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Bjork – Jarabak Analysis between Two Different Ethnic Groups: A Comparative Study

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ABSTRACT

Aims: *The aim of this study was to use Bjork-Jarabak analysis to evaluate and compare cranial base linear and angular measurements in Sudanese patients with skeletal Class I, II, and III relationships, and compare the results with previous reports from Jordan and other regions.*

Material and Method: *A total of 103 pretreatment lateral cephalograms of Sudanese patients aged 18-22 years were analyzed.*

Results *showed that Sudanese males had significantly higher mean values for the Gonial angle and mandibular body length, while Sudanese females had significantly higher mean values for the Articulare angle. In Class I, Jordanians had significantly higher mean values for the Gonial angle and Bjork sum of angles compared to Sudanese. In Class II, only the saddle and articular angles showed significant differences. In Class III, Jordanians had significantly higher mean values for the Articulare angle, Gonial angle, Bjork sum of angles, and body of mandibular length compared to Sudanese. Additionally, Jordanian males exhibited significantly higher mean values for the Saddle angle, Bjork sum, and posterior cranial base compared to Sudanese males. However, Sudanese females exhibited an extremely statistically significant difference in ramal height, while Jordanian females showed significantly higher mean values for the Gonial angle and Bjork sum of angles compared to Sudanese females.*

Conclusion: *These findings are important for orthodontists to make accurate diagnosis and treatment decisions for patients, considering both appearance and function.*

Keywords

Cephalometric, Bjork polygon, Cranial base measurements.

Introduction and Review of Literature

Physical anthropologists have utilized the analysis of variations and relationships in craniofacial features of humans to differentiate between different racial groups for a significant period of time. An ethnic group can be defined as a population or country sharing common characteristics such as geography, culture, language, or racial or historical affiliations. Morphological traits of various racial and ethnic groups tend to cluster together geographically. Furthermore, research has indicated that facial morphology is influenced by geography, climate, and culture [1].

Facial balance and harmony are determined by the facial skeleton and the soft tissues that cover it. Nevertheless, it is the structure of the soft tissues above the facial skeleton and their relative proportions that create the visual impression of the face [2].

Brodie highlighted the significance of investigating the growth and development of the cranial base for orthodontic practitioners. This is because the proper diagnosis and treatment of malocclusions heavily depend on the growth of the entire craniofacial region [3].

Enlow observed that the mandible operates with more independence from the rest of the craniofacial region due to its relatively distant location. However, the mandible's articulation in the glenoid fossa still allows for some influence from the cranial base. On the other hand, the growth of the maxilla is regulated by the growth of the cranial base [4].

Changes in the rate or direction of cranial base growth can directly or indirectly impact the growth of the maxilla and mandible. Therefore, a comprehensive understanding of facial growth and development is essential for precise orthodontic diagnosis and treatment planning. The growth of the cranial base is closely associated with the overall growth of the facial bones, specifically the maxilla and mandible. Jarabak's cephalometric study primarily focuses on vertical intermaxillary correlations and employs the cranial base as a reference. This approach can aid in predicting various facial biotypes and sagittal skeletal malocclusions. The summation of the Bjork angles, which includes the saddle angle, Articulare angle, and Gonial angle, can determine whether the mandible rotates backward or forward. If the angle is greater than 400 degrees, the mandible rotates backward, and if it is less than 392 degrees, the mandible rotates forward [5,6].

A disagreement arose regarding the selection of certain markers for cranial base analysis, such as the choice between using the Basion (Ba) or Articulare (Ar) points. Bjork suggested utilizing the Articulare (Ar) point instead, as it is simpler to identify and can be located on lateral skull radiographs [7].

Conversely, Varjanne and Koski have contested the use of the Articulare (Ar) point due to its distance from the cranial base, and have advocated for the use of the Basion (Ba) point, despite the challenge of identifying it [8].

In 1996, Dibbets discovered that the average saddle angle is approximately 130 degrees. A less acute or more open cranial base angle is often associated with a retruded mandible and, consequently, a Class II facial pattern. Conversely, a more acute or closed cranial base angle is typically related to a more forward-positioned mandible and a Class III facial pattern [9].

