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Research Article

Facial Width-to-Height Ratio Calculated via Direct Measurement and its Relation to Aggressive Behaviour

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ABSTRACT

The human face plays a fundamental role in communication and social interactions. Whether faces reflect behavioural or personality traits has been widely debated. The facial width-to-height ratio has emerged as a popular measure in this context because testosterone is believed to promote increased bizygomatic width in males, leading to a higher ratio. Testosterone is thought to be related with aggressive behaviour, thus, many previous studies have focused on the relationship between the facial width-to-height ratio and aggressiveness. However, most studies have focused on small Western samples, often relying on measurements derived from two-dimensional photographs. In this study, we examined the relationship between the facial width-to-height ratio and self-reported aggressive behaviour by directly measuring the facial height and width to calculate the facial width-to-height ratio. Our sample consisted of 196 students (88 males and 108 females). We assessed aggression using the Buss-Perry Aggression Questionnaire, which contains various subdomains. Supporting some prior research, our results did not reveal significant sexual dimorphism in the facial width-to-height ratio, nor did it associate with self-reported aggressiveness in the expected direction. In females, the subdomain of verbal aggression negatively predicted the facial width-to-height ratio, but after controlling for BMI, the relationship became insignificant. We also found a correlation between the facial width-to-height ratio and body mass index, suggesting that the facial width-to-height ratio may reflect underlying body mass differences rather than distinct facial morphological variations. Thus, we recommend a cautious approach when examining the facial width-to-height ratio as a sexually dimorphic feature.

Keywords: Facial Width-to-Height Ratio, fWHR, Aggressiveness, Testosterone, Facial Width

1. Introduction

The human face plays an important role in communication and social interactions. It can convey more than 20 emotions through facial muscles (Du, Tao, and Martinez, 2014). An observer can gain information about a person's identity, sex and gender age, ethnicity, sexual orientation, health status, attractiveness, emotions, physical pain, whether they are lying, physical satisfaction, and even social status just by looking at their face (Jack and Schyns, 2015; Todorov et al., 2015). In fact, an observer can make consistent judgments in about 100 milliseconds based on facial images (Willis & Todorov, 2006).

The question of whether human faces reflect behavioural or personality traits has been widely debated (Sarıbay, 2018). The facial width-to-height ratio (fWHR) has gained attention as a trait of interest over the past two decades. Sexual differences in facial width become more pronounced in males during puberty (Verdonck et al., 1999), leading to a higher fWHR in men. In support of this, Lefevre et al. (2013) reported a link between fWHR and testosterone levels, suggesting a hormonal influence on facial structure. Following this proposed connection, many studies have explored fWHR's relationship with various behavioural and social traits, such as trustworthiness (Ormiston, Wong, & Haselhuhn, 2017), attractiveness (Valentine et al., 2014), masculinity (Lefevre & Lewis, 2014), and financial decision-making (Mills & Hogan, 2020). Because testosterone affects aggression and dominance (Archer, 2006; Batrinos, 2012), much of this research has focused on these areas. Some studies have indicated that a higher fWHR is linked with greater dominance, aggression, or unethical behaviour (Carre & McCormick, 2008; Geniole et al., 2015; Haselhuhn, Ormiston, & Wong, 2015; Lefevre et al., 2014). Additionally, it has been debated that sexual dimorphism in facial width is a result of sexual selection (Weston, Friday & Lio, 2007)

Although research on the relationship between fWHR and aggressive behaviour has been increasing, the findings remain contentious. One limitation is that, aside from a few large-scale studies, the literature mainly consists of studies on small, Western samples. Another issue is that fWHR research largely relies on 2D photographs for measuring facial ratios (e.g., Özener, 2012). This method assumes that participants maintain an ideal posture during the measurement (Kramer, Jones, & Ward, 2012); however, even slight deviations from the ideal posture can introduce distortions and bias results. In addition to factors such as lighting or exposure, a change in focal length can affect image accuracy (Třebický et al., 2014). Without standardisation, these factors may introduce systematic measurement errors. Additionally, greater adiposity in women has been suggested as a potential factor complicating the assessment of facial sexual dimorphism (Kramer, Jones, & Ward, 2012; Lefevre et al., 2012). Consequently, measurements taken with spreading callipers, applying medium pressure on soft tissue, might help reduce the impact of adiposity on results.

