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The craniofacial indicators of aggression: a cross-sectional multiparametric anthropometry study

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Background: *The craniofacial features of a person are unique and critical in the evaluation of age, gender, and ethnicity. The relationships between craniofacial properties and behavioural patterns have been one of the most common research topics.*

Materials and methods: *There are studies on the association of facial width-to-height ratio (fWHR) and aggressive behaviour in men; however, no consensus has been reached as there are inconsistent study results. Most of the studies focus on measuring the pre-determined fWHR in searching for a link to aggression. As the literature lacks data on the associations of multiple craniofacial ratios and aggression, we aimed to study the correlation of aggressive behaviour and multiparametric anthropometric measurements of the craniofacial region in a study group consisting of university students aging 18–38 years.*

Results: *The aggression questionnaire results showed that male students had statistically higher scores than females in all subdomains, except physical aggression. Anthropometric studies revealed that males had higher mean values of craniofacial dimensions and indices than females, except the frontal height, the total lip height, frontal index, and cranial length-head circumference index. The statistical analyses for correlations showed that frontal, upper facial, and total facial height-facial width indices correlated with general and verbal aggression, frontal and upper facial indices correlated with physical aggression, and upper facial and total facial height-facial width indices correlated with indirect aggression only in males.*

Conclusions: *We conclude that our study represents the first example of an extensive craniofacial anthropometric research that correlates several craniofacial measurements and ratios with various aggression subdomains.* (Folia Morphol 2021; 80, 1: 55–62)

Key words: anthropometry, aggression, craniofacial, anatomy, behaviour

INTRODUCTION

Every human being is unique in their craniofacial features that are closely related to the overall form and proportions of the body. The human craniofacial variations in different populations have long been an interesting topic for scientists. The environmental factors and evolutionary mechanisms that act on craniofacial features have been investigated by an-

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thropologists, while the related databases are used routinely by forensic scientists, surgeons, dentists, and anatomists for diagnostic and therapeutic purposes. The information on the craniofacial dimensions is especially critical in evaluating the age, gender, and ethnic background of individuals [28].

Many craniofacial properties show dimorphism between sexes; for instance, males are known for the broader zygomatic region, supraorbital ridge, and prominent mandibula, while females have longer and narrower faces, rounder and broader foreheads, and thicker lips compared to males [24, 30]. In addition to the age, nutrition, biomechanical forces, the endocrine factors, especially pubertal sex hormones, have been established as the primary influencers of masculinisation and feminisation of craniofacial features [30]. The influence of pubertal testosterone was shown on facial width/lower facial height and cheekbone prominence decrease, and lower face height/full face height increase [16].

Apart from the dimorphism in craniofacial characteristics, males and females show dimorphism in some behavioural patterns, like aggression. When aggression is kept within normal limits, it provides and defends the required vital sources; however, its inappropriate manifestation can be harmful. Professionals dealing with aggressive behaviour need to know its aetiopathogenesis to provide optimal management strategies [35].

The research demonstrated that males, compared to females, display higher aggressive behaviour under unprovoked conditions [3] and higher physical aggression in real-world settings [2, 13]. The link between craniofacial features and aggression has been studied extensively. The ratio of facial width to height (fWHR) is the most common measurement of masculinity related to aggression [1, 7, 12, 15, 27]. The relationship between fWHR and testosterone levels has been indicated in some research studies [7, 16, 22]. However, the results of other studies did not support the presence of such an association [4, 20, 27]. Moreover, the dimorphism of fWHR had also been questioned [21].

The reasons for those inconsistencies might range from sampling variations to the size of the study group, from ethnicity and socioeconomic status of the investigated population to the unstandardised measurement techniques used in anthropometric studies [26]. The measurement of fWHR as the sole anthropometric factor in most studies that investigate a link between facial features and aggression has also been considered to be responsible for inconsistent results [19]. To the best of our knowledge, the literature lacks data on correlation studies of aggression and multiple craniofacial features. Hence, we aimed to fill in this gap by designing a study that investigates the association of aggressive behaviour and craniofacial features by using multiple anthropometric parameters in a large study population.

