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Is digit ratio (2D:4D) associated with the choice for the uniformed versus a civil study course by the Polish youth?

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ABSTRACT: The 2nd to 4th digit ratio (2D:4D) is a sexually dimorphic trait determined by the relative balance of prenatal testosterone (T) and oestrogen during the intrauterine development of foetus. Males on average have relatively lower 2D:4D than women in population. Lower 2D:4D is very often linked with greater physical ability, strength, superior sporting performance and many personality traits and behaviours which are seen more among the males. Recently, lower 2D:4D were associated with military and police services among the Polish women. The objectives of this study were to examine whether 2D:4D differed between the students of a study course for future military service and a civil study course and whether sex difference in this ratio is present in both these groups. The cross sectional study included 50 boys and 42 girls enrolled in the uniformed course and other 56 boys and 50 girls of a general course in an upper-secondary School. The lengths of the second (2D) and fourth fingers (4D) of each hand were measured to have the 2D:4D ratio. Height and weight were also recorded. Overall, as well as among the civil course students, males showed significantly lower mean 2D:4D compared to the females. But there was no significant sex difference in digit ratio among the uniformed course students. Besides, the females under uniformed course showed lower 2D:4D than the females in civil course, whereas, the male uniformed students had similar or almost same 2D:4D values with the male civil course students. Increased prenatal testosterone exposure might have a role in determining the choice towards a challenging future occupation and such effect is perhaps more pronounced in women than in males.

KEY WORDS: prenatal testosterone, foetal androgen, 2D:4D, digit ratio, behaviour, choice of a study course

Introduction

Foetal exposure to intrauterine androgens has an important role in the organizational development of brain leaving a lifelong influence on behaviour. The impact of prenatal testosterone exposure during early intrauterine develop-

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ment has critical role in 'masculinised' and sexually differentiated behaviours throughout lifespan (Lombardo et al. 2012; Auyeung et al. 2013; Hines et al. 2015; Manning et al. 2017). It is impossible to get a direct estimate of an individual's prenatal hormone exposure later in her adulthood. However, a simple ratio of the lengths of the second- to fourth digits (2D:4D) may serve as a useful proxy indicator of balance between prenatal- testosterone (PT) and oestrogen (PE); it correlates negatively with PT and positively with PE levels (Manning 2011; Zheng and Cohn 2011). Low 2D:4D were thus associated with a high PT, relative to PE, and a higher 2D:4D with higher PE, relative to PT (Manning 2011; Lutchmaya et al. 2004; Cohen-Bendahan et al. 2005). Confirmation of the role of PT to elongate the ring finger, and PE influencing the relative elongation of index finger, also came from experimental studies on animal models (Zheng and Cohn 2011). Thus, 2D:4D ratio represented an indirect estimate of the testosterone-oestrogen balance in a narrow developmental window, approximately between 8–10 weeks of gestation. At this time, the sex steroids act to exert their 'organisational' effects on the brain and other developing systems (Zheng and Cohn 2011; Auger et al. 2013). As male foetuses experience a higher level of PT exposure relative to PE, than the females, males tend to have longer 4^{th}- relative to 2^{nd} digits, resulting in a lower 2D:4D ratio (Manning 2011, Cohen-Bendahan et al. 2005). The sex difference in 2D:4D, that appears at the end of first trimester (Malas et al. 2006; Galis et al. 2010), does not alter significantly in rest of life (McIntyre et al. 2005; Trivers et al. 2006). Therefore, in the general population, males as a group, show lower mean 2D:4D than the females. Some genes that were also suggested to control skeletal development of fingers also influenced the developing brain (Zheng and Cohn 2011) establishing a plausible link between 2D:4D and brain 'organisation' that determined many behavioural traits expressed in adult life (Manning 2011).

A lower 2D:4D were frequently linked with higher sporting ability, physical fitness, and higher response to testosterone surge in challenged situation leading to increased muscular strength and endurance (Hönekopp and Schuster 2010, Manning et al. 2014; Koziel et al. 2017, Kociuba et al. 2019). However, several studies also linked 2D:4D with many sexually dimorphic behavioural and personality traits such as assertiveness, confidence, risk-taking attitudes and life outcomes such as occupational choice (Manning et al. 2010; Nye and Orel 2015). Significant group differences in 2D:4D were observed between members of different branches of military service and a low 2D:4D was linked with the selection of the type of military training associated with higher risk (Huh 2012). Risk taking behaviour was found more often in males (Daruvala 2007; Ball et al. 2010) and linked with prenatal hormone exposure (Apicella et al. 2008) as well as with lower 2D:4D (Garbarino et al. 2011; Hönekopp 2011). Enterprising nature, interest in male dominated jobs, sensation- and/or thrill-seeking behaviour, choice of academic disciplines were all found to be associated with lower 2D:4D (Weis et al. 2007; Fink et al. 2006; Austin et al. 2012; Kozieł et al. 2013). Significant difference in 2D:4D between faculties of science and social science departments was also demonstrated indicating its relationship with the choice of academic careers (Brosnan 2006).