Previous research has shown that individuals with Class II, Class I, and Class III anteroposterior (AP) relationships tend to exhibit a gradual decrease in cranial base angular and linear measurements. This finding was supported by Poff et al., who reported that participants with Class III sagittal relationships had smaller cranial base angles and shorter cranial base lengths compared to those with other skeletal relationships [10].

A comprehensive understanding of craniofacial growth and development is essential for successful orthodontic treatment. Differential growth in the transverse, vertical, and anteroposterior dimensions is all possible. Clinicians must pay careful attention to the assessment and significance of craniofacial growth when treating patients with a range of clinical situations because the face and teeth continue to change throughout life [11].

Patients are often enthusiastic about discussing their facial appearance and areas for potential improvement and are typically pleased to learn that orthodontic treatment is not solely focused on teeth. The face and temporomandibular joints (TMJs) are the first areas addressed in the treatment plan, and the objective of treatment is to preserve or enhance facial balance and harmony. Tooth movements should not cause any harm [12].

Aims

The current study's goal was to compare and ascertain the relationship between the cranial base characteristics between two different ethnic communities of Sudanese and Jordanian patients sought orthodontic treatment.

Materials and Methods

Sudanese data

The Sudanese sample consisted of 103 Sudanese adult patients (52 men and 51 women between the ages of 18 and 25) sought orthodontic treatment at the College of Dentistry in Khartoum University. Sudan. The *Web Ceph* application was used to digitally trace, measure, and evaluate the pretreatment lateral cephalometric measurements. All measurements were performed by one investigator. (I.G)

Jordanian data

The study conducted by Al Ma'aitah et al. [13] comprised of 288 Jordanian adult orthodontic patients (146 women, 142 men; mean ages of 21.24 +/- 2.72 and 22.94 +/- 3.28 years) attending orthodontic clinics at the dental teaching clinics/Jordan University of Science and Technology. Lateral cephalograms were hand traced in a dark room under the same standardized technique. Magnification of radiographs was adjusted using the radiopaque ruler (calibration marker). Points and lines were marked with a 3H pencil. All measurements were performed by the same investigator (E.A.M.) to reduce inter-examiner differences.

Individuals who had previously undergone orthodontic or orthognathic therapy, had craniofacial deformities, had sustained face injuries, or had asymmetries that were discovered were excluded from both ethnic groups.

Angular and Linear Measurements

The measurements derived from Bjork-Jarabak analysis included angular (Figure 1) and linear (Figure 2) measurements of a Bjork polygon. Moreover, the ANB angle—the angle created by points A, N, and B—was calculated.

Based on the ANB angle, the sample was divided into three skeleton classes. Class I, Class II, and Class III. Where, in Class I,

the ANB angle ranged from 2-4 degrees, Class II, the ANB angle was greater than 4, and Class III, the ANB angle was less than 2.

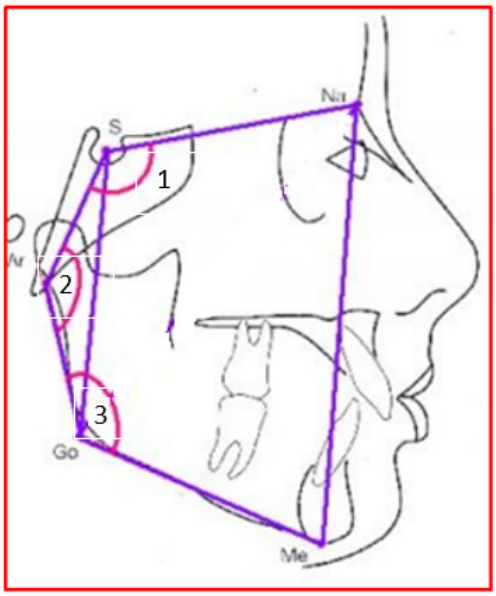

Figure 1: The angular measurements variables n.