MATERIALS AND METHODS

Study group

This study was conducted on university students older than 18 years. The sex distribution of participants showed that there were 156 female and 147 male subjects, aging 18–38 years, with a mean of 20.88 (standard deviation 2.9) and 21.23 (standard deviation 3.38) years for females and males, respectively. No statistically significant difference was observed between the mean age of females and males in the study ($p > 0.05$). The presence of a history of surgery, trauma, and congenital abnormalities in the craniofacial region were considered as exclusion criteria. The study participants provided informed consent, and Institutional Ethics Committee approval was obtained (approval number: KA09/306).

Study design and protocol

In this prospective cross-sectional study, the subjects who met the study criteria were evaluated by an adapted Turkish version of the "Aggression Questionnaire" [6] constructed originally by Buss and Perry [5]. The responses ranged on a scale of 1 to 5 points (e.g., "1 point" stood for "extremely uncharacteristic of me", and "5 points" stood for "extremely characteristic of me"). Five subdomains of aggressive behaviour assessed by the questionnaire included physical and verbal aggression, indirect aggression, anger, and hostility. Cronbach's alpha for the five aggressiveness scores were as follows: physical aggression: 0.82, verbal aggression: 0.79, anger: 0.81, hostility: 0.75, indirect aggression: 0.87.

The anthropometric studies were performed on all participants. A weighing scale and an anthropometer were used for measuring weight and stature. Craniofacial anthropometric measurements carried out according to a previously described technique [18] and pre-determined craniofacial landmarks were taken twice to minimise operator-related and technical errors. A measuring tape, spreading, and sliding

Table 1. Craniofacial anthropometric measurements

	Description
Cranial dimensions	
Cranial length (CL)	Between glabella to opisthocranion
Cranial width (CW)	Between right and left biparietale
Head circumference (HC)	
Frontal breadth (FB)	Between right and left frontotemporale
Frontal height (FH)	From trichion to glabella
Auricular head height (AHH)	From external meatus to vertex
Facial dimensions	
Facial width (FW)	Between right and left zygion
Lower facial heights (LWH)	Between subnasale and gnothion
Upper facial heights (UFH)	Between nasion and stomion
Mandibular breadth (MB)	Between right and left gonium
Mandibular height (MH)	Between sublabiale and gnathion
Mouth width (MW)	Between right and left chelion
Nasal height (NH)	Between nasion and subnasale
Nasal width (NW)	Between right and left alare
Supraorbital depth (SOD)	Between glabella and tragion
Interchantal breadth (ICB)	Between right and left endocanthion
Biocular width (BOW)	Between right and left exocanthion
Total lip height (TLH)	Between labium superius oris and labium inferius oris

callipers were used as required in craniofacial measurements (Table 1).

The body mass index (BMI) of the subjects was determined by dividing the weight to the height squared. A total of 8 craniofacial indices that were relevant to the study were derived from the craniofacial dimensions by formulas described previously [11]. The cranial indices calculated were cephalic index (C-I), the cranial length-head circumference index (CL-HC-I), and frontal index (F-I), while the facial indices consisted of total facial height-facial width index (TFH-FW-I), upper facial index (UF-I), mandible-facial width index (M-FW-I), nasal index (N-I), and total lip height-mouth width (TLH-MW-I) index.

Statistical analysis

Intraclass correlation coefficient analysis was performed to test the reliability of anthropometric measurements. The descriptive statistics were presented as the mean ± standard deviation. The normal distribution of numerical variables was controlled by the Kolmogorov-Smirnov test. Independent samples t-test was used for analysing the results of anthropometric measurements and aggression scores concerning sex. The correlation among variables was assessed by using the Pearson correlation coefficient. Multiple-regression model was used to evaluate the effect of craniofacial indices on the scores of aggression questionnaire. The statistical analyses were done by using Statistical Package for Social Sciences (SPSS Version 18.0; SPSS Inc. Chicago), and a p-value of or lower than 0.05 was considered significant.

