdiri lama.

Kesimpulan: Terjadi penurunan puncak tekanan pada plantar ketika berdiri dan berjalan, penurunan luas daerah kontak ketika berdiri setelah menggunakan penyangga lengkung medial.

ABSTRACT

Background: The activity with prolonged standing position is one of the causes of abnormalities in the lower leg and foot. The aim of this study is to discover the effect of medial arch support over the distribution of plantar pressure when standing and walking.

Methods: This was an experimental study with pre- and post-design the strength of triceps surae muscle after prolonged standing, was also evaluated in an experimental study with pre- and post-design. Variables of plantar pressure measurement are the contact area and pressure peak were measured by using the Mat-scan tool. The measurement of the triceps surae muscle strength was done with a hand-held dynamometer, before and after using the medial arch support. Measurement was performed before and after working with prolonged standing position which took place about seven hours using the medial arch support inserted in the shoes. Data was analyzed using paired T-test.

Results: There was a significant difference of peak pressure between standing ($p = 0.041$) and walking ($p = 0.001$). Whereas the contact area showed a significant decrease in the width of the contact area when standing (104.12 ± 12.42 vs 99.08 ± 10.21 $p = 0.023$). Whereas, the triceps surae muscle strength pre- and post-standing prolonged did not indicate a significant difference.

Conclusion: There was decrease in peak pressure when standing and walking and decrease in contact area when standing on plantar after used of the medial arch support after prolonged standing.

Keywords: medial arch, plantar pressure, prolonged standing, triceps surae

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Working in a standing position for a long time is one of the causes of abnormalities in the lower extremities especially in the legs and feet. Standing more than 50% of the time or more than four hours from our overall activities have caused complaints. Eleven million people in the United Kingdom suffer from health problems caused by this position. American Pediatric Association reported that 83% of its workers in United States experienced discomfort and pain caused by prolonged standing.^{1,2} Some disorders can be caused by prolonged standing, joint abnormalities, plantar fasciitis, the formation of callus that may cause the flattening of foot arch. The most common complaint revolves around the foot was mainly due to its functional abnormality.³

The medial arch plays an important role in the foot stability. This arch serves as weight support and functions in foot locomotion. This arch is higher, more flexible, and more mobile than the others.^{4,5} There are changes in the structure of the medial arch while standing and walking. When standing, the arch will become depressed because it is supporting the weight from the upper body. Whereas, when walking the height and length of the arch will change according to the phases of walking.⁶⁻⁸ The muscle can function to absorb and produce energy during movement. Triceps surae muscle is one of the muscles of the lower legs that plays a dominant role when standing and walking and its strength affects the ability to walk.⁹

Plantar pressure is a description of the pressure that occurs between the foot and the surface it touches that is sustained during daily activities both during weight supporting and walking.¹⁰ The support of the medial arch is one of the foot orthosis that serves to redistribute the pattern for weight and maintain the foot in neutral position of the subtalar joint. It also serves to maintain the structure of the medial arch.¹¹

The aim of this study was to evaluate the effect of medial arch support on the distribution of plantar pressure when standing and walking. In addition, the strength of the triceps surae muscle after prolonged standing was also evaluated.

METHODS

This study used a pre- and post-experimental design. The subjects consisted of 16 security

guards from Cipto Mangunkusumo Hospital, Jakarta. Who were selected according to the following inclusion criteria: male aged 25-50 years, normal body mass index, working more than 50% of day time in standing or walking position (work duration \pm seven hours), normal arch of the foot and does not have musculoskeletal disorders. Written informed consent was obtained from each subjects before enrollment in the study. The protocol of this study has been approved by the Ethical Committee of the Faculty of Medicine Universitas Indonesia / Cipto Mangukusumo Hospital (No.292/H2.F1/ETIK/2014).

The measurement of plantar pressure was done in standing and walking in the morning before the subject went to work and after they got home by using a Mat-scan, made by Tekscan USA. The measurement was performed in the fundamental standing position. Firstly, the Mat-scan was prepared and calibrated according to the weight of subject. After calibration, the subjects were asked to stand on the floor mat of the mat-scan and the image was recorded when the subject was walking. They were asked to walk as comfortable as possible in accordance to their own walking pattern with the trajectory of approximately seven meters.

The measurement was taken when the foot is in contact with the Mat-scan at the mid stance phase. For the plantar pressure measurement, the parameters measured were peak pressure and contact area on the entire surface of the left and right foot. Muscle strength was measured with hand-held dynamometer and performed over two days. The first day without using the medial arch support, while in the second day the measurement was done after using the medial arch support after prolonged standing. The subject was ordered to stand on his/her left foot while placing their right knee on a stable surface. Then, the subject was ordered to flex the right foot and the hand-held dynamometer tool restrained the foot while doing plantar flexion. After all the measurements were conducted, the subjects were asked to use the medial arch support that was inserted into the shoes. The medial arch support used was Universal III, "dr Kong" with the serial number 007050. The support was used during the subject's working hours and it was not removed. After the subjects completed working, then the support was removed and the measurement of plantar pressure and triceps surae muscle strength were then performed.

