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Research

Cranial morphology and facial type: Is it appropriate to describe the face using skull terminology?

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A B S T R A C T

Background: Terminology that comes from the anthropometric index, which is indicative of the form of the skullcap, is widely used to describe the face in orthodontics. Using this terminology assumes that the face and skull always follow the same pattern of morphology. The aim of this study was to test the hypothesis that the morphology of the face corresponds with the morphology of the skull.
Methods: Measures related to the cranial and facial indexes were taken randomly from 51 dry human skulls with neutral occlusion, selected from a larger collection. Skulls were classified, according to the cranial index, as dolichocephalic (<76.0), mesocephalic (76.0–<81.0), or brachycephalic (≥81.0) and according to the facial index as leptoprosopic (≥90.0), mesoprosopic (85.0–<90.0), or euryprosopic (<85.0). The McNemar-Bowker test and linear regression models were used to assess the relationship between the cranial and facial morphologies.
Results: The correspondence values between the cephalic and facial index ratings in expected cephalofacial pairs (brachycephalic and euryprosopic, mesocephalic and mesoprosopic, and dolichocephalic and leptoprosopic) were observed to be only 3.9%, 7.8%, and 13.7%, respectively. Coefficients of linear regression confirmed a weak influence of facial measurements on the morphology of the skull.
Conclusions: Facial morphology exerts little influence on skull shape and, therefore, does not support the widespread use of a terminology derived from the cranial index. The development of a standardized diagnostic terminology is timely given the increasing use of electronic records in health research and facilitating data sharing across different areas.

1. Introduction

The use of standardized terminology in the medical sciences is essential for both clinical practice and scientific research [1,2]. In addition to facilitating communication between professionals, it enhances the reliability of comparisons made between studies from different areas and thereby contributes to a higher level of scientific evidence. Attempts to standardize the terminology have been made in other medical fields engaged in the study of craniofacial morphology, such as medical genetics and plastic surgery [3,4]. However, there is plenty of old and new literature in orthodontics that presents a variety of terms to describe the facial pattern. Some of the terminology often used includes *dolichofacial, mesofacial*, and *brachyfacial* [5,6]; *hyperdivergent, neutral*, and *hypodivergent* [7]; *long, medium*, and *short* [8]; and *skeletal open bite* and *skeletal deep bite* [9]. The use of standardized diagnostic terminology is also advantageous considering the educational setting because it renders a more accurate diagnosis and improves patient care [2].

Another aspect to be considered is the origin of the terms used to describe the facial type. *Brachycephalic, dolichocephalic*, and *mesocephalic* are anthropometric terms related to the *cranial index* (CI), calculated as the ratio between the maximum width and length of the head. The CI is therefore a measure related to skull shape. The anthropometric *facial index* (FI), which is used to describe the face, is calculated from the ratio of the height to the maximum breadth of the face. From this index, the facial type is classified as *euryprosopic, mesoprosopic*, or *leptoprosopic* [10–12]. Most medical studies use anthropometric nomenclature to describe

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the facial pattern [3,4]. The term *brachycephaly*, for example, describes individuals with the skullcap shortened in the anteroposterior dimension, whereas the term *dolichocephaly* represents an anomaly in which the skull is elongated and abnormally narrow [3,13].

The growing presence of orthodontics in the context of scientific research makes it necessary to adopt a language that is consistent with other biological fields. Investigating the influence of skull shape on the facial shape can provide a benchmark against which the nomenclature used can be validated. If the assertion that skull type determines facial type is true, it would then be appropriate to use terms derived from the cephalic index, such as *brachyfacial*, *mesofacial*, and *dolichofacial*, to describe the face. On the other hand, in the event that it is not possible to determine this correlation, the use of this nomenclature would not be justified, and its use in this context would hinder communication within clinicians and with other medical specialties. Thus, reflecting on the origin and differences of the terms used to describe the human facial phenotype may pave the way toward a consensus regarding the meaning that best represents the craniofacial patterns. Considering these aspects, this study was developed with the aim of investigating the relationship between skull and facial morphology.

