ORIGINAL ARTICLE

UDC: 616-071.3:611.98/.986]::617.585/.586
DOI: https://doi.org/10.2298/VSP201030015K

The value of Gissane's angle in the population of Central Serbia

Vrednost Gissane-ovog ugla kod stanovništva centralne Srbije

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Abstract

Background/Aim. Determining the value of Gissane's angle (GA) plays a role in the diagnosis and prognosis of heel fractures, determining treatment methods, and assessing the outcome of surgical treatment. Normal values of the GA vary in relation to ethnicity, age, and gender of the examined group, which indicates its anthropometric significance. The aim of this study was to determine the range of normal GA values in the population of Central Serbia. **Methods.** GA was determined on lateral radiography of the foot of 145 subjects of both sexes (67 women and 78 men), with subjects divided into 6 age groups. The patients included in the study did not have a calcaneus fracture. The obtained results were processed in the Graph Pad program. **Results.** The average value of GA in Central Serbia was 110.8° ± 8.1°, ranging from 93° to 132.9°. The mean value of GA decreased with age, and no difference was observed between women and men, except in the youngest age group, where women had higher GA values than men. **Conclusion.** The results of the study showed a wide range of normal GA values, as well as the existence of a difference in subjects of different ages and sex.

Key words:
anthropometry; calcaneus; fractures, bone; heel; radiography; sex factors; serbia.

Apstrakt

Uvod/Cilj. Određivanje vrednosti Gissane-ovog ugla (GU) ima ulogu u dijagnostikovanju i prognozi preloma pete, određivanju metoda lečenja, i u proceni uspeha operativnog lečenja tog preloma. Normalne vrednosti GU pokazuju varijacije u odnosu na etničku pripadnost, životno doba i pol ispitivane grupe, što ukazuje na njegov antropometrijski značaj. Cilj istraživanja bio je utvrđivanje raspona normalnih vrednosti GU kod stanovništva centralne Srbije. **Metode.** GU je određivan na lateralnim radiografijama stopala 145 ispitanika, oba pola (67 žena i 78 muškaraca), a ispitanici su bili podeljeni u 6 starosnih grupa. Ispitanici koji su bili uključeni u istraživanje nisu imali prelom petne kosti. Dobijeni rezultati su obrađivani u *Graph Pad* programu. **Rezultati.** Prosečna vrednost GU u centralnoj Srbiji iznosila je 110.8° ± 8.1°, u rasponu od 93° do 132.9°. Utvrđeno je smanjenje srednje vrednosti GU sa povećanjem godina života, a nije nađena razlika između žena i muškaraca, izuzev u najmlađoj starosnoj grupi, u kojoj su žene imale veće vrednosti GU od muškaraca. **Zaključak.** Rezultati ispitivanja pokazali su veliki raspon normalnih vrednosti GU, kao i postojanje razlika kod ispitanika različite starosti i pola.

Ključne reči:
antropometrija; kalkaneus; kost; prelomi; zaceljenje; radiografija; pol, faktori; srbija.

Introduction

The calcaneus, the heel bone, is the largest tarsal bone, whose role is to provide stability and maintain a high degree of whole-body pressure [1]. All fractures of the calcaneus can be divided into extraarticular and intraarticular, totaling 2% of all bone fractures, as well as 75% of tarsal bone fractures [1, 2]. Fractures occur most often due to a fall from a height, and in most cases in the younger adult population aged 21–45 [3]. The morphometric dimensions of the calcaneus show ethnic heterogeneity and, in addition, may influence the plan of surgical treatment after injury [4]. Depending on the study, different normal values were reported: 95°–105°, 96°–152°, 100°–130°, 120°–145° [5]. The diagnosis of fractures is made based on lateral and anteroposterior radiographs of the foot [6]. Radiographs of the foot provide accurate information about calcaneus morphology and angular relationships and are, therefore, the

