Annals of Clinical and Analytical Medicine

Original Research

A corroborative study of effects of body mass index on the anatomical region of hindfoot

Obesity and hindfoot region

Wajid Ali Chatha
Department of Anatomy, College of Medicine, Northern Border University, Arar, Kingdom of Saudi Arabia

Abstract

Aim: An experimental study was designed to find an anatomical correlation between the area of the hindfoot, height and weight of an individual.

Material and Methods: Medical students of preclinical years were recruited into the study and their footprints were taken on a predesigned A4-sized paper. The foot was divided by geometrical tools into three regions: forefoot, midfoot and hindfoot area. The area of the hindfoot was calculated using the specific image-J software after standardizing the metric units into pixels.

Result: Analysis through SPSS showed a strong relationship between the studied parameters.

Discussion: As per our knowledge, this is the first study defining the hindfoot surface area and correlating it with the height and weight of the individual. A strong association was found between the studies parameters that may be useful in predicting complications related to obesity in near future.

Keywords

Area, Body Mass Index, BMI, Hindfoot, Foot Arch, Obesity

DOI: 10.4328/ACAM.21088 Received: 2022-01-27 Accepted: 2022-03-10 Published Online: 2022-03-29 Printed: 2022-06-01 Ann Clin Anal Med 2022;13(6):679-682

Corresponding Author: Wajid Ali Chatha, Department of Anatomy, College of Medicine, Northern Border University, Arar, Kingdom of Saudi Arabia.

E-mail: drchatha@hotmail.com P: +966 53 352 85 31

Corresponding Author ORCID ID: https://orcid.org/0000-0003-1740-555X

Introduction

Foot and ankle injuries are among the most severe in daily life and sports [1]. The complicated foot-ankle complex consists of 26 bones moving ground reaction forces to the lower extremity. The rear-foot is often subjected to injury and deformity due to its role in receiving and transmitting such forces to and from the rest of the body.

One of the seven articulating bones that make up the tarsus is calcaneus. The calcaneus along with the talus forms the skeleton called the hindfoot bone. The part of calcaneus that is in contact with the ground is commonly called "Heel" that articulates mainly with the talus and cuboid bones. Numerous ligaments and muscles bind themselves to the calcaneus and aid with its role in biomechanics of human bipedals. The calcaneus acts as an attachment point for a powerful tendon (Achilles tendon), which aids in standing, walking, running and jumping and the plantar flexion of the foot. The calcaneus also serves as a point of attachment for the muscles, which move the toes.

In a simplified fashion, the subtalar joint can be divided into two parts: anterior and posterior. However, it is important to note that not only the articulating surfaces of the calcaneus and the navicular bone support the talar head, but also the 'spring' ligament. This network of ligaments plays an important role in stabilizing the talar head. The insufficiency of this structure can lead to deformity of the acquired flat foot.

The size and shape of the three facets of the calcaneus differ among individuals. Both the anterior and middle facets are concave, while the posterior facets are convex [2]. The posterior facets are larger than the middle and anterior facets and are separated by the interosseous calcaneal ligament from the other two facets [3].

In the past, several studies were conducted to search for the relation between the foot structure and the body mass index (BMI). Though those researching a relationship between the individual foot areas and the index of body mass were scanty. Many of those researches indicated a certain relationship between the arches of the foot and the BMI [4].

The current paper evaluates another hypothesis that an individual's hindfoot area is directly proportional to one's body mass index in the given context information.

Material and Methods

A theoretical, quantitative and experimental analysis was planned to verify the hypothesis. The scientific proposal was submitted for approval to the Ethics Committee. The data collection began after the approval of the study. The subjects' confidentiality was thoroughly protected in the report.

The data collection included documenting the individual's weight, height and foot imprint. Any individual with any foot infection, deformity and foot injury was excluded. The rationale of the research, to investigate the relationship between the foot pattern and the structure of the body, was clarified to the volunteers. The procedure obtained verbal consent and the intention was thoroughly explained to the subjects, beforehand.