This study has two primary objectives. First, we tested whether the fWHR calculated from direct measurements taken from the face differs according to sex. Second, this study assesses the associations between fWHR and various aspects of self-reported aggressiveness in a Turkish sample. Although studies are increasingly diverse in sample size and ethnic background, research on non-Western samples remains limited. Therefore, this study offers valuable insights into the universality of this relationship. Furthermore, given that most research on the fWHR relies on 2D imaging, direct soft-tissue measurements may enhance the understanding of the fWHR and its associations.

2. Material and Methods

2.1. Participants

This study was conducted at Istanbul University and included 196 students (88 men and 108 women) from different regions of Türkiye. Ethics approval of the study obtained from Sivas Cumhuriyet University Ethics Review Committee for Social Sciences Research Proposals. The median age of the participants was 22.21 years (*IQR* = 3.09 y. 95% CI [21.78, 22.76]), and no significant age difference was found between sexes (*Mann-Whitney U* = 5334, $P > 0.05$). For a consistent sampling, those with facial defects or other noticeable deformities were excluded.

2.2. Procedure

First, the participants were verbally informed about the objectives of the study, and their written consent was collected. After participants were confirmed to be in the study, two forms were shared with them. The first contained sociodemographic questions on education, date of birth, and gender, and the second contained the aggression questionnaire. After completing the forms, anthropometric measurements of body weight, height, and facial features were performed.

2.3. Aggression Questionnaire

In order to quantify the aggressive behaviour, the Turkish version of the Buss and Perry Aggressiveness Questionnaire (BPAQ; Buss & Warren, 2000) was used. The questionnaire contains 34 items clustered by 5 sub-domains: anger, physical aggression, indirect aggression, verbal aggression and hostility. The questionnaire was translated into Turkish by Can (2002) and the Cronbach's alpha for 5 sub-domains was high (0,75 to 0.82). Responses were recorded using a Likert scale ranging from 1 (extremely uncharacteristic of me) to 5 (extremely characteristic of me).

2.3.1. Anthropometric Measurements

Participants' weight (in kilogrammes) was measured using a Tanita BC730 body composition analyser, while heights (in centimetres) were recorded using a Seca 213 portable stadiometer. After obtaining body measurements, facial anthropometric measurements were conducted to assess the facial width-to-height ratio (fWHR). Facial width, defined as bizygomatic breadth (zygion-zygion), was measured using a spreading calliper (in mm) following Farkas (1994). After the participants were seated in the standard anatomical head position and relaxed, the most lateral points on the left and right zygions were identified, and the distance between them was recorded as bizygomatic breadth. For the assessment of upper facial height, the distance between the midpoint of the upper lip (labiale superius) and the midpoint between the brows (nasion) was measured (Carre & McCormick, 2008) using a sliding calliper with 0.01 mm accuracy. Each measurement was repeated to test reliability, resulting in a high intraclass correlation coefficient ($ICC = 0.934$, $P < 0.001$, 95% CI [0.913, 0.951] for facial height; $ICC = 0.997$, $P < 0.001$, 95% CI [0.995, 0.998] for facial width).

2.3.2. Statistical Analyses

The facial width-to-height ratio (fWHR) was calculated by dividing the facial width (bizygomatic breadth) by the facial height (nasion to labiale superius). Aggression scores were calculated by averaging across the subdomain scores, which were determined by dividing each subdomain's total score by the number of items in that subdomain. A Kolmogorov-Smirnov test indicated that most variables (e.g., age, BMI, fWHR, aggression scores) were not normally distributed according to sex. Consequently, we used nonparametric methods (e.g., Spearman's correlation) and permutation-based analyses (e.g., permutation-based ANOVA, MANOVA, and multiple linear regression) that did not assume normality. Analyses were conducted in R using base functions and libraries (R Core Team, 2024; Wickham, 2016; Wickham et al., 2023; Zeileis & Hothorn, 2002) We employed 95% confidence intervals. For non-normally distributed data, confidence intervals were calculated using 1,000 bootstrap resamples.

3. Results

Although males exhibited slightly higher facial width-to-height ratios (fWHR) than females (Table 1), the difference was not statistically significant ($R^2 = 0.004$, $F = 0.829$, $Z = 0.398$, $P = 0.369$, Table 2).

Table 1. Descriptive statistics of anthropometric measurements. Facial width and height were measured in millimetres, body height was measured in centimetres and body weight was measured in kilogrammes. BMI was calculated using the following formula: Weight / ((Height / 100) ** 2).

