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1 **Title**

2 Higher facial width-to-height ratio predicts fighting performance and perceived aggressiveness in MMA
3 fighters

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11 **Summary**

12 Previous studies have shown that facial width-to-height ratio (fWHR) is associated with sport
13 performance, aggression and homicide. It has, however, been argued that the effect of fWHR might be
14 a by-product of associations between size and behavioural measures. Here we tested whether fWHR
15 and body measures are associated with perceived aggressiveness, fighting ability and success in
16 physical confrontation in Mixed Martial Arts (MMA) fighters. Although perceived fighting ability was
17 predicted by weight but not by fWHR, both fWHR and body weight independently predicted perceived
18 aggressiveness. Furthermore, we found positive associations between fWHR and fighting
19 performance, which appear independent of any effects of body size. Our results indicate that fWHR,
20 as a testosterone-related morphological feature, is associated with fighting ability and perceived
21 aggression, independently of body size, and that fWHR might therefore be considered a viable and
22 reliable marker for inference of success in male intra-sexual competition.

23 **Introduction**

24 A growing body of evidence indicates an association between facial morphology and some aspects of
25 human psychology. In particular, facial width to upper facial height ratio (fWHR) has been proposed as
26 a trait used in competitor assessment. fWHR has been associated with anti-social behaviour [1,2],
27 perceived aggressiveness [3,4] and aggressive behaviour [5,6], sport performance [7], strength [8],
28 and the probability of being killed in violent physical encounters [9] or during wartime [10]. It was
29 initially proposed that fWHR is a sexually dimorphic trait [11], although this has not been confirmed in
30 subsequent studies [12,13]. Nevertheless, intrasexual variation of fWHR in men is related to levels of
31 sex hormones [14]. Testosterone influences growth trajectories of craniofacial shape during puberty
32 [15] resulting in higher fWHR in individuals with higher testosterone levels [14] and higher levels of
33 testosterone are also correlated with aggressive behaviour [16].

34 Several recent studies have suggested that the proposed link between fWHR and aggression might be
35 an epiphenomenon of body size. For example, studies have demonstrated that body weight is a better
36 predictor of aggression than fWHR [17] and that BMI is a better predictor of sport performance [18]. It
37 has been further shown that variation in body dimensions such as weight (or BMI) affect the size of the
38 face and dimensions of morphological traits including fWHR [19]. This strongly suggests that studies
39 testing the potential association between fWHR and psychological characteristics should control for
40 the effect of confounding morphological variables such as body size.

41 Here we tested whether variation in fWHR is associated with 1) perception of aggressiveness and
42 fighting ability, and 2) actual fighting performance, while controlling for the effects of body height and
43 weight. For this purpose, we used data from a sample of professional Mixed Martial Arts (MMA)
44 fighters. We compared measures of fWHR with perceptions of fighters' aggressiveness and fighting
45 ability, judged by independent raters from the fighters' facial photographs, as well as data on actual
46 fighting performance.

47 **Material and methods**

48 i) Stimuli

49 The set of stimuli consisted of 146 portrait photographs of UFC MMA fighters available from
50 <http://www.ufc.com> (for details see [20]). For each fighter, data on age ($M = 29.77$ years, $SD = 4.6$),
51 height ($M = 179.5$, $SD = 8$), weight ($M = 79.08$, $SD = 14.55$), and number of fights ($M = 8.78$, $SD =$
52 7.02) and wins ($M = 5.86$, $SD = 5.19$) in the UFC were obtained. To account for varying numbers of
53 fights among fighters, we computed fighting performance as the proportion of wins relative to the total
54 number of fights.

55 i) Facial width-to-height ratio

56 Each fighter's bizygomatic width and distance between the upper lip and brow [6,15] was
57 independently measured using GIMP 2.8 (GNU Image Manipulation Program). This was done twice
58 (by VT and JF) to assess inter-rater reliability; intra-class correlation was high for both bizygomatic
59 width ($r = 0.947$, $p < 0.001$, $N = 146$) and upper facial height ($r = 0.835$, $p < 0.001$, $N = 146$). The
60 fWHR ratio was calculated by dividing the width by the height.

61 ii) Participants and ratings

62 618 individuals from the Czech Republic (216 men, $M = 26.98$ years, $SD = 6.35$; 402 women, $M =$
63 26.18 years, $SD = 6.22$) rated photographs of fighters for perceived aggressiveness. A further 278 (98
64 men, $M = 28.31$ years, $SD = 9.99$; 180 women, $M = 27.1$ years, $SD = 7.52$) rated the same
65 photographs for perceived fighting ability (for details see [20]). Each participant's ratings were
66 converted to z scores to account for differences in scale use, and a mean standardized score was
67 calculated for each fighter. Ratings of male and female raters were highly correlated for both
68 aggressiveness ($r = 0.933$, $p < 0.001$, $N = 146$) and fighting ability ($r = 0.946$, $p < 0.001$, $N = 146$), so
69 we analysed the ratings of both sexes together.