An A4-sized paper with fixed measured calibrations printed was used to take the ink embossed footprints of the subjects. In addition to a space for writing the weight and height of the person, the paper had numbered square boxes of 1cm2. For recording the weight and height, respectively, an electronic weighing scale was used with the embedded stadiometer.

A customized thick foam pad was used as a stamping pad. This pad was pasted into a tray with a pasting solution and soaked with office stamp ink that is used for normal thumb impressions.

Weight was measured in kilograms at the beginning of the experiment, while height was noted in centimeters for each person. The subject's body mass index (BMI) was then measured and noted using the standard formula as shown below:

BMI = Weight (in kilograms) / Height (in square centimeters).

The subjects were asked to better soak the sole of their feet in the ink by pressing and standing barefoot on the ink-soaked foot-pad; they were then asked to step out of the foam pad and emboss their foot on the A4 size paper mentioned above. The foot ink prints thus taken, were then let to air dry on the paper. Next, the exact outline of the footprint was then delicately drawn by hand with a dark marker in the dried footprint. The long axis of each sample was drawn to standardize the alignment. The middle of the middle finger was used as a guide for this purpose. The extent of the foot area that needed to be measured has been marked using the mathematical square package. The long axis of the foot was then split into three equal regions; the perpendiculars were drawn using the same square set to outline the three regions of the foot, namely: fore-foot (F), mid-foot (M) and rear or hind-foot (R) (Figure 1).

Next, at a high resolution, these papers were scanned in color and saved as JPEG files. In the "FIJI" image software, which is an advanced version of the "ImageJ2" software, these files were opened. A fixed unit of length (3 cm) was standardized into the pixels on the opened images. The area for each divided region of the foot was measured using the free hand drawing tool of the image-J program, and the mean reading in square centimeters was registered.

Using SPSS tools, reported data were analyzed and p-values were determined by applying a single sample t-test for the variables. A p-value ≤ 0.05 was taken as a significant level of difference in the calculated results.

Results

Extrapolation of the data using SPSS showed a strong correlation between the two parameters. The calculated p -value came out to be 0.00 showing the highly significant difference between the means of the two calculated parameters. The mean BMI was closer to, but slightly above normal. The hindfoot area was found to have a low deviation from the mean and hence significant.

Table 1. One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean	p-value
Hind Foot Area	49	33.2360	5.17380	.73911	≤0.05
Body Mass Index	49	27.2847	8.98068	1.28295	

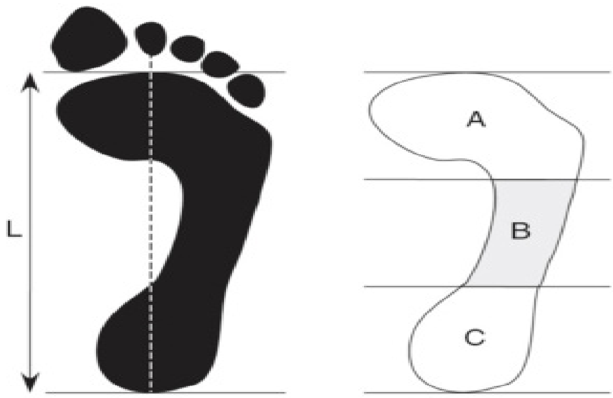

Figure 1. Footprint with reference lines for calculating the arch index. The length of the foot (excluding the toes) is divided into equal thirds to give three regions: A -- forefoot; B -- midfoot; and C – heel or Hindfoot region [5].

Discussion

Foot pain is a common complaint which affects nearly one in four adults after the age of 45 [6]. Obesity is a contributing factor in foot pain development [7], and elevated body mass index (BMI) is closely correlated with both chronic plantar heel pain and non-specific foot pain [8]. In addition, the feet of obese people are structurally and physically different from their non-obese counterparts, manifesting as thicker, broader and heavier, along with flatter-foot postures, reduced joint motion range and increased plantar peak pressures [9, 10].

This study investigated associations between weight status and normal plantar surface area among youth and specially calculated the heel region. The limitation of this study was that the number of participants was not enough.

