

# The differences in the ankle range of motion in distinct ethnical groups measured by goniometry

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## Keywords

Range of motion, ankle joint, ethnicities, goniometry

## Summary

The aim of this study was to evaluate if there are any differences in the range of motion of the ankle joint for distinct ethnicities measured by goniometry. A total of 288 ankles of 152 individuals were evaluated and divided into four ethnic groups: 18 male and 20 female Caucasians (75 ankles), 11 male and 26 female Oriental individuals (72 ankles), 25 male and 16 female Black people (70 ankles) and 19 male and 17 female Mulattos (71 ankles). All of the participants were of similar ages and were examined in a single evaluation in the morning by the same examiner using the same goniometric device. Statistical analysis was achieved using means and standard deviation and a comparison of the scores, z-statistics of the normal distribution were calculated with an alpha error of 5% considered acceptable. The total mean obtained from all ethnical groups, considering both left and right legs and both genders, was 60.45°. The averages of the distinct ethnicities were: 63.84° for Caucasians, 66.91° for Orientals, 55.21° for Black people and 55.87° for Mulattos. All groups were significantly different in relation to ankle motion range compared to the other groups, except between Black people and Mulattos. There were statistically significant differences when separately analyzing the means of goniometric measures of the right and left ankles in men and women of the Caucasian and Oriental ethnic groups.

**Conclusion:** There are significant differences in respect to the ankle motion range among the distinct pure ethnic groups and there is a predominance of characteristics of Black people in the Mulatto group in respect to this variable compared to Caucasian traits.

## Schlüsselwörter

Bewegungsumfang, Sprunggelenk, Ethnien, Goniometrie

## Zusammenfassung

In dieser Studie sollte untersucht werden, ob bei verschiedenen ethnischen Gruppen Unterschiede im goniometrisch gemessenen Bewegungsumfang des Sprunggelenks bestehen. Insgesamt wurden 288 Knöchel von 152 Personen aus 4 ethnischen Gruppen untersucht: 18 männliche und 20 weibliche Kaukasier (75 Knöchel), 11 männliche und 26 weibliche Asiaten (72 Knöchel), 25 männliche und 16 weibliche Schwarze (70 Knöchel) sowie 19 männliche und 17 weibliche Mulatten (71 Knöchel). Alle Teilnehmer waren etwa gleich alt und wurden einmalig morgens von demselben Untersucher und mit demselben goniometrischen Messgerät vermessen. Statistische Auswertung: Mittelwert, Standardabweichung und Vergleich der Messwerte, bei der Berechnung der Z-Statistik der Normalverteilung galt ein alpha-Fehler von 5% als akzeptabel. Der Mittelwert über alle ethnischen Gruppen, sowohl für linke als auch rechte Knöchel und für beide Geschlechter, lag bei 60,45°. Die Durchschnittswerte in den einzelnen Ethnien betragen 63,84° für

Kaukasier, 66,91° für Asiaten, 55,21° für Schwarze und 55,87° für Mulatten. Hinsichtlich des Bewegungsumfangs des Sprunggelenks ergaben sich signifikante Unterschiede bei allen Gruppen im Vergleich zu den anderen Gruppen, außer zwischen Schwarzen und Mulatten. Statistisch signifikante Unterschiede ergaben sich bei der getrennten Auswertung der mittleren goniometrischen Messwerte der rechten und linken Knöchel bei Männern und Frauen der kaukasischen und asiatischen Gruppen. **Schlussfolgerung:** Es gibt signifikante Unterschiede in Bezug auf den Bewegungsumfang des Sprunggelenks zwischen einzelnen reinrassigen ethnischen Gruppen, und bei Mulatten dominieren bezüglich dieser Variablen die Charakteristika der Schwarzen im Vergleich zu den kaukasischen Merkmalen.