RESULTS

The responses of participants to the aggression questionnaire were evaluated, and the mean scores of five aggression subdomains were calculated for each gender. The scores of aggressive behaviour of female and male subjects were shown in Table 2. In all subdomains, except in physical aggression, the scores of the male subjects were significantly higher than those of the females ($p < 0.001$). Although the physical aggression scores of males (24.44 ± 7.66) were higher than the females (18.41 ± 7.17), it was not statistically significant ($p > 0.05$). The mean of general aggression score of the male subjects was 25.86 ± 4.96, while the females had a mean score of 22.90 ± 5.55, and there was a statistically significant difference between males and females concerning general aggression scores ($p < 0.001$).

The mean values of weight, stature, and BMI of males (75.69 ± 12.94 kg, 174.93 ± 59.75 cm, 24.69 ± 3.66, respectively) were significantly higher than those of the females (58.67 ± 9.03 kg, 162.2 ± ± 57.82 cm, 22.28 ± 3.04, respectively; $p < 0.001$, Table 2). The mean value of all cranial and facial anthropometric measurements was calculated and compared between genders. Except for the frontal height, all mean values of the cranial measurements were significantly higher in the male subjects than the females ($p < 0.001$). Among the 12 facial anthropometrical measures, the mean value of the total lip height was similar in both genders ($p = 0.991$), while the remaining eleven measurements showed a statistically significantly higher value in male subjects compared to those in the females ($p < 0.001$). The distribution of mean value for all craniofacial anthropometric measurements was presented in Table 2.

We did not find any significant difference in the C-I between sexes ($p > 0.05$). The remaining two cranial indices (CL-HC-I, F-I) were found to be significantly higher in males compared to female subjects ($p < < 0.001$). None of the facial indices showed a significant difference between the genders ($p > 0.05$).

Table 2. Anthropometric measurements, cranial indices, aggression scores (mean ± standard deviation)

	Gender		P	P*
	Male (n = 147)	Female (n = 156)		
Weight	75.69 ± 12.94	58.67 ± 9.03	**< 0.001**	-
Stature	174.93 ± 59.75	162.2 ± 57.82	**< 0.001**	-
Body mass index	24.69 ± 3.66	22.28 ± 3.04	**< 0.001**	-
Cranial measurements:				
Cranial length	189.9 ± 7.54	178.56 ± 6.48	**< 0.001**	**0.006**
Cranial width	155.44 ± 6.87	146.97 ± 5.1	**< 0.001**	**0.0001**
Head circumference	562.58 ± 15.78	537.08 ± 13.61	**< 0.001**	**0.0001**
Frontal breadth	119.33 ± 4.85	112.37 ± 4.16	**< 0.001**	**0.0001**
Frontal height	53.77 ± 7.58	53.63 ± 5.65	0.855	0.669
Auricular head height	69.81 ± 8.57	64.52 ± 10.12	**< 0.001**	**0.001**
Facial measurements:				
Facial width	142.22 ± 5.57	132.31 ± 4.98	**< 0.001**	**< 0.001**
Lower facial height	65.49 ± 5.20	59.74 ± 5.17	**< 0.001**	**0.006**
Upper facial height	75.57 ± 6.23	70.45 ± 5.63	**< 0.001**	**0.020**
Mandibular breadth	97.48 ± 8.25	89.35 ± 8.2	**< 0.001**	**0.001**
Mandibular height	26.03 ± 3.75	24.09 ± 3.28	**< 0.001**	0.061
Mouth width	51.55 ± 4.64	49.15 ± 4.53	**< 0.001**	**0.025**
Nasal height	51.63 ± 3.64	48.28 ± 4.30	**< 0.001**	**0.028**
Nasal width	36.71 ± 2.90	33.16 ± 2.89	**< 0.001**	**< 0.001**
Supraorbital depth	124.2 ± 5.26	116.48 ± 4.8	**< 0.001**	**< 0.001**
Interchantal breadth	34.10 ± 3.93	31.85 ± 3.57	**< 0.001**	0.191
Biocular width	107.6 ± 6.03	103.78 ± 5.79	**< 0.001**	0.056
Total lip height	16.45 ± 3.92	16.27 ± 3.43	0.991	0.907
Indices:				
Cephalic index	82.12 ± 4.7	82.42 ± 4.18	> 0.05	–
Cranial length-head circumference index	33.73 ± 0.92	33.25 ± 0.85	**< 0.001**	–
Frontal index	45.06 ± 6.47	47.68 ± 5.11	**< 0.001**	–
Upper facial index	189.63 ± 19.52	189.07 ± 17.07	> 0.05	–
Total facial height-facial width index	101.25 ± 7.73	102.08 ± 7.42	> 0.05	–
Mandibular-facial width index	68.57 ± 5.62	67.57 ± 5.88	> 0.05	–
Total lip height-mouth width index	32.1 ± 7.6	33.2 ± 6.79	> 0.05	–
Nasal index	71.42 ± 7.19	69.15 ± 7.71	> 0.05	–
Buss and Perry Aggression Score:				
General aggression	25.86 ±4.96	22.90 ±5.55	**< 0.001**	–
Physical aggression	24.44 ± 7.66	18.41 ± 7.17	> 0 .05	–
Verbal aggression	27.67 ± 6.83	26.37 ± 6.89	**< 0.001**	–
Anger	27.71 ± 6.20	25.43 ± 6.78	**< 0.001**	–
Hostility	25.50 ± 6.63	23.78 ± 6.87	**< 0.001**	–
Indirect aggression	24.46 ± 6.42	21.31 ± 6.25	**< 0.001**	–