	Male			Female		
	Med.	**IQR**	***95% CI***	**Med.**	**IQR**	***95%CI***
Facial Width	143.500	7.750	141.756-144.500	132.500	5.500	131.500, 133.500
Facial Height	74.552	5.180	73.460-75.225	69.775	6.520	68.602, 70.865
Body Weight	75.200	0.122	72.900-77.800	56.800	10.800	54.700, 59.550
Body Height	176.300	10.070	175.500-178.900	161.300	7.550	160.000, 162.550
BMI	24.002	3.180	23.387-24.249	21.729	4.080	21.076, 23.128

For aggression, while the composite aggression scores showed no significant sex differences, males scored significantly higher in physical and verbal aggression (Table 2). Females, on the other hand, scored significantly higher in anger. Additionally, the PERMANOVA results indicated a small but statistically significant difference in aggression sub-scores between sexes ($R^2 = 0.024$, $F = 4.887$, $Z = 2.512$, $P = 0.006$).

Table 2. The left part of the table presents the descriptive statistics of the facial width-to-height ratio and aggression sub scores across sexes. The right side comprises individual ANOVAs examining the difference in aggression scores between males and females. The significance of the tests was assessed via 10.000 permutations.

	Male		Female			ANOVA			
	Med.	**IQR**	**Med.**	**IQR**		***R2***	***F***	***Z***	***P***
fWHR	1.930	0.122	1.900	0.152		0.004	0.829	0.398	0.369
Composite Aggr.	2.195	0.710	2.135	0.710		0.006	1.284	0.706	0.255
Verbal Aggr.	3.00	1.025	2.600	1.000		0.031	6.233	2.036	**0.013***
Hostility	2.380	0.860	2.290	0.925		.0002	0.056	0.923	0.807
Physical Aggr.	1.880	0.782	1.630	0.750		0.044	8.941	2.385	**.003****
Anger	2.130	0.910	2.250	1.160		0.023	4.467	1.757	**0.032***
Indirect Aggr.	2.000	0.830	1.830	0.710		0.018	3.668	1.548	0.054

Additionally, composite aggression was not significantly associated with fWHR for either sex ($R^2 = 0.019$, $F = 2.099$, P > 0.05 for females; $R^2 = 0.00001$, $F = 0.001$, $P > 0.05$ for males). However, within the aggression sub-scores, a weak negative correlation was observed between fWHR and verbal aggression in females (Table 3). To explore the potential for non-linear relationships, individual curve estimations were performed for these variables, but no significant relationships emerged.

Table 3. Multiple regression with aggression subscores with the facial width-to-height ratio as a dependent variable. The significance of the tests was assessed via 10.000 permutations.

		R2	***ß***	***F***	***Z***	***P***
Male	**Verbal Aggr.**	.00006	-0.003	0.004	-1.662	0.945
	Hostility	0.007	-0.019	0.596	0.176	0.449
	Anger	0.001	-0.007	0.097	-0.719	0.750
	Physical Aggr.	0.012	0.022	1.025	0.532	0.313
	Indirect Aggr.	.00006	0.002	0.004	-1.641	0.942
Female	**Verbal Aggr.**	0.059	-0.050	6.602	2.102	**0.011***
	Hostility	.00007	0.002	0.007	-1.581	0.933
	Anger	.0004	-0.014	0.052	-0.959	0.817
	Physical Aggr.	.0002	-0.012	0.023	-1.224	0.875
	Indirect Aggr.	0.022	0.044	2.555	1.215	0.115

We also observed a significant positive correlation between fWHR and body mass index (BMI) in females ($R_s = 0.234$, $P = 0.015$) but not in males ($R_s = 0.195$, $P = 0.06$), even though the significance value was borderline. Accordingly, we assessed the relationship between fWHR and aggression sub-scores by controlling for BMI in both males and females. All relationships remained insignificant, including the relationship between fWHR and verbal aggression in females ($R_s = -0.175$, $P = 0.06$), although the P value was still very close to being significant.

4. Discussion

The only study conducted on fWHR in Turkish sample belongs to Özener (2012). Özener conducted his study by taking measurements from digital facial photographs of 470 university students (230 females, 240 males) and found that the mean fWHR was 1.89±0.12 for males and 1.91±0.11 for females. In this study, there were no differences in fWHR between males and females. Consistent with Özener (2012)'s findings on digital photographs, we observed no significant difference between sexes in the direct measurement of the facial width-to-height ratio, nor did we find any significant relationship between aggression scores and the fWHR. In our study, although verbal aggression negatively predicted fWHR in females, this relationship, while statistically significant, appeared to be weak. Additionally, this negative relationship is contrary to what previous studies have expected. Thus, given that the relationship became insignificant after controlling for BMI, the relationship may be a statistical artefact influenced by various factors, including sampling. Therefore, we recommend caution when interpreting the results, as they can be speculative. Furthermore, our analysis indicated that body mass index (BMI) was positively correlated with fWHR in females—and almost in males—supporting findings from previous research (e.g., Coetzee et al., 2010). This lack of sexual dimorphism in fWHRs, —which we failed to detect via direct soft tissue measurements— may reflect underlying differences in body mass rather than true facial morphological variations (Kramer, Jones, & Ward, 2012).

