



## Second to fourth digit ratio confirms aggressive tendencies in patients with boxers fractures



C.W. Joyce<sup>a,\*</sup>, J.C. Kelly<sup>b</sup>, J.C. Chan<sup>a</sup>, G. Colgan<sup>b</sup>, D. O'Briain<sup>b</sup>, J.P. McCabe<sup>b</sup>, W. Curtin<sup>b</sup>

<sup>a</sup>Department of Plastic and Reconstructive Surgery, National University of Ireland, Galway, Ireland

<sup>b</sup>Department of Orthopaedic Surgery, National University of Ireland, Galway, Ireland

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### ABSTRACT

**Background:** Upper limb second to fourth digit ratio (2D:4D) has been shown to be dependent on prenatal androgen exposure. A longer relative fourth digit to second digit is indicative of increased intrauterine testosterone exposure prenatally and the converse is also true for oestrogen exposure. The 2D:4D ratio has implications in the sporting, academic, financial and sexual arenas. The purpose of this study was to examine the association between smaller finger length ratios (2D:4D) and boxers fractures, in both men and women, by comparing the 2D:4D ratios in 150 boxers fractures and comparing them to matched controls. Boxers fractures are an injury classically incurred during acts of aggression and we postulated that this cohort of patients would have a smaller 2D:4D ratio in comparison to the normal population mean ratio.

**Methods:** One hundred and fifty radiographs from patients with boxers fractures secondary to aggressive actions were analysed and the 2D:4D ratio was calculated. A further 150 X-rays from patients not involved in aggressive activities were used as a control group and the 2D:4D ratio was calculated in the same manner. We then performed statistical analysis to compare the 2D:4D ratios between our two groups.

**Results:** As predicted, the 2D:4D in males was smaller than females in all of the groups. However, our results showed that those presenting with a boxers fracture due to an aggression related injury had a statistically significant smaller 2D:4D ratio when compared to the normal population.

**Conclusion:** Boxers fractures are injuries that typically occur from an aggressive act. It is well documented that a low 2D:4D ratio is reflective of an increased prenatal exposure to androgens, particularly testosterone. We have shown that boxers fractures are associated with a smaller 2D:4D ratio than the normal population, thus suggesting that persons exposed to high levels of prenatal androgens are more likely to exhibit aggressive tendencies in adulthood. Our results suggest that smaller digit ratios may predict a predisposition to acts of aggression, and as such result in an increased likelihood of sustaining an injury such as a boxers fracture. This relationship seems to be present independently of gender.

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### Introduction

The advent of digit ratios as potential markers for prenatal androgens arises from the well-established observation that males have longer ring fingers than females.

Second digit (index finger) to fourth digit (ring finger) ratio (2D:4D) is the ratio of the length of the second digit to the length of the fourth digit and is a sexually dimorphic trait. The 2D:4D ratio is smaller for males in humans, mice and baboons [1–3]. The ratio is

the strongest human dimorphic digital ratio combination and is a reliable indicator of the relative exposure to androgens prenatally [3,4]. Second digit (2D) length is reflective of oestrogen exposure prenatally and fourth digit length (4D) is reflective of intrauterine testosterone exposure [4,5]. There is a genetic basis for the level of sex steroid exposure during gestation. The *Homeobox (Hox)* group of genes control digit and urogenital development [6,7]. The *Hoxd* gene is responsible for digit length and penis differentiation in mice [8] with mutations of the *Hoxa* gene resulting in defects of the digits, toes and genitalia in humans [9]. Allelic variation in androgen receptor sensitivity also influences digit ratio with more masculine ratios occurring in the presence of androgen receptor alleles, with fewer CAG base pair microsatellite repeats in the terminal domain [10]. Subjects with lower androgen sensitivity resulting from a higher number of CAG base pair repeats display a

\* Corresponding author at: Department of Plastic, Reconstructive and Hand Surgery, University Hospital Galway, Newcastle Road, Galway, Ireland. Tel.: +353 876815514.

E-mail addresses: [cormacwjoyce@gmail.com](mailto:cormacwjoyce@gmail.com), [cjoyce78@hotmail.com](mailto:cjoyce78@hotmail.com) (C.W. Joyce).

higher 2D:4D ratio [11]. Children with congenital adrenal hyperplasia (CAH) are exposed to high levels of androgens throughout gestation [12] and they have been shown to exhibit more masculinised digit ratios when compared to controls [13,14].

Differences in digit ratio are consistently more dimorphic on the right hand [15,16] as it is a more reliable indicator than the left when investigating the correlation between digit ratio and various psychological traits [1,16,17].