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method of choice in measuring the value of Gissane's angle (GA) [7]. Imaging methods play a major role in the diagnosis of calcaneus fractures, thus radiological measurement of GA values, together with Bohler angle (BA) values, is an important parameter both in the diagnosis and in the treatment and prognosis [8]. However, it should be emphasized that they cannot be used as an independent criterion when choosing a method of treatment and diagnosis and that in addition to measuring calcaneal angles, it is necessary to determine the severity and location of fractures as well as dislocation of fragments, insight to which these angles do not provide [9]. GA (also known as the critical angle, the critical angle of Gissane) is named after Dr. William Gissane (1898–1981), an Austrian professor of orthopedics [10]. GA is measured by the intersection of a line drawn from the highest point of the posterior articular facet to the highest point of the posterior tuberosity and a line from the former to the highest point on the anterior articular facet (Figure 1).

Fig. 1 – Measurement of the critical angle of Gissane.

Since it was described before the discovery of computed tomography in the 1960s, its values, along with BA values, have been the only parameter in assessing the severity of calcaneus fractures for a long time. Although nowadays the use of computed tomography is standard for assessing those injuries, GA and BA are still used in the assessment of fracture severity and decision-making about the therapy of calcaneus fractures [11].

Previous studies have shown different mean GA values measured in subjects who did not have a heel bone fracture. The aim of this study was to determine the range of normal GA values in the population of Central Serbia in order to help surgeons in decision-making. Moreover, possible differences in relation to gender, ethnicity, and the age of the respondents indicate the anthropometric significance of GA.

Methods

This retrospective study included 145 lateral radiographies of the foot, subjects of both sexes (67 women and 78 men) divided into 6 age groups (10–20; 21–30; 31–40; 41–50; 51–60; > 60 years). The research was conducted at the Military Medical Academy in Belgrade from October 1st, 2017, to June 30th, 2018. The images were taken on a Shimadzu digital X-ray machine with a Bucky grid, 40 kV, 5 mAs, and 110 cm focus film distance. Images were analyzed from radiographies taken for medical indications. The population in which the calcaneus fracture was not present was included in the study. In addition, the population under 10 years of age was not included considering that the calcaneus completes its development after the tenth year of life. The values were measured by two observers, independently of each other, and the measurement was repeated after two weeks in order to reduce the error.

Results were presented as mean ± standard deviation (SD). The obtained results were analyzed using Sigma Plot 12.0 (Systat Software) statistical program. As data had normal distribution and equal variance, as asserted by Shapiro-Wilk and equal variance tests, the appropriate parametric test was used. Data were analyzed by the two-way analysis of variance (ANOVA) followed by Holm-Sidak post hoc, with factors "sex" and "age". Significance was accepted at $p < 0.05$.

Results

GA was examined in 145 subjects of both sexes, divided into 6 age groups. The mean GA value in the whole examined group was 110.3° ± 8.4°, in the range from 93° to 132.9°. In the group of female subjects, the measured angle averaged 110.9° ± 8.9° in the range from 93° to 132.9°, while in male subjects, its value was on average 109.9° ± 8.1° while the range was from 93.8° to 132°. There was no statistically significant difference between males and females ($p = 0.0213$).

The GA value was also compared in different age groups. The youngest age group (respondents aged 10–20) had the highest mean value of the measured angle, which was expected due to the characteristics of the heel bone in the adolescent period. GA shows a tendency to decrease with age, and accordingly, the lowest values were observed in subjects older than 60 years. Differences between group mean values were shown between the 10–20 years and 21–30 years groups and all older groups (Figure 2A).