Prosperity with the mechanization of nations brings with it a sedentary lifestyle in which the morbid person enters a cascade of obesity, contributing to, but not limited to hypertension, diabetes, etc., and many related diseases. A new class of patients has emerged in the recent past that can be termed as suffering from lifestyle diseases.

In our study, we have attempted to equate body size of the individuals with an important anatomical region of the foot skeleton. We hope that this simplest data can be converted into useful predictors of the imminent risk factors for obesity-related diseases using basic calculations. Furthermore, in this study, hindfoot surface area is investigated according to BMI to obtain data for future use in the fields of physiotherapy intervention, assistive devices, and shoes that address foot diseases.

Studies have shown that people with obesity show an increase in non-uniform plantar pressures, with midfoot and forefoot areas of highest pressure relative to non-obese people [10–12]. Provided that obesity is strongly associated with plantar heel pain [13, 14], increased plantar pressure became discordant where the pain was strongly associated with unnecessary pressure. Paradoxically, as opposed to monitors, people with chronic heel pain show reduced load under the heel [15].

Musculoskeletal pain has a bidirectional relationship with both obesity [16] and depression [17], whereas depression and obesity frequently intensify each other [18]. Such associations, however, are not restricted to weight-bearing joints with a reported association between elevated BMI and symptomatic hand osteoarthritis [19], indicating that metabolic mechanisms, including systemic inflammation [20], can underpin the relationship between obesity and joint pain [21].

The Western Pacific Regional Committee of the WHO on a new BMI for Asians identified 23kg/m2 or higher as overweight, and 25 kg/m2 or higher as obesity [22]. It is associated with increased body fat, BMI, and waist measurements, which adversely affect daily and physical activity activities [23]. The incidence of degenerative foot diseases is also growing with rising life expectancy, and diabetic foot disease is also growing with increasing numbers of patients with diabetes [24]. Plantar pressure is also assessed in patients with pain, diabetes or rheumatism to overcome foot problems [25].

In addition, several comparative studies have been performed on plantar pressure and balance in patients suffering from different diseases, but not many of them have been on foot changes in the general population. One of the drawbacks of this analysis is its modest sample size. Further future research involving more cohorts of different ages may improve reliability with a variety of outcomes.

Conclusion

The findings of this study can be used as basic evidence for exercise programs in order to increase the level of spontaneity in the obesity community by increasing the hindfoot level, or for studies on reducing foot swaying.

Clinically, our findings imply that barring progressive metabolic changes that may precipitate type II diabetes and associated neuropathy, youth with obesity. Further clinical studies on patient populations are needed to validate these conclusions, as well as to determine whether and how they can be precisely applied to different populations. Our findings could prove valuable in various areas of application. However, despite limitations, the results of this study provided preliminary information for future prospective, randomized clinical trials with larger samples. In addition, to the best of our knowledge, this is the first study defining the hindfoot surface area and correlating it with the height and weight of the individual.

