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Second to fourth digits ratio (2D:4D) and subjective pain experience in tattooing

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Abstract: This aims of this research are to determine if the 2D:4D digit ratio is related to subjective pain experience during tattooing and to examine gender differences therein. The study involved 43 male and 28 female Polish adults recruited from two tattoo salons in Wroclaw and Leszno in Western Poland. These subjects were asked if they felt pain during their tattooing and answers were recorded as 'Yes' or 'No'. The ventral surface lengths of the second and fourth digits of each hand were measured, and analysis of variance was performed to assess significant differences in the 2D:4D ratios of right and left hands and two-hand averages between genders and the Yes/ No groups reporting pain experience. Results revealed that although the digit ratios for females had systematically higher values than those in males, differences were not statistically significant. Both sex and subjective pain feeling were significantly associated with 2D:4D ratio in both hands and their average values, while sex and pain experience were independently associated with digit ratio. Subjects who felt pain during tattooing had a significantly lower digit ratio. In conclusion, the study did not support the hypothesis that the lower masculine 2D:4D ratio is associated with a higher pain threshold. Prenatal sex hormonal exposure generating the gender dimorphic 2D:4D index may not predispose the actual feeling of all kinds of pain; in this instance, not in pain associated with tattooing.

Key words: 2D:4D digit ratio, subjective pain, tattoo

Introduction

Gender differences in human pain perception have been reported in numerous studies; from laboratory experiments to epidemiological studies of clinical conditions (Craft 2007). It is also well established that men and women differ in pain sensation and pain related behaviours (Fillingim 2000), and that these differences are both qualitative and quantitative (Craft 2004). Laboratory tests showed that females feel more pain induced by heat, pressure and chemical irritants than males (Chesterton et al. 2003; Sarlani et al. 2003;

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Frot et al. 2004). Sex hormones have been proposed as potential candidates to help explain pain-related differences between, and within, males and females (Fillingim 2000; Fillingim and Ness 2000). Oestrogen, progesterone, and other gonadal hormones have a complex role in inflammatory processes and pain perception through the intermediate mechanism of central nervous system hormone receptor actions (Mansion 2010). Mintaze et al. (2002) reported that sex hormone levels influence pain perception in healthy women (Mintaze et al. 2002) and Choi et al. (2006) considered that pain perception in menstruating women can differ between the follicular and luteal phases.

However, the digit ratio (2D:4D) appears a good putative indirect marker of prenatal hormone exposure (Keogh et al. 2007). The ratio between the second and the fourth digit length (2D:4D) tends to be lower in males than in females, so that men tend to have longer fourth digits compared to their second, than women (Manning 2002; Cohen-Bendahan et al. 2005). Low 2D:4D value was also associated with high intrauterine testosterone exposure (Manning et al. 1998; Lutchmaya et al. 2004; Cohen-Bendahan et al. 2005). The fact that males generally report less pain than females may be attributed to some protective effect of testosterone (Hau et al. 2004). Low 2D:4D indicates high prenatal testosterone and sperm counts, and high 2D:4D is an indicator of high prenatal oestrogen (Manning 2002). The digit ratio has also been also reported to be determined at approximately two years of age (Manning et al. 1998), and amniotic fluid analysis has indicated that foetal testosterone and oestradiol were correlated with digit ratio measured at two years of age. Low 2D:4D with a high level of foetal testosterone relative to foetal oestradiol was associated with the development of a low 2D:4D ratio; and vice versa (Lutchmaya et al. 2004). This ratio may therefore indirectly indicate prenatal hormone exposure, and can be taken as a proxy link between hormone exposure and perception of pain. Because women are generally more sensitive to pain than men, it can be hypothesized that the higher more-feminine value of 2D:4D is associated with subjective pain perception. However, relevant study results are inconsistent. Keogh et al. (2007) highlighted that the cold-pressor pain threshold was positively associated with digit ratio in women, but not in men.

In view of these findings, the primary aim of this study is to determine whether the 2D:4D ratio is related to subjective pain experience during tattooing. An additional aim is to determine if gender differences existed in subjective pain experience related to digit ratio.