2. Methods and materials

The ethics research committee of the State University of Rio de Janeiro, Rio de Janeiro, Brazil, approved the study protocol (CAAE 0064.0.228.000-11). The sample used in the current study was composed of 51 dry human skulls, selected from the collection at the Federal University of Bahia, Bahia, Brazil. Specimens were obtained from the same population, predominantly of African descent, with recorded information on the cause of death, age, and skin color. The skulls were selected on the basis of the following criteria: 1) absence of cranial and dental anomalies; 2) a stable and reproducible occlusion, with most of the teeth present; 3) absence of mechanical damage in the alveolar process; and 4) a skeletal Class I jaw relationship (Table 1). The sample size was determined by the availability of suitable skulls in the collection.

The skulls were measured randomly by a professor of head and neck anatomy blinded to the objectives of the research. The measurements were taken by a digital caliper (model 500-684, Mitutoyo Corp., Tokyo, Japan), with a measurement interval of 300 mm and a resolution of 0.01 mm. The measured variables are described in Table 1.

After measurements, the skulls were classified using the CI and FI, defined by Farkas and Munro [10]. Using the CI as a reference, the calvaria were classified into three categories: dolichocephalic (<76.0), mesocephalic (76.0–<81.0), and brachycephalic (≥81.0). Using the FI as a reference, the face was classified into three categories: leptoprosopic (≥90.0), mesoprosopic (85.0–<90.0), and euryprosopic (<85.0).

Table 1
Description of variables

Variable	Description
Cranial length (CL) (glabella-opisthocranion [G-Op])	Linear distance from glabella to opisthocranion points
Cranial breadth (CB) (eurion-eurion [Eu-Eu])	Linear distance from eurion points, right and left
Facial height (FH) (nasion-gnathion [N-Gn])	Linear distance from nasion to gnathion points
Facial breadth (FB) (bizygomatic [Zy-Zy])	Linear distance from zygion points, right and left
Inferior facial height (IFH) (anterior nasal spine-gnathion [ANS-Gn])	Linear distance from anterior nasal spine to gnathion points
Mandibular breadth (MB) (gonion-gonion [Go-Go])	Linear distance from gonion points, right and left
Cranial index (CI)	Calculated according to the formula CI = (Eu-Eu/G-Op) × 100
Facial index (FI)	Calculated according to the formula FI = (N-Gn/Zy-Zy) × 100

Table 2
Sample descriptive statistics (N = 51)

Variable	Value
Age (y)	
Mean (SD)	26.4 (9.5)
Median (IQR)	23.0 (19.0–32.0)
Sex (no. [%])	
Male	27 (52.9)
Female	24 (47.1)
Cranial index	
Mean (SD)	78.5 (4.4)
−1/2 SD	76.3
+1/2 SD	80.7
Facial index	
Mean (SD)	90.6 (5.4)
−1/2 SD	87.9
+1/2 SD	93.3

IQR, interquartile range.

2.1. Statistical analysis

Statistical analyses were performed using SPSS version 13.0 (IBM SPSS Statistics, IBM Corporation, Armonk, NY). The intraexaminer reliability of the variables describing the calvaria and facial dimensions was determined by intraclass correlation coefficients. Double assessments of each measure were compared at 14-day intervals in 16 skulls (33%) that were selected at random from the sample. Descriptive statistics (mean [SD]) were calculated to show the features of the sample.

The McNemar-Bowker test was used to measure the agreement between the cranial and facial classifications. Linear regression models were used to assess the relationship between cranial and facial morphology. Statistical significance was set at $P < 0.05$.

3. Results and discussion

The description of the statistical sample is reported in Table 2, in addition to the descriptive statistics of the CI and FI that were used as references to classify the types of skull and face. The data revealed a satisfactory ratio of boys to girls and homogeneity in age. The reliability evaluation of the measurements showed a high level of agreement between the first and second assessments. All measurements showed intraclass correlation coefficients higher than 0.98 (Table 3).

The concordance between cranial classification and facial classification was analyzed with a 3 × 3 contingency table and tested with the McNemar-Bowker test for paired data (Table 4). A weak correspondence between the classification of the skull and face was

Table 3
Intraclass correlation coefficients (95% confidence interval [CI])

Measurement	Intraclass correlation coefficient (95% CI)
Cranial breadth	0.994 (0.983–0.997)
Cranial length	0.998 (0.969–0.996)
Cranial index	0.994 (0.968–0.995)
Facial height	0.996 (0.990–0.998)
Facial breadth	0.988 (0.970–0.995)
Facial index	0.991 (0.974–0.996)
ANS-Gn	0.992 (0.981–0.997)
Go-Go	0.997 (0.993–0.999)