The angular measurements include the following:

1) Saddle angle (N-S-Ar) is the angle formed between Nasion-Sella-Articulare.
2) Articular angle (S-Ar-Go): formed between Sella-Articulare-Gonion.
3) Gonial angle (Ar-Go-Gn): formed between Articulare-Gonion-Gnathion.
4) Sum of Bjork polygon angles: formed by the Sum of saddle, Articular and Gonial angles (Figure 1).

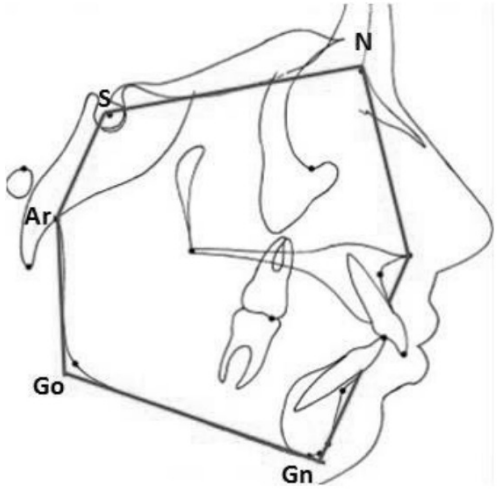

Figure 2: The linear measurements variables (Al Ma'aitah et al.)[13]].

The linear measurements include the following:

1) Sella-Nasion (S-N) is the distance between point Nasion and point Sella forming the anterior cranial base length.
2) Sella-Articulare (S-Ar) is the distance between point Sella and point Articulare forming the posterior cranial base length.
3) Articulare-Gonion (Ar-Go) is the distance between point Articulare and point Gonion representing the ramal height.
4) Gonion-Gnathion (Go-Gn) is the distance between point Gonion and point Gnathion representing the body of mandibular length (Figure 2).

Statistical Analysis

Statistical analysis was done using IBM SPSS version 22. Descriptive statistics, including means and standard deviations, were calculated for all measured variables. Additionally, an independent t-test was used to determine gender differences and differences between the Sudanese and Jordanian groups. A statistical significance level of $P < 0.05$ was used.

Results

Based on the table 1 results, it indicated that there are significant differences between Sudanese males and females in terms of Articulare angle and mandibular body length. Sudanese males have higher mean values of mandibular body length and Gonial angle compared to females, while Sudanese females have higher mean values of Articulare angle compared to males. However, there were no significant differences observed in the other angular and linear measurements.

Table 2 compares cranial base measurements between Sudanese and Jordanian individuals with class I skeletal relationship. The results show that there were no significant differences in saddle angle, articular angle, posterior cranial base, anterior cranial base, and mandibular body length between the two groups. However, significant differences were found in the Gonial angle and Bjork sum angle, with Jordanians having higher mean values than Sudanese. Additionally, the Sudanese sample had a significantly higher mean value for Ramal height (48.2mm) compared to the Jordanian sample (46.3mm) with a p-value of 0.001, indicating a very significant difference.

Table 3 showed the comparison between the Sudanese and Jordanian samples in class II group. The results indicated that there was no statistically significant difference in the Gonial and Bjork sum angles, posterior and anterior cranial base, ramal height, and mandibular body length ($P>0.05$). However, there were extremely statistically significant differences in the saddle angle, indicating that Jordanians had higher mean values than Sudanese, and in the Articular angle, indicating that Sudanese had higher mean values than Jordanians ($P<0.0001$).

The results of table 4 showed that Jordanians had significantly higher mean values for the Articular and Gonial angles compared to Sudanese, and extremely significant differences were noted in the mandibular body length. However, Sudanese individuals had quietly significant higher mean values for ramal height, while no statistically significant differences were observed in the saddle angle, anterior and posterior cranial base.

Table 1: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese males and females.