70 iii) Statistical analysis

71 As fighters' weight, height and fighting performance were not normally distributed (Kolmogorov-
72 Smirnov tests), associations between bivariate variables were assessed using two-tailed Kendall's
73 correlations. The effect of fWHR on other measures was also tested by general linear models (GLM)
74 with fighter's fWHR, height and weight as covariates. The covariates were added in the model only if
75 either or both of the body characteristics were found to be significantly associated with the relevant
76 measure. Effect sizes were expressed by partial η^2 . Data were analysed using SPSS 20.

77 **Results**

78 i) Perceived aggressiveness and fighting ability

79 First, we found significant positive correlations between fWHR and fighter's height ($\tau = 0.171$, $p =$
80 0.003 , $N = 146$) and weight ($\tau = 0.210$, $p < 0.001$, $N = 146$).

81 Perceived aggressiveness was positively correlated with fighter's fWHR ($\tau = 0.161$, $p = 0.004$, $N =$
82 146) and weight ($\tau = 0.189$, $p = 0.002$, $N = 146$). In contrast, fighter's height was not significantly
83 correlated with perceived aggressiveness ($\tau = 0.08$, $p = 0.171$, $N = 146$). A GLM including fWHR and
84 fighter's weight revealed that perceived aggressiveness was significantly and independently
85 influenced by both fWHR ($F_{(1, 143)} = 7.108$, $p = 0.009$, $\eta^2 = 0.047$) and weight ($F_{(1, 143)} = 6.335$, $p =$
86 0.013 , $\eta^2 = 0.042$).

87 Similarly, perceived fighting ability was positively correlated with fWHR ($\tau = 0.157$, $p = 0.005$, $N = 146$)
88 and fighter's weight ($\tau = 0.153$, $p = 0.01$, $N = 146$) but not with fighter's height ($\tau = 0.072$, $p = 0.215$, N
89 $= 146$). Therefore, fWHR and fighter's weight were added as covariates in the GLM. Here, however,
90 GLM results showed that perceived fighting ability was predicted by weight ($F_{(1, 143)} = 4.018$, $p = 0.047$,
91 $\eta^2 = 0.027$) but not by fWHR ($F_{(1, 143)} = 2.649$, $p = 0.106$, $\eta^2 = 0.018$).

92 ii) Fighting performance

93 We first tested for potential associations between fighting performance and fighter's body size, but
94 found no significant correlations between fighting performance and either fighter's height ($\tau = 0.021$, p
95 $= 0.73$, $N = 146$) or weight ($\tau = 0.03$, $p = 0.625$, $N = 146$). However, fWHR was positively correlated
96 with fighting performance ($\tau = 0.114$, $p = 0.046$, $N = 146$).

97 Discussion

98 In a sample of professional MMA fighters, we found a positive association between perceived
99 aggressiveness and fWHR and this effect was independent of body weight. In contrast, perceived
100 fighting ability was significantly predicted only by body weight, but not fWHR. Moreover, actual fighting
101 performance was associated with fWHR and this association was independent of any effects of body
102 size.

103 Previous studies have indicated a relationship between fWHR and sport performance [7] or aggression
104 [4,5]. However, from these results it was not possible to conclude whether fWHR is directly associated
105 with these characteristics or whether it is an epiphenomenon of another morphological traits such as
106 body size [17,18]. Our results suggest that fWHR, but not body height and weight, predicts fighting
107 performance in our sample. This is not to say that body weight is irrelevant, because MMA fights take
108 place between fighters in specified weight categories [see 20]. Further research is therefore needed to
109 test possible interactions between fWHR, body weight and fighting performance in other samples. Our
110 results indicate that fWHR is a predictor of outcome at least when competitors are relatively matched
111 for weight. Interestingly, we also found no significant effect of height on fighting performance. Body
112 height is correlated with upper arm length, which could provide an advantage of longer reach and
113 higher striking force [21]. However, this effect appears to be relatively minor, at least among
114 professional fighters.

115 In agreement with previous findings [17], we also found that fWHR and weight independently
116 contribute to the perception of facial aggressiveness. In contrast, perceived fighting ability was
117 predicted solely by body weight. Based on our findings, we suggest that the assessment of potential
118 opponents acts on multiple dimensions. The first step, a 'fight or flight' decision, might depend
119 predominantly on the overall size of the opponent, as suggested in our ratings of fighting ability.
120 However, when the rivals are of roughly equal size, a further level of assessment takes place which is
121 related to the perception of aggressiveness, affected by fWHR, as well as other facial traits [20].

122 To conclude, in a set of professional fighters we found positive associations between fWHR and
123 fighting performance and these associations were not affected by body height and weight. Further,
124 perception of aggressiveness was significantly associated with fWHR, independently of the effect of
125 the weight. This suggests that human perception may have been selected to be attentive to cues
126 related to variation in the propensity for fighting ability and aggression. Morphological characteristics,
127 such as facial width, may reflect signals as suggested by some authors [5,22]. However, there are a
128 number of criteria for the definition of biological signals, including that the trait was selected specifically
129 for the purpose of communication [23], and more research is needed to determine if fWHR fits the
130 criteria of a signal. Our data do support the notion that fWHR can act as a cue to fighting ability and so
131 play an important role in intra-sexual selection.

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