*The effects of height and body mass index values were controlled by ANCOVA model

The data and results of statistical analyses regarding the craniofacial indices were presented in Table 2.

We evaluated the correlation between the craniofacial indices and the subdomains of aggressive be-

Table 3. Correlation of craniofacial indices and aggression types by multi-regression analysis

Aggression	Dependent variables					
	General	Physical	Verbal	Anger	Hostility	Indirect
Independent variables (Model fit p-value)	**0.010**	**< 0.001**	**0.004**	0.109	0.198	< 0.001
Male			**Standardised beta coefficient**			
C-I	–0.206	–0.342	–0.244	0.064	0.191	0.279
CL-HC-I	–0.180	–0.230	–0.189	0.063	0.139	0.210
F-I	**0.264***	**0.224***	**0.313***	0.126	0.174	0.114
UF-I	**0.551***	**0.335***	**0.487***	**0.586****	0,284	**0.598***
TFH-FW-I	**0.441***	0.067	**0.355***	**0.493***	0.166	**0.387***
M-FW-I	–0.037	–0.060	0.001	0.039	0.053	–0.049
TLH-MW-I	–0.010	–0.015	0.027	0.076	0.032	–0.186
N-I	0.080	0.102	0.045	0.089	–0.118	0.089
Independent variables (Model fit p-value)	0.120	0.131	0.341	0.093	0.196	0.195
Female			**Standardised beta coefficient**			
CL-HC-I	–0.083	–0.101	–0.109	–0.017	0.030	0.031
F-I	0.066	–0.174	–0.221	–0.045	0.117	–0.034
UF-I	0.108	0.173	–0.001	–0.021	–0.022	0.089
TFH-FW-I	–0.226	0.255	–0.041	0.002	0.139	–0.103
M-FW-I	–0.048	0.160	–0.046	–0.093	–0.220	–0.099
TLH-MW-I	0.166	–0.055	0.054	–0.010	–0.030	–0.088
N-I	0.160	0.073	0.163	0.197	0.139	0.078