Acknowledgment

The author acknowledges the efforts of Mr. Hassan Mohammad Iqbal, lecturer of the anatomy, college of medicine, Northern Border University for all his extended help during this project.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Wade FE, Mok KM, Fong DT. Kinematic analysis of a televised medial ankle sprain. Asia Pac J Sports Med Arthrosc Rehabil Technol. 2018;12:12-16.
2. Maceira E, Monteagudo M. Subtalar anatomy and mechanics. Foot Ankle Clin. 2015;20(2):195-221.
3. Jotoku T, Kinoshita M, Okuda R, Abe M. Anatomy of ligamentous structures in the tarsal sinus and canal. Foot Ankle Int. 2006;27(7):533-8.
4. Chatha WA. Correlation of Planter Arch index from Ink foot prints with BMI in medical students at Northern Border University Arar – A preliminary study. Pakistan J Medical Health Sci. 2019;(13): 956-58.
5. Murley G, Menz H, Landorf K. Foot posture influences the electromyographic activity of selected lower limb muscles during gait. J Foot Ankle Res. 2009;2(1):35.
6. Thomas MJ, Roddy E, Zhang W, Menz HB, Hannan MT, Peat GM. The population prevalence of foot and ankle pain in middle and old age: a systematic review. Pain. 2011;152(12):2870–80.
7. Gill TK, Menz HB, Landorf KB, Arnold JB, Taylor AW, Hill CL. Predictors of foot pain in the community: the north West Adelaide health study. J Foot Ankle Res. 2016;9:23.
8. Butterworth PA, Landorf KB, Smith SE, Menz HB. The association between body mass index and musculoskeletal foot disorders: a systematic review. Obes Rev. 2012;13(7):630–42.
9. Mickle KJ, Steele JR. Obese older adults suffer foot pain and foot-related functional limitation. Gait Posture. 2015;42(4):442–7.
10. Butterworth PA, Urquhart DM, Landorf KB, Wluka AE, Cicuttini FM, Menz HB. Foot posture, range of motion and plantar pressure characteristics in obese and non-obese individuals. Gait Posture. 2015;41(2):465–69.
11. Birtane M, Tuna H. The evaluation of plantar pressure distribution in obese and non-obese adults. Clin Biomech (Bristol, Avon). 2004;19(10):1055–9.
12. Fabris SM, Valezi AC, de Souza SA, Faintuch J, Cecconello I, Junior MP. Computerized baropodometry in obese patients. Obesity Surgery. 2006;16(12):1574–78.
13. Van Leeuwen KD, Rogers J, Winzenberg T, van Middelkoop M. Higher body mass index is associated with plantar fasciopathy/"plantar fasciitis": systematic review and meta-analysis of various clinical and imaging risk factors. Br J Sports Med. 2016;50(16):972–81.
14. Irving DB, Cook JL, Young MA, Menz HB. Obesity and pronated foot type may increase the risk of chronic plantar heel pain: a matched case-control study. BMC Musculoskelet Disord. 2007;8:41.
15. Sullivan J, Burns J, Adams R, Pappas E, Crosbie J. Plantar heel pain and foot loading during normal walking. Gait Posture. 2015;41(2):688–93.
16. Cameron AJ, Magliano DJ, Dunstan DW, Zimmet PZ, Hesketh K, Peeters A, et al. A bi-directional relationship between obesity and health-related quality of life: evidence from the longitudinal AusDiab study. Int J Obes. 2012;36(2):295–303.
17. Kroenke K, Wu J, Bair MJ, Krebs EE, Damush TM, Tu W. Reciprocal relationship between pain and depression: a 12-month longitudinal analysis in primary care. J Pain. 2011;12(9):964–73.
18. Luppino FS, de Wit LM, Bouvy PF, Stijnen T, Cuijpers P, Penninx BW, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. Arch Gen Psychiatry. 2010;67(3):220–9.
19. Jiang L, Xie X, Wang Y, Wang Y, Lu Y, Tian T, et al. Body mass index and hand osteoarthritis susceptibility: an updated meta-analysis. Int J Rheum Dis. 2016;19(12):1244–54.
20. Cancello R, Clement K. Is obesity an inflammatory illness? Role of low-grade inflammation and macrophage infiltration in human white adipose tissue. BJOG. 2006;113(10):1141–47.
21. Viester L, Verhagen EA, Oude Hengel KM, Koppes LL, van der Beek AJ, Bongers PM. The relation between body mass index and musculoskeletal symptoms in the working population. BMC Musculoskelet Disord. 2013;12(14):238.
22. Al Snih S, Graham JE, Kuo YF, Goodwin JS, Markides KS, Ottenbacher KJ. Obesity and disability: relation among older adults living in Latin America and the Caribbean. Am J Epidemiol. 2010;171(12):1282–88.
23. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27(5):1047–53.
24. Hong DJ, Park SB, Lee SG; Lee KM. Analysis of the stance phase in a Hemiplgeic patient by measurement of plantar pressure. J Korean Acad Rehabil Med. 1998;1123-28.

How to cite this article:
Wajid Ali Chatha. A corroborative study of effects of body mass index on the anatomical region of hindfoot. Ann Clin Anal Med 2022;13(6):679-682