Additionally, when age groups were separated by gender, a significant difference was found within the

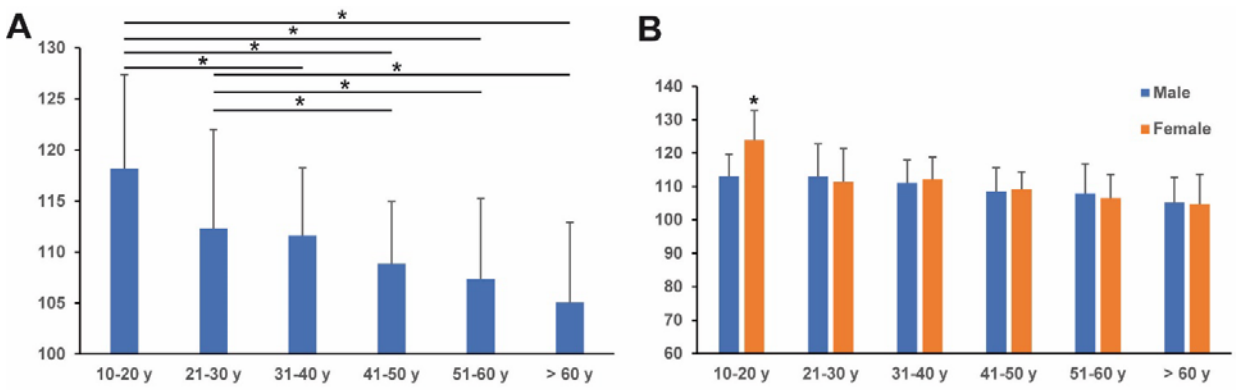

Fig. 2 – Mean values of Gissane angles per age group and gender: A) The mean ± standard deviation (SD) values for angles at various age groups. Asterisks mark significant differences in group mean values ($p < 0.05$; two-way ANOVA with Hold-Sidak post hoc); B) The mean ± SD values for angles at various age groups, separate for males and females. Asterisk marks significant differences in group mean values ($p < 0.05$; *t*-test). y – years.

youngest group (10–20 years), with females having significantly larger angles (123.9° ± 6.5°) compared with males (118.2° ± 9.2°), as shown in Figure 2B.

Discussion

On the lateral radiography of the foot, facies articularis anterior and posterior calcanei form a crucial angle or the GA. During the action of excessive axial compression forces, a calcaneus fracture occurs when the talus process acts as a 'wedge', disrupts the bone between anterior and posterior articular surface [12] of the calcaneus as well as underlying Ward's neutral triangle leading to an even bigger displacement or depression of fragments. All this leads to changes in the values of GA and BA. Since the calcaneus is the most vulnerable tarsal bone [8], knowledge of the value of GA proved important in the diagnosis of heel bone fracture, with an increase in GA values relative to the uninjured side.

We were attracted by the variations in the range of normal GA values in different populations and also by the fact that no literature suggested similar research done on the topic of average GA values in the population of Serbia.

Our study has shown a wide range of normal GA values, which coincides with previous research done on this topic [11–13]. The average value of GA in the examined population of Central Serbia was 110.3° ± 8.4°, while the range of values varied from 93° to 132.9°. The values obtained in the population of Central Serbia were lower than the values of most previously obtained results in various populations [5, 8, 9, 12, 14]. We did not observe significant differences among genders in GA values of the whole study group, similar to findings in previous studies done in Turkey, Saudi Arabia, Egypt, and Brazil [5, 11, 12]. The radiological study conducted in Brazil [11] did not show a statistically significant difference in the value of GA between the subjects of different sexes, as well as among subjects of different age groups, and the values that they reported (110.6° ± 11.9°) were similar to those in our study [11]. The mean values of the measured angle in the Egyptian population were higher (122.9° ± 6.52°) [12]. In the Serbian population, clear differences in GA values were observed between the examined age groups. Unlike our research, where the highest GA values were measured in the youngest group (10–20 years), in the Egyptian study, the highest value was found in the 41–50 years age group [12]. In the population of Egypt, the lowest values were measured in people aged 51–60 [12], while we observed a linear decline in GA values among the age groups, with the lowest values measured in people older than 60.