Digit ratio (2D:4D) has been found to be related to numerous psychological and physiological traits. People with lower, more male-typical 2D:4D ratios tend to be better at competitive sports, fitter, more assertive, more aggressive and sexually selected more frequently [17–22]. The 2D:4D ratio is thought to correlate with numerous health, physical and personality traits due to the organising effects of prenatal hormone exposure [16,23–29]. Men with lower 2D:4D ratios are perceived as being more dominant and masculine by female observers [30]. A study by Brown et al. examined a group of lesbians participating in a gay pride parade in which they found that lesbians who identified themselves as ‘butch’ had a significantly lower 2D:4D ratio than those who identified themselves as ‘femme’ [31]. Studies on high frequency financial traders found that men with smaller 2D:4D ratios generated more profit and had more long term success in financial trading [32,33]. They implied that their increased success was due to increased aggression and risk taking as a result of prenatal biological conditioning as opposed to what they would expect based on rational processes. Studies have suggested that any personality or cognitive trait which is sexually dimorphic and determined by prenatal testosterone exposure will correlate with digit ratio, within each gender [34]. Testosterone levels have been positively correlated with increased drug use, violence, delinquency, search behaviour, persistence, high risk health behaviour, aggression and dominance [25,35–38]. Aggression is also a sexually dimorphic trait and aggressive people classically partake in more high risk behaviour than their more passive counterparts and consequently expose themselves to more life-threatening injuries [25,37]. Correlations between digit ratio and aggression have been made for both men and women [17,18].

Boxers fractures (fracture of the fourth or fifth metacarpal neck) are classically associated with aggressive behaviour, usually incurred whilst striking an opposing object, animate or inanimate. 2D:4D is a proposed anatomical marker of early testosterone exposure has been implemented in organising aggressive behaviour. The purpose of our study was to examine the 2D:4D ratios in patients who sustained boxers fractures as a consequence of an aggressive act, and to compare these ratios to a age and gender matched control group. We hypothesised that patients who sustain boxers fractures have a smaller 2D:4D ratio than the general population due to possible increased aggressive tendencies. Second digit to fourth digit ratio (2D:4D) may enable us to reflect on the effect of prenatal testosterone exposure on aggressive behaviour [21].

## Methods

We reviewed 2500 X-rays of fractured hands taken over a three-year period between 2007 and 2010. One hundred and ninety-seven boxers fractures of the right hand were identified in total. Cases were excluded if the AP X-ray was not adequate for 2D:4D ratio analysis. Some films did not adequately display the digit ratio due to excessive flexion of the digits and some X-rays did not display both digits required for analysis. X-rays with a pre-existent fracture of the 2nd or 4th digits were excluded. Thirteen fractures were not related to aggressive acts and were excluded. One-hundred and fifty suitable X-rays of right sided boxers fractures

**Table 1**

Aetiology of the boxers fractures ( $n = 130$ ).

Aetiology of boxers fracture	Number of patients
Street-fighting	113
Martial arts/boxing	12
Aggression during sporting activity	25

were identified and found on chart review to have occurred as a consequence of an aggressive act and were selected for further analysis. Of these, 130 were male and 20 were female. Injuries were sustained most commonly from street-fighting, boxing or martial arts ( $n = 125$ ) (Table 1). The remainder occurred during aggressive sporting exploits ( $n = 25$ ). All charts were reviewed for gender, age and mode of injury. Radiographs of all boxers fractures were reviewed using the IMPAX ES DS3000 (AGFA, Mortsels, Belgium) radiological analysis system. The lengths of the ring and index fingers were calculated by measuring from the base of the proximal phalanx to the tip of the distal phalanx. Each measurement was taken to the nearest 0.1 mm. As a control group, 150 right hand X-rays were reviewed which did not have a boxers fracture and which were not taken as a result of an injury sustained in an aggressive act. This control group of radiographs of the right hand was matched for gender and age (130 males, 20 females). Measurements were performed in exactly the same manner described above. The 2D:4D ratio was calculated by dividing the length of the index finger (2D) by the length of the ring finger (4D). Plain radiographs were used to measure the 2D:4D ratio in our study but the ratio can also be calculated by measuring directly from the skin surface or by using photocopies or digital scans [26]. No hand X-rays were included in either group in which a pre-existent fracture or degenerative condition was present. All data were then analysed to determine if a relationship existed between the digit ratio and boxers fractures.

## Statistical analysis

The Kruskal–Wallis non-parametric test was used to compare the difference between groups. A  $p$ -value of  $<0.05$  was considered statistically significant. Dunn's multiple comparisons test was carried out to examine the difference between groups.

## Results

The statistical significant difference between all groups was extremely significant ( $p < 0.0001$ ). Boxers fractures had the lowest 2D:4D ratios, regardless of their gender (Table 2). The 2D:4D ratios for male ( $0.922 \pm 0.01$ ) and female boxers fractures ( $0.948 \pm 0.009$ ) were statistically highly significant ( $p < 0.001$ ). Similarly, these two groups also had smaller ratios when compared with the corresponding non-boxer fracture male/female control, and they were statistically highly significant ( $p < 0.001$ ) (Table 3). The 2D:4D ratio for male non-boxers fractures (control) was still lower than female non-boxers fractures (control) and this difference was significant ( $p < 0.05$ ).

**Table 2**

The mean  $\pm$  standard deviation of second digit to fourth digit ratios in our four groups.

	Males	Females
Control	$0.972 \pm 0.0139$	$0.9887 \pm 0.0149$
Boxer's	$0.922 \pm 0.0147$	$0.948 \pm 0.0091$

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