Materials and Methods

The subjects in this study were 43 males and 28 females opportunistically recruited from two tattoo salons located in Wroclaw and Leszno in Western Poland, and they participated in the research on a voluntary basis without remuneration. All participants reported having tattoos on various body parts. Forty-seven subjects (66.2%) had one tattoo and the remaining 24 (33.8%) had more than one. Tattooed body areas were as follows; 45% on the back, 11.3% on the abdomen, 36.6% on hands, 30.9% on legs, 11.3% on the head and 4.2% on the chest. There were no significant differences in tattoo body location in participants reporting "pain/no pain" during the procedure.

All subjects were Polish with a mean age of 23.0 years (Range =16–41 years; SD =3.73 years). The majority of participants were single (n=65; 91.5%), with only 6 (8.5%) married. Most subjects had completed secondary school (n=53), while 17 were postgraduates and one had some vocational education.

Participants filled out a questionnaire in which a question concerning subjective feeling of pain during body decoration read as follows: "Was the tattoo operation painful?" and subjects could choose "yes" or "no". They were approached almost immediately after tattooing. There were no significant relationships between feeling pain and tattoo body site in both sex.

The lengths of the second and fourth digits of each hand were measured to the nearest 0.1 mm by a trained physical anthropologist using a digital slide calliper (Mitutoya). The finger length measurements from the middle of the basal crease to the tip of the digit were made on the ventral surface of the hand. This procedure maintains good reliability (Manning 2002) and low measurement error (Keogh et al. 2007).

The gender differences in 2D:4D ratio of right, left hand and two-hand average and the groups reporting subjective pain experience (Yes/No) were evaluated by two-way univariate analysis of variance (ANOVA), where gender and groups were the independent variables and the 2D:4D values comprised the dependent variable. The differences in the means between the two groups in both genders were assessed using the post hoc NIR Fisher's test, and all analyses were performed on STATISTICA 10.0 software (StatSoft 2010).

Results

The feeling of pain was more frequently reported by females than by males; 64.3% and 27.9% respectively, $\chi^2=9.2$; $p<0.01$. Table 1 presents the means and standard deviations of digit length ratio of each hand and the two-hand average ratio in males and females. Although all these values were higher in females than in males, the differences were not statistically significant.

Results of the two-way ANOVA are shown in table 2. Both gender and subjec-

Table 1. Means and standard deviations of digit-length ratio in tattooed males and females

	Male		Female		t*
	mean	SD	mean	SD	
Right hand 2D:4D ratio	0.985	0.03	1.001	0.02	–1.343
Left hand 2D:4D ratio	0.981	0.03	0.992	0.03	–1.740
Average 2D:4D ratio	0.983	0.03	0.994	0.03	–1.624

*The differences are not statistically significant.

Table 2. Results of univariate two-way analyses of variance, where gender and subjective feeling of pain (yes/no) were independent variables and the 2D:4D ratio of right, left and two-hand average were dependent factors

Factors	Right hand		Left hand		Average of two hands	
	F	P	F	p	F	P
Sex	9.84	<0.01	6.77	<0.05	9.31	<0.01
Pain feeling	12.41	<0.001	13.33	<0.001	15.03	<0.001
Interaction	1.21	>0.05	1.04	>0.05	0.02	>0.05