Cranial base measurements	Males N = 52	Males	Females N -51	Females	P- value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	122.7	5.0	123.5	4.4	0.391	Not Significant
Articular angle S-Ar-Go	145.5	6.6	148.1	5.9	0.044	Significant
Gonial angle Ar-Go-Gn	126.0	6.7	122.7	7.0	0.016	Significant
Bjork sum angle Sum of the above three angles	394.2	8.3	394.2	8.2	0.100	Not Significant
Posterior cranial base S-Ar mm	35.7	3.8	35.4	3.7	0.967	Not Significant
Anterior cranial base N-S mm	71.2	1.6	71.3	0.9	0.998	Not Significant
Ramal height Ar-Go-mm	48.9	5.4	47.7	5.4	0.626	Not Significant
Mandibular body length Go-Gn mm	78.7	6.5	76.4	5.1	0.049	Significant

* P < 05; ** P < 0 .01; *** P < 0.001, **** P< 0.0001.

Table 2: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese and Jordanian with class I skeletal relationship.

Cranial base measurements	Sudanese N =24	Sudanese	Jordanian N = 94	Jordanian	T. value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	123.7	4.7	124.1	5.1	0.4647	Not Significant
Articular angle S-Ar-Go	147.0	5.2	146.7	7.0	0.6105	Not Significant
Gonial angle Ar-Go-Gn	123.3	6.2	126.5	6.7	0.0001	Extremely Sig.
Bjork sum angle Sum of the above three angles	394.1	7.5	397.2	7.7	0.0001	Extremely Sig
Posterior cranial base S-Ar mm	37.0	3.8	36.0	4.0	0.2719	Not Significant
Anterior cranial base N-S mm	71.1	1.4	71.4	3.6	0.6902	Not Significant
Ramal height Ar-Go-mm	48.2	4.7	46.3	5.1	0.001	Very Significant
Mandibular Body length Go-Gn mm	77.6	5.2	76.6	5.2	0.0947	Not Significant

* P < 05; ** P < 0 .01; *** P < 0.001. **** P< 0.0001

Table 3: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese and Jordanian with class II skeletal relationship.

Cranial base measurements	Sudanese N =44	Sudanese	Jordanian N = 99	Jordanian	T. value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	123.4	4.1	125.6	5.2	0.0001	Extremely Sig
Articulare angle S-Ar-Go	149.4	6.7	146.2	7.1	0.0001	Extremely Sig
Gonial angle Ar-Go-Gn	123.7	7/0	124.6	6.1	0.2176	Not Significant
Bjork sum angle Sum of the above three angles	396.5	7.9	396.4	7.0	0.9044	Not Significant
Posterior cranial base S-Ar mm	35.2	4.0	36.2	3.3	0.1200	Not Significant
Anterior cranial base N-S mm	71.5	1.5	71.5	3.2	1.0000	Not Significant
Ramal height Ar-Go-mm	46/9	5.3	45.3	5.4	0.0009	Not Significant
Mandibular Body length Go-Gn mm	75.4	5.2	76.5	5.3	0.0700	Not Significant

* P < 05; ** P < 0 .01; *** P < 0.001. **** P< 0.0001

Table 4: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese and Jordanian with class III skeletal relationship.

Cranial base measurements	Sudanese N = 35	Sudanese	Jordanian N =95	Jordanian	T. value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	124.0	5.3	123.4	5.4	0.573	Not Significant
Articular angle S-Ar-Go	143.2	5.2	145.1	6.1	0.005	Very Significant
Gonial angle Ar-Go-Gn	125.9	7.4	128.2	5.8	0.001	Very significant
Bjork sum angles Sum of the above three angles	391.5	8.3	396.7	6.5	0.000	Extremely Sig
Posterior cranial base S-Ar mm	35.0	3.2	35.5	4.0	0.507	Not Significant
Anterior cranial base N-S mm	71.1	1.1	71.6	3.4	0.395	Not Significant
Ramal height Ar-Go-mm	50.2	5.5	48.2	5.1	0.055	Quietly Significant
Mandibular Body length Go-Gn mm	75.4	5.2	80.3	5.0	0.000	Extremely Significant

* P < 05; ** P < 0 .01; *** P < 0.001. **** P< 0.0001

Table 5: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese males and Jordanian males.