## Mots clés

Degré de mobilité, chevilles, différences ethniques, goniométrie

## Résumé

Le but de cette étude est d'évaluer d'éventuelles différences du degré de mobilité de la cheville dans différents groupes ethniques par goniométrie. Au total 288 chevilles de 152 personnes ont été évaluées et divisées en 4 groupes ethniques : 18 hommes et 20 femmes de type caucasien (75 chevilles), 11 hommes et 26 femmes de type oriental (72 chevilles), 25 hommes et 16 femmes de race noire (70 chevilles), 19 hommes et 17 femmes métissés

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## Goniometrisch erfasste Unterschiede der Sprunggelenkbeweglichkeit in verschiedenen ethnischen Gruppen

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## Différences du degré de mobilité de la cheville dans différents groupes ethniques mesurés par goniométrie

(71 chevilles). Tous les participants étaient d'âge semblable et ont subi une évaluation unique un matin par le même examinateur utilisant le même appareil de goniométrie. L'analyse statistique a été effectuée en utilisant des déviations standard et des moyennes et en comparant les scores, „Z-statistique” par rapport à une sélection normale; le calcul a été admis avec une marge d'erreur alpha de 5%. La moyenne générale obtenue pour tous les groupes ethniques, en considération des deux jambes et des deux sexes était de 60,45°. Les moyennes des différents groupes ont été de 63,84° pour les caucasiens, de 66,91° pour les orientaux, de 55,21° pour les gens de race noire et de 55,87° pour les métis. Les deux premiers groupes ont montré des différences significatives de la mobilité de la cheville comparés aux groupes de race noire et des métis. On a noté des différences significatives dans les analyses séparées de la moyenne des mesures goniométriques entre le côté droit et le côté gauche chez les hommes et les femmes caucasiens et chez les orientaux. **Conclusion** : Différences significatives de la mobilité de la cheville entre les groupes ethniques purs et une prédominance des caractéristiques des gens de race noire chez les métis par rapport au groupe de race caucasienne.

Normal amplitude of flexibility is essential for human motion and this depends on an adequate function of the bones, muscles, nerves, tendons, capsules, ligaments and cartilages (1, 2). The mobility of the talocrural or

tibiotarsal joints, due to their importance in movement and the venous return system of the lower limbs, with consequent participation in the diagnosis of chronic venous insufficiency (CVI), has been the subject of research over the last few decades (3–6). A limitation in the degree of flexibility of the ankle related to CVI has been demonstrated in patients categorized as C2 in the CEAP classification and edema can limit patients with classification of C3 or greater (7). Limbs with severe CVI present with very impaired flexibility of the ankle, that means, there is a direct relationship between the severity of the CVI and the rigidity of the ankle. This shows that although venous return is multifactorial, it depends on the flexibility of the talocrural joint to guarantee an adequate ejection of the calf muscle pump (CMP) (2).

Current authors consider the ankle to be one of the main so-called impulse-suction pumps of the lower limbs (8). This joint connects and enables synergism between the distal pumps of the foot and leg and is directly responsible for much of the volume ejected by the CMP, whose impairment is frequently the cause of high walking pressures and can lead to more serious complications with CVI, including ulcers due to stasis (9, 10).

Studies have proven that there are variations in the degree of mobility of the ankle related to gender and age, in apparently normal individuals (1, 11).

The aim of this work was to identify, by means of goniometry, possible differences in the mobility of this joint in distinct ethnic groups.

## Patients and methods

Individuals were randomly selected from the community in order to evaluate differences in the flexibility of the talocrural joint. The individuals were divided into four ethnic groups: Oriental (individuals born in Japan or children of Japanese) with ages between 17 and 61 years old (mean 37.05 years); Caucasians with ages between 18 and 56 years old (mean 31.13 years); Black people (the majority being university students from Guinea Bissau) with ages from 17 to 63 years old (mean 34.4 years) and mulattos (from the marriage of Caucasians with black people) with ages between 15 and 66 years old (mean 31.36 years). In total 288 ankles of 152 individuals were evaluated in this study. The mobility of the legs was classified using the CEAP system as 169 ankles categorized as C0, 88 ankles as C1 and 31 ankles as C2 (12). All the participants were evaluated but only ankles classified as C2 or less were included in the research. The study sample consisted of 72 ankles of 37 oriental individuals (26 women and 11 men), 75 ankles of 38 Caucasians (18 men and 20 women), 70 ankles of 36 black people (25 men and 16 women) and 71 ankles of 36 mulattos (19 men and 17 women).

Individuals who presented with edema or dermatological diseases in the region of the ankle, as well as those with acquired or congenital orthopedic pathologies, rheumatic or recent or long term trauma that might limit the flexibility of the talocrural joint were excluded from the study. Moreover, individuals with edema of the lower limbs caused by other conditions such as renal, hepatic, cardiac or myxomatous diseases were also excluded.