*$p < 0.05$; **$p < 0.01$; abbreviations — see text

haviour by a multi-variant regression model. First, the model fit p-value was used to assess the presence of a statistical significance for the model. Male participants showed a statistical significance for models of indices on physical, verbal, indirect, and general aggression ($p < 0.001$, $p = 0.004$, $p < 0.01$, $p = 0.01$, respectively); however, there was no such statistical significance in female subjects (Table 3). Further evaluation of the correlations between subdomains of aggression and craniofacial indices in male subjects revealed that the F-I, UF-I, and TFH-FW-I were significantly related with higher scores of verbal and general aggression, while F-I and UF-I were only significantly related with higher physical aggression scores, and UF-I and TFH-FW-I were only significantly related with indirect aggression (p values below 0.05 for all correlations). There was no significant relationship between craniofacial indices and anger and hostility ($p > 0.05$). The correlations between the craniofacial indices and the types of aggression were presented in Table 3.

DISCUSSION

Facial WHR is an important characteristic that emerged as a result of sexual selection in the evolution of the genus Homo, therefore fWHR provided information about general level of testosterone and masculinisation. Due to its relevance to testosterone and masculinisation, WHR is considered an indirect indicator of aggression. In the current study, we investigated the relationship of craniofacial features and aggression by extensive anthropometric studies and a questionnaire [5, 6] for assessing aggression subdomains in a group of university students. The strength of this study is that not only WHR, but also many craniofacial characters have been studied. The weakness of this study is that it does not contain moderator variables such as social status and income level.

Only one study reported relationships among income, craniofacial features, and aggression. In this study it was shown that the income of subjects could be a moderator in the association of aggression and fWHR; the authors observed that fWHR predicted aggressive behaviour only in subjects with low income [13]. Another study demonstrated the effects of social status moderated the association of fWHR and risk-taking behaviour in males [36]. Noser et al. [26] found that income played a critical role in fWHR and physical aggression relation, so the authors suggested

that social status had to be taken into account in such anthropometric studies.

Aggression was recently defined as "the feelings of anger or antipathy resulting in hostile or violent behaviour" by Im et al. [17]. The manifestation of aggression has been widely studied by using aggression paradigms [35] and self-report questionnaires [5]. Studies on aggression with self-reported data were argued against an inherent social-desirability bias, and a recent study investigating the relationship between fWHR and aggressiveness was designed to incorporate data collected from the colleagues of the study subjects [34]. However, that study design still carries an intrinsic risk of bias, as the colleagues might hesitate to reveal real opinions on the behavioural characteristics of the subjects studied. For nearly three decades, the Buss-Perry questionnaire [5] has been one of the most commonly used instruments for assessing aggression with confirmed statistical relevance. Most studies revealed that aggressive tendencies of males, especially in physical and direct subdomains of aggression were more prominent than females, and under unprovoked conditions [2, 3, 17]. We used an adapted version of the Buss-Perry questionnaire [6], and found that general aggression scores of males were significantly higher than the scores of females. The males had higher scores in verbal aggression, anger, hostility, and indirect aggression subdomains. Although male students scored higher in physical aggression, the statistical analysis did not show any significant difference between genders. In a very recent study, the gender difference was shown to be erased for physical aggression in situations that involved provocative stimulations [35]. Based on those recent findings, it can be speculated that the questions, in particular, the ones assessing the physical aggression subdomain, might have provoked emotionally stimulative responses in female students.