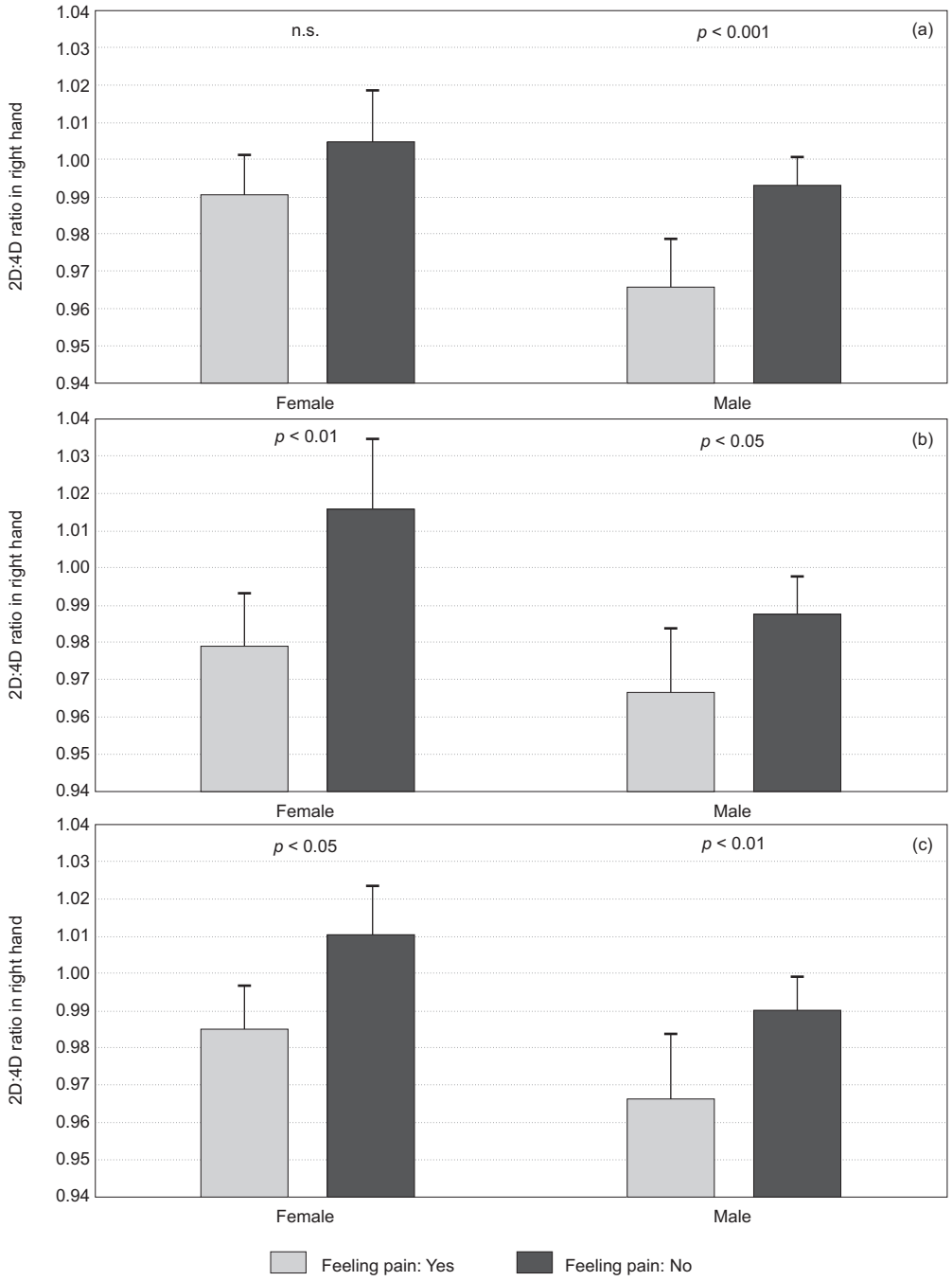

Figure 1. Comparison of means ± S.E. value of 2D:4D ratio of right (a), left (b) and two-hand average (c) with subjective pain sensation in males and females with body decoration. Differences in these groups were assessed by the post hoc NIR Fisher's test

tive pain experience had significant effect on digit ratios in both hands and also on average values. The co-efficient of interaction between gender and feeling pain was not significant. This indicated that these factors independently affected digit ratio. Subjects of both genders who reported pain during their tattoo procedure had significantly lower digit ratio values in both hands and in the two-hand average (Fig. 1a, b, c).

Discussion

Pain is an overall experience consisting of both sensory and affective/emotional components (Loeser and Treede 2008). Gender differences exist in pain thresholds, tolerance levels and the prevalence of clinical pain conditions; with females usually more sensitive than males (Robinson et al. 1998). The relative digit length ratio between the second and fourth finger (2D:4D) is an indirect biological marker of pain which highlights dimorphic anatomical gender differences in males and females; and here men have a lower ratio than women. This dimorphic gender 2D:4D index is believed to reflect prenatal testosterone and oestrogen levels. A higher index in women (= or >1) results from prenatal exposure to lower testosterone levels while a lower index in men (<1) results from higher levels (McIntyre 2006). The 2D:4D ratio may therefore constitute an indirect method of examining the potential organizational role of uterine hormone exposure in pain sensation (Keogh et al. 2007).