We also analyzed data from two studies performed in India. In the first study, the value of GA was measured in the population of South India, and it was on average lower (108.5°) than in the Serbian population [8]. In another study, which involved subjects from all regions in India, average GA values were measured at 126.72°, higher than those in our study [3]. Neither of these two studies found an association between the value of the measured angle and age or sex [3, 8].

A similar retrospective study was also conducted in South Korea using cadaveric calcaneus and a digital goniometer for the estimation of calcaneal angles. The mean value of GA was 114° ± 8.2°, and their values were higher than in our study. In this study, a statistically significant difference was shown between the values obtained in the female population (112.5° ± 8.1°) and the male population (117.7° ± 7.4°) [14]. In our study, the difference between males and females was present only in the youngest age group, and it was the opposite – females had larger angles than males. The GA of the population of Serbia is higher compared to the populations of Japan and Thailand, where the mean GA value was 105.1° ± 7.5° [15]. Similar mean GA values were obtained in a study conducted in Nigeria (116.29° ± 8.29°), Turkey (115° ± 6.5°), and Saudi Arabia (116.16°) [5, 13, 16]. None of these studies demonstrated a significant difference between the results obtained in males and females. In studies conducted in Turkey and Saudi Arabia, the value of GA was measured on both lower extremities, and no statistically significant difference between the left and the right side was shown [5, 13].

Table 1

The review of various studies reporting regional Gissane's angle (GA) values

Country	GA value	Age difference	Sex difference	Reference
Serbia	110.3	young > old	F > M	Our study
Brazil	110.6	no	no	11
Egypt	122.9	yes	N/D	12
South India	108.5	no	no	8
India	126.7	no	no	3
South Korea	114.8	N/D	M > F	14
Japan, Thailand	105.1	N/D	N/D	15
Nigeria	116.3	no	no	16
Turkey	115	no	no	13
Saudi Arabia	116.2	no	no	5
Kwara	64	N/D	no	17

F – female; M – male; N/D – not done.

The lowest GA values of all previously published research on this topic were reported among the population of Kwara, where a significant difference was found in the values of the measured angle on the right and left foot (right foot: 63.94° ± 20.58°; left foot: 80.23° ± 26.68°) [17]. In this study, there was also no difference between the sexes [17].

Variations in normal GA values concerning the ethnicity of the subjects were shown in different studies. The highest values obtained in the works published so far were observed in the population of India (126.79°) and Egypt (122.9° ± 6.952°), among Caucasians [3, 12]. In a study conducted in Nigeria, the mean GA value was 116.29° ± 8.29°, while in the Kwara population, it was 63.94° ± 20.58°, indicating a wide range of normal values of the negroid race [16, 17]. Within the Mongoloid race, the study was conducted on the population of the Korean people and Thai and Japanese people, where the mean GA value was 114° ± 8.2° and 105.1° ± 7.5° [14, 15], respectively. The mean values in a Portuguese group of subjects older than 18 years were 112.8° ± 7.4° [18]. The summary of the aforementioned studies in relation to our data is shown in Table 1.

When diagnosing a calcaneus fracture, it is important to know that GA values may be enlarged due to this injury [19], whereby maintaining normal GA values is a good prognostic sign. Therefore, such patients are considered to have a better long-term outcome [20]. Conservative treatment is usually recommended for extraarticular fractures, while intraarticular fractures should be treated surgically, where one of the goals is to return GA to the normal, pre-injury range [19].

One of the study limitations is that the measurements were performed on one foot only. In available studies among Caucasians, no significant difference was published comparing left and right foot calcaneal angle values. However, some authors recommend the use of lateral radiographies of the contralateral foot while planning operative procedures [3].

Conclusion

The range of normal GA values varies in different populations, which was confirmed in this study as well. A statistically significant difference in GA in the population of Central Serbia in relation to the age of the respondents was also shown.

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Received on October 30, 2020
Revised on February 10, 2021
Accepted on February 10, 2021
Online First February 2021