The dimensions and shape of the craniofacial region that are extremely variable among human populations and ethnic groups [23] have been routinely used by anthropologists, forensic experts, anatomists, and surgeons. Although indirect methods of anthropometric measurements have been used, the gold standard is still considered to be the direct in-vivo technique, which is conventional and low-cost. This quantitative method allows an accurate measurement of hair-covered areas and lacks the risk of causing distorted views that are occasionally caused by photographic images used in indirect anthropometry [23, 33]. Pouya et al. [29] compared the direct and indirect anthropometric measurements for the analysis of cephalofacial dimensions and found that the mean cranial length of males was higher than females. As a negligible difference was found between the two techniques, they suggested using the robust and low-cost direct anthropometric methodology for constructing more extensive normative databases. A complete assessment of the craniofacial region, consisting of the shape and form of cranium and face, can be performed thoroughly by using anthropometrical indices derived from craniofacial measurements [9, 33]. In recent anthropometric studies of the face, the results showed that total facial height, upper facial height, and facial width of males were higher than those of females. The facial indices were also found to be higher in males compared to females [9, 28]. The results of a multiparametric cranial morphometric study in a Turkish population showed that fourteen radiologically assessed measurements were higher in males than females [10]. In the current study, out of the 6 cranial and 12 facial dimensions measured, we found that only the frontal height and the total lip height were not significantly different between male and female students. The remaining 16 craniofacial measurements were significantly higher in males compared to females. The total lip height of males was found to be significantly higher than the females in a study [31]. A recent study showed that the mean value of frontal height in males was significantly more than that of the females [32]. The discrepancy between our findings and the results of the study by Sirinturk et al. [32] might be due to direct and indirect anthropometric techniques used in ours and theirs, respectively.

There is extensive research on the association of physical characteristics and behavioural tendencies, and fWHR appears to be the most common point of consensus on its relationship with aggression in males [1, 12, 13, 15], although there are some study results that did not reveal this relationship [14, 27]. Testosterone has been suggested as the primary mediator of the fWHR and aggression relationship [7, 16, 22]; however, several study results did not support this suggestion [4, 22]. In a recent genetics study, three single nucleotide polymorphisms associated with the testosterone levels in the body were reported to have an apparent effect on mandible shape and fWHR [30]. The considered dimorphic property of fWHR [12] is

also questioned in a meta-analysis [21]. Köllner et al. [19] argued against those negative claims and emphasized the importance of conducting investigative studies without pre-specification of facial features of interest. The authors further suggested the measurement of additional points, ratios, and distances to keep the research from over-focusing on the same subset of indicators with inconsistent results. Moreover, the authors of a study suggested the facial height and width should be tested independently to reduce the ambiguity of using the ratio between these two components [8]. In another study, the authors discussed that the missing link causing inconsistent results between fWHR and aggression could be the lack of control over critical influencing factors such as BMI [25].

In consideration of the arguments and suggestions reviewed from the available literature, we analysed our results statistically for the correlation between aggression and craniofacial characteristics by controlling the BMI. We measured 6 cranial and 12 facial anthropometric dimensions and derived 3 cranial and 5 facial indices from those. None of the facial indices showed a significant difference between the genders, while cranial CL-HC-I and F-I indices were significantly higher in the male students compared to those of the females.

When we analysed the correlation between aggression and craniofacial characteristics, we found that none of the craniofacial indices of female students were significantly correlated with aggression or its subdomains. For male students, no correlation in anger and hostility subdomains was present for any of the craniofacial indices. The general and verbal aggression in males correlated with frontal, upper facial, and total facial height-facial width indices. The physical aggression subdomain in males was found to be correlated with frontal and upper facial indices, while indirect aggression in males correlated with upper facial and total facial height-facial width indices.

To the best of our knowledge, this is the first anthropometric evaluation of multiparametric craniofacial features and their correlation with aggression and subdomains in a large sample size with both genders represented. The strengths and limitations of our study should be acknowledged. The sample size, as well as the sampling homogenisation, the evaluation of multiparametric craniofacial characteristics by using direct measurement technique, constitute the advantages of the current study compared to similar studies. Nevertheless, we should note that the study population only involves students, so the results cannot be safely extrapolated to the general population. The current study also has the same disadvantages inherent to most anthropometric studies, which is the lack of standardised terminology and methodology. These two points are crucial and need to be improved for reducing the errors in measurement and interpretation of the results.

CONCLUSIONS

In conclusion, we suggest that further studies designed with multiple anthropometric measurements and a study group reflecting the general structure of the population should be conducted for investigating the association of aggression and craniofacial features, and replicate and extend the current findings.

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