Analysis of data was performed by using SPSS 13. Saphiro Wilk test was used to test the normality of data distribution. When the data were normally distributed, analysis was performed using the paired T-test. If the data were not normally distributed, the Wilcoxon test was used.

RESULTS

Out of 228 of security guards from Cipto Mangunkusumo Hospital, Jakarta, 16 subjects were selected, the mean age of subjects was 30.06 ± 5.5 years, body mass index 21.83 ± 2.2 kg/m², and mean arch height was 0.24 ± 0.02 cm.

During measurement of the plantar pressure at standing position it was found that nine of the 16 subjects had a contact area of the right foot decrease, and the peak pressure was found to decrease in 10 of the right foot and in seven of the left foot. Data of mean and p-value plantar pressure on standing position are shown in table 1.

We found nine of the 16 subjects had a decrease in contact area of the right foot and 11 had a decrease in the left foot, after measuring the peak pressure it was found that there was a decrease in 12 of the subject's right foot and in nine of the subject's left foot. Data of mean and p-value plantar pressure on walking position are shown in table 2.

During the measurement of triceps surae strength, from the 16 subjects we found no significant difference between pre- and post-prolonged standing. Result of tricep surae muscle

strenght was mean 50.12 ± 3.10 vs 51.45 ± 4.15 ($p = 0.302$).

DISCUSSION

The results of the study showed that the medial arch support showed a decrease of peak pressure and a decrease of the contact area when standing. This was consistent with the function of foot orthosis which is to redistribute weight with the main purpose of decreasing pressure on areas that are sensitive to pressure. Giving support to the medial arch aimed to redistribute weight, comfort and protection as well as sustaining the foot in a desired position (neutral position) of the subtalar joints. The specific objectives of using the foot arch pad were to reduce sensitive areas over pressure and to reduce pain by decreasing the amount of pressure area unit of the plantar surface. It was also aimed to reduce the friction force on the plantar surface, especially during weight-bearing. Reduction of the frictional force is very important because it often causes abnormalities towards the plantar surface of the foot that includes callus, ulcers formation, and bunion.¹¹

The pads in arch medial support can increase pressure on areas that were tolerant on stress and decrease pressure on sensitive areas, so that there will be a change in the contact area when sustaining weight and width of the contact area of plantar surface which was sensitive to pressure, thereby reducing pain in the area which had bony prominences. The mechanism used was to reduce the amount of pressure per unit on the plantar surface area.¹¹

The measurement result of plantar pressure was not significant in this research and it was similar to a previous research that was conducted by Landsman, et al¹² who studied the effect of the foot arch support by comparing when these various types of objects were and were not being used. However, these results only showed that there was no significant difference at the time of measurement when not using the support and using it either on the left or right foot.¹³

In some of the previous studies it was reported that several different results over the contact area

Table 1. Plantar pressure on standing position (n=16)

Parameter	pre	post	p
Peak pressure (kPa)	152.50 ± 23.14	140.63 ± 19.51	0.041
Contact area (cm ²)	104.12 ± 12.42	99.08 ± 10.21	0.023

Table 2. Plantar pressure of right and left foot while walking (n=16)

Parameter	pre	post	p
Peak pressure	156.19 ± 34.58	135.75 ± 25.10	0.001
Contact area	110.56 ± 15.31	106.23 ± 14.28	0.075

on the plantar pressure may also be seen due to the different types of samples and treatment in each study. In this study, samples were different from the previous research with the usage of the medial arch support by comparing before and after prolonged standing. During prolonged standing, the leg will sustain body weight for a length of time so that there will be a chance that structure of the arch will be flatter and the possibility of extensive area contact between the surface of the foot and the ground will become spread out. In addition, the medial arch support after prolonged standing will be supported by a foot arch support, therefore the contact area on the surface will be reduced or declined. However, there was no significant difference in the contact area of the left foot.

The test result analysis over muscle strength showed no significant difference before and after prolonged standing position. The result of this analysis was unable to describe muscle strength after using the medial arch support due to a short usage of only \pm seven hours and it could not compare strength among people with prolonged standing activity or not. In the previous study, it was found that application of the medial arch support could increase tension and length of the triceps surae muscles during stretching.

Basically, prolonged standing can cause pain in the leg muscles due to continuous contraction of the muscles aimed at maintaining posture during standing.¹³ Standing static contractions also occurred, especially in the back and in legs that could reduce the work of the triceps surae muscles.

The results of this study show that medial arch support is useful for any worker who spends a large portion of their day in a prolonged standing position to reduce abnormalities in their foot.

In conclusion, there was decrease in peak pressure when standing and walking and decrease in contact area when standing on plantar after use of the medial arch support after prolonged standing.

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Conflict of interest

The author affirm no conflict of interest in this study.

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