A goniometric method modified by Belczak was utilized to measure the flexibility of the ankle (13). The evaluations were all performed by the same examiner.

All the patients signed informed written consent forms before participating in the study and the study design was approved by the Ethics Committee of the institution. All the examinations were performed in the morning over a period of about three months (from May to August 2005). Statistical analysis was achieved using means and standard deviations and to compare the scores, z-statistics of the normal distribution were calculated with an alpha error of 5% considered acceptable.

**Tab. 1** Mean of each ethnic group considering right and left ankles separately and combined and mean degree of flexibility

ethnicity	total of means (°)	mean (°)		gender	AR (°)	total mean (°)	AL (°)
		right	left				
oriental	66.91	66.95	66.41	11 men	65.90	66.08	66.27
				26 women	68.00		
caucasian	63.84	63.85	63.92	18 men	65.16	65.08	65.00
				20 women	62.55		
black people	55.21	54.88	55.39	25 men	56.84	55.86	54.89
				16 women	55.94		
mulatto	55.87	56.39	55.35	19 men	56.84	55.86	54.89
				17 women	55.94		

AR: mean right ankle; AL: mean left ankle

## Results

The mean obtained of all individuals, including both left and right ankles and men and women, was 60.45°. ► Tables 1 to 3 show the means for the ethnic groups, the mean degree of flexibility of the ankle and the calculation of the measurements of the position and spread of the total goniometric measurements of the right and left ankles of men and women.

The mean age was 37.05 (standard deviation 11.64) years for the Oriental individuals, 31.13 (standard deviation 12.08) for Caucasians, 31.36 (standard deviation 13.84) for mulattos and 34.47 (standard deviation 13.02) for black people, without demonstrating statistically significant differences between groups ( $p < 0.1$ ).

There was no significant difference between the means of all the measurements for the right and left ankles of the men and women between the mulattos and black people but there was a significant difference between mulattos and Caucasians, mulattos and Oriental individuals, Caucasians and Oriental individuals, Caucasians and black people, mulattos and Caucasians, and Oriental individuals and black people ( $p < 0.05$ ).

As the variation coefficients are contained within the interval of 10 to 20% for the total means of the right and left ankles of men and women in each of the four ethnic groups, the representativity is considered good because the spread (standard deviation) of the data is close to the mean.

## Discussion

In the current study, precautions were taken to exclude individuals with classifications of greater than C2 according to the CEAP classification. This was because there have been reports of limitations in ankle mobility in patients with CVI classified as C3 or above (7). It has also been reported that limbs with severe CVI present with reduced mobility of the ankle, that is, there is a direct relationship between the severity of the CVI and the rigidity of the articulation. This shows that although venous return is multifactorial, it depends on the flexibility of the talocrural joint to guarantee an adequate ejection of the CMP (2). Epidemiological studies (14, 15) did not con-

**Tab. 2** Calculation of the position and spread of the measurements, goniometric measurements (totals) of the right and left ankles of men and women in respect to ethnic group

ethnicity	N	mean	variance	standard deviation	total amplitude	coefficient of variation
mulatto	71	55.8732	105.4551	10.2691	79–30=49	18.38%
Caucasian	75	63.84	51.4876	7.1755	77–45=32	11.24%
Oriental	72	66.9167	76.5	8.7464	86–48=38	14.52%
black people	70	55.2143	60.6635	7.7886	75–45=30	14.11%

clude whether there are differences in the amplitude of the movement of the talocrural joint in the various ethnic groups or whether these differences interfere in the incidence or prevalence of CVI of the lower limbs.

An important aspect to be analyzed is the suggestion that the age influences the degree of flexibility of this articulation (11). It has been reported that there is a general decrease in the amplitude of movements of the talocrural and tibiotarsal joints from early adulthood (ages between 20 and 39 years old) up to 70 to 89 years old (16). However, the age at which reduction in the flexibility starts has not been precisely defined. In the elderly, the alterations are notable; a reduction of activities in this group is considered to be the main cause of these limitations. The flexibility of the ankle has been compared in different age ranges demonstrating that there is a reduction of 15% in the mobility of this joint between individuals in their 80s and those in their 30s (1). Another study showed a variation in the articular movement according to age with the greatest fluctuations in children and the elderly (17). With increasing ages there is a decrease in the

amplitude of ankle movements of both genders with a greater flexibility reported for women when compared with men (18); a fact that was not proven in the current study.