Despite an increasing number of studies exploring the relationship between the facial width-to-height ratio and aggression, no scientific consensus has been reached. One significant issue is that the underlying mechanisms connecting fWHR and testosterone levels have yet to be clearly established. While some studies have indicated a relationship between facial masculinity and testosterone (e.g., Penton-Voak & Chen, 2004; Pound, Penton-Voak, & Surridge, 2008; Whitehouse et al., 2015), the only study—to the best of the authors' knowledge—that demonstrates a significant relationship between fWHR and testosterone levels is by Lefevre et al. (2013). Conversely, numerous studies have failed to find such a correlation (e.g., Bird et al., 2016; Eisenbruch et al., 2018; Hodges-Simeon et al., 2016; Kordsmeyer et al., 2018;), further complicating the understanding of these associations.

While the underlying mechanisms of sexual dimorphism in the facial width-to-height ratio (fWHR) remain unclear, numerousnumerous studies have failed to demonstrate significant sexual dimorphism in the fWHR. In fact, some studies have found that females exhibit larger fWHR values, contrary to expectations (Kordsmeyer et al., 2018; Kramer, Jones, & Ward, 2012; Özener, 2012). At this juncture, without a thorough assessment of the sexual dimorphism of this trait, investigating its relationship with behavioural traits may prove problematic.

Although some studies have reported relationships between fWHR and aggressive, dominant or unethical behaviour (Carre & McCormick, 2008; Geniole et al., 2015; Haselhuhn, Ormiston, & Wong, 2015; Lefevre et al., 2014;), some have presented contrary results. For example, Kosinski (2017) found that the fWHR was correlated with prosocial features, such as agreeableness, in a large-scale study (n = 137.163) conducted using 55 psychometric scale.

We caution that drawing conclusions based solely on the facial width-to-height ratio (fWHR) may be problematic. Even large-scale studies showing significant differences in fWHR between sexes have reported effect sizes that are small (e.g., Geniole et al., 2015), suggesting considerable overlap in fWHR distributions across sexes. Thus, if there is a relationship between sexually dimorphic facial features and behaviours such as aggression, the fWHR may not be the most sensitive or appropriate measure to capture it. In fact, many studies have demonstrated that sexual dimorphism in facial shape and its association with physical and social traits has been effectively analysed using multivariate methods (e.g., Caton et al., 2022; Windhager, Schaefer & Fink, 2011). Given that the use of ratios in biology has been previously critiqued (e.g., Atchley & Anderson, 1978; Packard & Boardman, 1988), we argue that more comprehensive, multivariate approaches are essential for analysing facial shape in behavioural research.

Similarly, the second-to-fourth digit ratio (2D:4D) has recently faced similar criticisms as an easy-to-measure sexually dimorphic feature (Lolli et al., 2017). We find both 2D:4D and fWHR to be very similar because both aim to ‘explain’ various physical and psychological traits. First, they are both considered as markers of testosterone exposure (with 2D:4D indicating prenatal and fWHR indicating pubertal exposure); second, they both show small sexual dimorphism across sexes; and third, the literature contains mostly mixed results for both of them. Thus, we believe that the same criticisms apply to both.

At this point, we recommend a cautious approach regarding the interpretation of the facial width-to-height ratio (fWHR), given that the literature presents mixed results. The inherent challenges of defining and collecting data on psychosocial behaviours, such as aggression and dominance, complicate drawing conclusions in this area. Investigating the relationships between these behaviours and an ambiguous ‘sexually dimorphic’ morphological feature, such as fWHR, could produce inconsistent results. Therefore, in line with the recommendations of Kramer, Jones, and Ward (2012), we believe it would be more fruitful to focus on more clearly defined sexually dimorphic features when examining the links between facial appearance and behaviour. We recommend that researchers apply more comprehensive, multivariate methods for further investigations into the relationship between facial shape and behavioural traits to enhance understanding and improve the reliability of findings.

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