Cranial base measurements	Sudanese Males N 52	Sudanese Males	Jordanian Males N =142	Jordanian Males	P- value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	122.7	5.0	124.8	5.1	0.011	Significant
Articular angle S-Ar-Go	145.5	6.6	145.1	7.3	0.972	Not Significant
Gonial angle Ar-Go-Gn	126.0	6.7	126.8	6.2	0.437	Not Significant
Bjork sum angles Sum of the above three angles	394.2	8.3	396.9	7.2	0.027	Significant
Posterior cranial base S-Ar mm	35.7	3.8	37.4	3.8	0.010	Significant
Anterior cranial base N-S mm	71.2	1.6	72.9	3.4	0.541	Not Significant
Ramal height Ar-Go-mm	48.9	5.4	48.4	5.7	0.584	Not Significant
Mandibular Body length Go-Gn mm	78.7	6.5	79.0	5.7	0.755	Not Significant

* P < 05; ** P < 0 .01; *** P < 0.001. **** P< 0.0001

Table 6: Comparison of Means and Standard Deviations (SDs) of Cranial Base measurements between Sudanese females and Jordanian females.

Cranial base measurements	Jordanian Females N =146	Jordanian Females	Sudanese Females N =51	Sudanese Females	P- value	Significant level
	Mean	SD	Mean	SD		
Saddle angle N-S-Ar	124.0	5.4	123.5	4.4	0.558	Not Significant
Articular angle S-Ar-Go	147.0	6.7	148.1	5.9	0.299	Not Significant
Gonial angle Ar-Go-Gn	126.1	6.5	122.7	7.0	0.002	Very Significant
Bjork sum angles Sum of the above three angles	396.7	6.9	394.2	8.2	0.034	Significant
Posterior cranial base S-Ar mm	34.5	3.2	35.4	3.7	0.098	Not Significant
Anterior cranial base N-S mm	70.1	3.2	71.3	0.9	0.009	Very Significant
Ramal height Ar-Go-mm	44.9	4.3	47.7	5.4	0.0002	Extremely Significant
Mandibular Body length Go-Gn mm	76.5	4.9	76.4	5.1	0.988	Not Significant

* P < 05; ** P < 0 .01; *** P < 0.001. **** P< 0.0001

Table 5 showed that there were significant differences between Sudanese and Jordanian males in terms of Saddle angle, Bjork sum angles, and posterior cranial base measurements, indicating that Jordanian had statistically mean values than Sudanese males (P<0.05). However, no significant differences were observed in the other angular and linear measurements.

Table 6, demonstrated that there were significant differences between Sudanese females and Jordanian females in ramal height, Gonial angle, and Bjork sum of angles. The Jordanian females had higher mean values in the Gonial angle and Bjork sum of angles, while the Sudanese females had a higher mean value in ramal height. Additionally, there was a very significant difference in anterior cranial base measurements between the two groups, with the Jordanian females having a higher mean value. However, no statistically significant differences were found in the other angular and linear measurements**.**

Discussion

Bjork proposed that the cranial base originates mainly from the chondrocranium, and its shape undergoes significant changes during development. During the first 10 years of life, the cranial base gradually flexes from a flat position at birth to acquire its final shape [14].

A noteworthy observation is that Bhatia and Leighton found remarkable resemblances in growth patterns in angles and distances determined by Articulare or Basion. Therefore, for the present study, the Articulare point was chosen as the posterior boundary of the cranial base [15].

Establishing a proper diagnosis and treatment plan is crucial in determining the patient's treatment goals and procedures. It is essential to determine if a dental malocclusion is related to an underlying skeletal abnormality, as this can affect how the patient is treated based on the location and severity of the skeletal dysplasia. However, if the orthodontist believes that following a particular course of action would be damaging, it is necessary to discuss alternative plans, as this commonly leads to disappointment for both the patient and the orthodontist [16].

The analysis using Bjork-Jarabak method in this study revealed significant differences not only between Sudanese and Jordanian individuals, but also between males and females within the Sudanese population. Specifically, Sudanese males had a higher significant difference in angular and linear variables such as Gonial angle and Mandibular body length compared to Sudanese females. This finding is consistent with a previous study by Valiathan et al., [17] which also reported longer mandibular body lengths in male patients and larger Articulare angles in female patients.