This study demonstrated; (1) pain experience was more frequently reported by females than by males, (2) no statistically significant difference existed in 2D:4D ratio between males and females, although women had slightly higher values than men for both hands, and this finding was inconsistent with Manning's (2002) results, and (3) the two way ANOVA test revealed independent gender effect on the digit ratio in our sample. Additional studies found that men reported less intense pain sensation than women (Riley et al. 1998; Keogh et al. 2007).

Regarding the relationship between digit ratio and reported feeling of pain, we found that both male and female subjects who reported pain had significantly lower digit ratio values in both hands and also a lower two-hand average value. It was previously mentioned herein that digit ratio could indicate exposure to prenatal sex-hormones. Since exposure here was related to the feeling of pain, it was expected that low 2D:4D as an indicator of high prenatal testosterone exposure would be associated with negative pain perception. But our results did not support this assumption.

Results from other studies proved inconsistent for the association between 2D:4D ratio and feeling pain. As in our research, Yamamotova et al. (2009) found that a more feminine higher index in men was associated with higher pain threshold, and therefore higher pain tolerance. They also determined that pain intensity in all their subjects correlated positively with 2D:4D, although correlation approached significance only in men when separate analysis was applied. They therefore hypothesized that the 2D:4D index is associated with the perception of long-duration tonic pain which is more dependent on the entire structural and functional sensory and affective nociceptive system rather than being connected with short-duration phasic pain (Yamamotova et al. 2009).

Since Keogh et al. (2007) reported a positive correlation between the gender dimorphic 2D:4D index and pain threshold in women but not in men, the combined results obtained from our work and the two studies above failed to support the hypothesis that the more masculine lower index is associated with a higher pain threshold.

Although the 2D:4D ratio may be a reliable indicator of gonadal hormone levels in the intrauterine environment, it does not necessarily follow that it determines the actual circulating adult hormone levels reportedly associated with subjective feeling of pain (Choi 2006). The pain experienced by our subjects during tattooing was short-lasting pain which may have depended on their circulating hormone levels at the time of their procedure rather than being connected with prenatal sex-hormone exposure from a structural-developmental nociceptive system. Support for this assumption can be drawn from a recent meta-analysis which found no association between adult hormone levels and 2D:4D ratio (Hönekopp et al. 2007).In contrast, other studies recorded a significant negative correlation between 2D:4D and adult testosterone in men (Roney et al. 2004) and a positive correlation with oestradiol levels in women (McIntyre et al. 2007). These studies did not consider that the association of digit ratio with pain perception could also depend on stimulous intensity. Here, Schwerdtfeger and Heer (2008) observed a significant association between digit ratio and higher electrical stimulus intensity which was absent in lower intensity stimulus application. It can be assumed that the pain generated by tattooing was low-intensity in nature. Therefore, we did not find the expected association pattern generated by intense pain sensation. It would be very interesting to observe the results of comparative research between current fashion tattooing and the different techniques with varying degrees of incision and piercing used in tribal communities and initiation ceremonies.

However, some assumptions herein should be viewed with caution because of the following shortcomings in this study. (1) the sample size was small, (2) the number of tattoos and their type, size and site were neither qualified nor quantified (3) pain reported during different female menstrual cycle phases was not considered and (4) the pain intensity variable was not investigated. While these inclusions in future studies should produce interesting scientific results, this study is intended to stimulate interest in new research directions based on linking digit ratio to physiological and behavioral developmental aspects of human life. One example of new research is the association of pain sensation during tattooing and health and reproductive success linked with indices such as the 2D:4D ratio. This research can be conducted at the population level, similar to recent investigations linking tattooing, body symmetry/asymmetry and reproductive success (Kozieł et al. 2010).

In conclusion, this study did not confirm the hypothesis that the lower, more masculine 2D:4D value is associated with less or zero pain sensation. Perhaps, this gender dimorphic ratio which is a proxy measure of prenatal sex-hormone exposure does not actually reflect the feeling of all types of pain; for instance, pain felt during tattooing.

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Author contribution

SK conceived this research paper, was a principal investigator in the research and wrote the first and final versions. RCh was project investigator and co-author of the first and final versions. AS performed statistical analyses, interpreted results and co-wrote the first and final versions.

Conflict of interests

The authors declare that there is no conflict of interests.

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