The talocrural angle, introduced for the first time in 1980, shows the flexibility of this joint and provides data on the mobility of the ankle (18). This became known as the range of ankle motion. The normal range is considered to be

- 45 to 54° for plantar flexion and
- 7 to 15° for dorsal flexion (20, 21).

The measurement of the amplitude of the movement of the talocrural joint has been widely used to plan rehabilitation therapies for both orthopaedic and vascular problems (22–25).

The association between ulcers caused by venous stasis and a reduction of ROAM was established for the first time in 1931 (7). Later, in 1982 it was demonstrated that 32% of patients with ulcers had considerable limitations in the movements of the ankle and that only 9% of them suffered from rheumatoid arthritis (26). However, there is no consensus on the affect of joint mobility in ethnic

**Tab. 3** Calculation of the z-statistics of the normal distribution for the differences between the two measurements, total goniometric measurements of the right and left ankles of men and women in respect to racial background and the z-statistics value of the normal table

difference between racial groups	Z				p- value
	table	calculated			
Caucasian-mulatto	1.96	5.46	2.64	5.71	<0.05*
mulatto-black people		0.37	0.1027	0.99	>0.05
Oriental-mulatto		6.97	4.30	6.52	<0.05*
Oriental-Caucasian		2.33	2.59	0.53	
Oriental-black people		8.43	6.45	5.30	
Caucasian-black people		6.92	4.34	5.71	

\*statistical difference

groups on the severity of chronic venous insufficiency.

The differences in the degree of mobility between individuals is not only attributed to genetic traits, but also to the habits of individuals, including posture, and daily activities (27). This is an important consideration when the study sample compares distinct ethnic groups as in the present study.

In one study, the variations of the range on ankle mobility between German Caucasians and Japanese reduced with increases in age. This was interpreted as a normal process of aging, but there was a greater loss of mobility among the Germans. In the current study, the miscegenation of the ethnic groups in Brazil enabled an analysis of mulatto individuals (marriages between black people and Caucasians). The mixed marriages influenced articular mobility of the ankle with a predominance of the genetic aspects of black people compared to Caucasians.

The gender and age was stressed in a study that identified women between the ages of 20 and 39 years old as having greater flexibility than men of the same age range. On the other hand, in older age ranges the men have greater mobility than women (16). These data were not confirmed in the current study.

Another consideration concerning the ethnic and age aspects is the style of life associated to articular mobility (19). For example, classical western ballerinas have higher degrees of plantar flexion. However, Japanese sumo wrestlers present with the greatest dorsal flexion because they are accustomed to spending long periods crouched on their heels, thereby facilitating the articular movement of the ankle.

This study identified differences between the mobility of the left and right ankle joints in respect to the gender and ethnic group. On considering the mean value for right and left ankles together, only women demonstrated significant differences between groups with the exception of the comparison between the mulatto and black people groups. With men there were no significant differences detected in relation to ethnicity.

Comparing only the right ankles or only the left ankles in isolation, there are significant differences both for the women and the men among the ethnic groups. The exceptions were when comparing black people with mulattos and Oriental individuals with Caucasians.

A study demonstrated that in normal German and Japanese individuals, the talocrural joint amplitude in the relaxed position was 78.4° for women and 78.6° for men and thus without significant difference between genders. The maximum extent of movement, that is, the total angle obtained was 63.9° for women. In terms of statistical significance, it was greater than for men (58.2°), as was demonstrated by these authors in two non-related random tests (18). They suggest that the greater mobility for women is based on the greater capacity of plantar flexion compared to men and showed that Japanese also did not present any difference in the talocrural angle in the relaxed position between the genders. It resulted in 75.5° for women against 75.4° for men. No statistically significant differences were observed in the maximum extent of the movement for women (68.5°) and men (65.9°).

There have been insufficient comparative studies to come to a consensus on this subject, with only a few studies published about Caucasians in Europe and Oriental individuals and even less on black people and those of mixed origin (28). For more definitive conclusions to be reached an analysis of larger study samples will be necessary and a study of individuals with more advanced venous pathologies.

## Conclusion

There are differences in the degree of mobility of the ankle between ethnic groups with an influence of the gender and whether the right or left ankle is being evaluated. With mixed marriages between black people and Caucasians, the genetic factors of the black people predominate in the amplitude of movements.

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