It was found that females had a significantly higher mean value for the Articular angle compared to males, which is consistent with previous studies by Rodriguez Cardenas et al.[18] and Al Maaitah et al.[13] On the other hand, male patients had relatively higher measurements for anterior and posterior cranial base and ramal height, although these differences were not significant. These findings are in agreement with previous studies by various authors [19-21].

A comparison of the present study with Al Maaitah et al.13 investigation among Jordanian adult patients showed that Jordanian males had significantly higher mean values of Saddle angle, Bjork sum angles, and posterior cranial base length (P < 0.05) than Sudanese males. However, there was no significant difference in the remaining five linear and angular variables. In contrast, Jordanian females had significantly higher mean values of Gonial (P <0.01) and Bjork Sum (P< 0.05) angles than Sudanese females. In contrast, the Sudanese females had significantly higher mean values of anterior cranial base length (P<0.01) and ramal height (P<0.001) compared to Jordanian females. This indicates that there may be some differences in the growth and development of the craniofacial complex between these two populations, which could have important implications for orthodontic diagnosis and treatment planning. Further research is needed to explore these differences and their potential impact on clinical outcomes.

When comparing Sudanese and Jordanian individuals with Class I skeletal relationships, no significant differences were found in Saddle and Articulare angles, anterior and posterior cranial base, and mandibular body length. However, in Class II skeletal relationships, significant differences were found in Saddle and Articulare angles. In Class III skeletal relationships, Jordanians had significantly higher mean values in Articulare and Gonial angles, Bjork sum of angles, and mandibular body length compared to Sudanese individuals. These findings are consistent with previous studies [22,23].

The above-mentioned differences could be attributed to the different ethnicity, genetics, Further; environmental factors can play a role in the variability of skeletal features. Additionally, differences in sample size, methodology, and measurement tools can affect the results. Therefore, further research is necessary to replicate these findings in larger, more diverse populations using standardized methods of data collection and analysis. Such studies can provide valuable information for orthodontic treatment planning and contribute to our understanding of human skeletal variation.

Further, the present study highlights the importance of considering gender differences in craniofacial skeletal measurements. The significant differences found between Sudanese males and females and their Jordanian counterparts suggest that gender-specific treatment approaches may be needed in orthodontics. Therefore, orthodontists should take into account the gender of their patients when making treatment decisions. Moreover, it is important to note that these findings should not be generalized to other populations, as different ethnic groups may have distinct craniofacial features. Therefore, orthodontists must consider the specific ethnic background of their patients when making treatment decisions.

In summary, the present study results shed light on the importance of considering ethnic and gender differences in craniofacial skeletal measurements when making treatment decisions in orthodontics. It also highlights the need for further research to explore the underlying genetic and environmental factors contributing to these differences and their implications for clinical practice leading to improved treatment outcomes in the field of orthodontics and anthropology.

Additionally, it confirms that, in contrary to what was claimed in the literature, each ethnic community should be treated using its own mean values regardless of reported other ethnic population values.

Conclusions

In summary, the present study revealed:

1) Significant differences in skeletal patterns between Sudanese and Jordanian populations, as well as between males and females within each population.
2) Sudanese Male patients generally had longer mandibular body lengths and larger Gonial angles, while female had significantly larger Articulare angles. However, there were no significant differences in the anterior and posterior cranial **base** measurements between both genders.
3) Significant differences were noted in ramal height and Gonial angle between Sudanese and Jordanian females
4) Significant differences were observed between Sudanese and Jordanian males and females, particularly in saddle angle, Bjork sum, posterior cranial base, ramal height, and anterior cranial base.
5) In Class I skeletal, the Jordanian showed significant higher mean values in Gonial angle and Bjork sum of angles than Sudanese.
6) In Class II skeletal the Sudanese higher mean value of Articulare angle than the Jordanian ($P< 0.0001$). whereas, the Jordanian had higher mean value of Saddle angle,
7) In Class III skeletal, the Jordanians had higher means values in Articulare angle, Gonial angle, Bjork sum and mandibular body length than in Sudanese. Whereas, Sudanese demonstrated quietly significant mean value of ramal height.

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