A lower 2D:4D among women was also associated with typically male dominated jobs in wide varieties of occupations (Manning et al. 2010). Choice of participation in individual-, rather than in group sports among Polish men (Koziel et al. 2016), and opting for a specific type of sport among Polish women, were associated with low 2D:4D (Kociuba et al. 2017). Although it was argued that the decision to venture in a highly competitive environment was not significantly correlated with 2D:4D (Apicella et al. 2011), there was strong evidence of a negative association of 2D:4D with self-reported competitiveness (Bönte et al. 2017). Occupation and sports types that involved higher relative risk and required greater physical ability and competitiveness were reported to be associated with low 2D:4D. Several recent studies among Polish population by the present group of researchers also indicated such associations. For instance, the Polish girls who preferred high risk sports like Judo as a regular and compulsory activity also showed lower 2D:4D compared to other girls, who, on the contrary, chose relatively low risk sports and games, such as aerobics (Kociuba et al. 2017). In another study, the female police officers in Poland, compared to a civil group of females, demonstrated lower 2D:4D values (Koziel et al. 2018). The Polish women who went for military training course showed lower 2D:4D than women choosing a civil course in the same academy (Kociuba et al. 2016).

With this background knowledge, the present study tested whether low 2D:4D (i.e., higher intrauterine androgen effect) was associated with voluntary selection of a study course leading to a high risk- and challenging occupation in a very young Polish boys and girls aged around 18 years. We compared two groups of students participating in two kinds of study courses, the first one leading to a career in military services (hereinafter 'uniformed course') and another normal course suited for civil jobs in future (hereinafter 'civil course'), respectively. Another objective of this study was to further investigate whether such association, if any, was present in both sexes or not. It was hypothesised that the participants in the uniformed course would have lower 2D:4D compared to the children in the civil course. In other words, we hypothesised that the individuals exposed to higher PT (represented by lower 2D:4D) had an organizational impact that resulted in a personality type inclined to a challenging career relative to those exposed to lower PT and higher PE (represented by relatively higher 2D:4D).

Material and Methods

Participants and settings

This cross sectional study included 198 young individuals closely around 18 years of age. Among them 50 boys and 42 girls were the experimental group attending The European School of Uniformed Services in Wrocław (ESUS). Another 56 boys and 50 girls were included as the controls from Upper-secondary School (USS) in Bierutów, a town located around 30 km from Wroclaw, Poland. All participants aged above 18.0 year and provided written consent of participation in the study. Ethical standards according to Helsinki Declaration were obeyed (Goodyear et al. 2007).

The study courses

All students chose the type of school voluntarily and independently after consultation with parents. The recruitment was based on the results of the final examination of secondary level school. The basic teaching curriculum was the same in ESUS and USS included in the study. However, the program in ESUS was specially designed for preparing graduates for military services; several additional trainings of physical activity were included, namely, close-order drill, combat training, topography, medical rescue, shooting and close-range fight. Selected lessons were also carried out in military academies. Once a year, students of ESUS had to take part in training camps and several special trainings in military academy. After successful completion of the course, the graduates had priority in enrolment for a professional military service in Poland. In contrast, the civil course in USS was only concerned with academic training and performances without any rigorous physical training and orientation programme.

Anthropometric measurements

Examinations for the study were conducted in morning hours at the respective institutes. First, the participants were asked to fill in a questionnaire that included age and parental occupation. Individuals with history of serious injuries or deformities of digits were excluded. Measurements of height using an anthropometer (GPM, Switzerland) with accuracy to nearest 1 mm and body weight by a weight scale (FAWAG, Poland) with accuracy to 100g were recorded. Lengths of second and fourth digits of both hands were measured by a digital calliper (TESA SHOP-CAL) up to the second decimal place, on the ventral surface of the hand, from the mid-point of the basal crease (most proximal to palm) to the tip of the digit. Two boys were excluded due to past injuries of digits and 2 girls and 3 boys declined to participate in study.

Statistics

Descriptive statistics of mean and standard deviation of 2D:4D were calculated for each hand and for the average of two hands. For both the boys and girls groups, the Kolmogorov-Smirnov test showed normal distribution of 2D:4D in both hands. Students't-test was performed separately for boys and girls to observe the significance of difference in left, right and the average 2D:4D between uniformed and civil course cohorts. Multivariate analysis of covariance was conducted to test the differences in 2D:4D between course types, allowing for age, height and BMI. Two-way analyses of variance were also conducted to test the impact of sex and the course type (uniformed and civil) on digit ratio, separately for left hand-, right hand- and the average 2D:4D of both hands in each sex. Differences in mean ($\pm$SE) 2D:4D between the uniformed and civil groups were assessed by Tukey's post-hoc analysis of variance. In all calculations, values of $p<0.05$ was considered significant. The differences were also presented by appropriate diagrams (Figures 1, 2 and 3). All the statistical analyses were performed by Statistica13.1 software (Dell Inc. 2016).

Results

The mean (SD) ages were almost equal for boys and girls, 18.57 (0.51) and

18.67 (0.51), respectively, with no significant difference. Within each sex, there were also no significant age difference between the uniformed and civil groups (t=1.03, $p<0.05$, and t=0.23, $p<0.05$, for boys and girls respectively). Besides, there was also no significant difference in height or BMI between the uniformed and civil groups within each sex.

Table1 presents the mean (SD) of 2D:4D according to sex among all participants, civil course students and uniformed course students, respectively. It also shows the values according to course type in males and females, separately. Overall mean (SD) values for right-, left- and the average 2D:4D differed significantly between sexes, males showing lower value in each case. Similar and clear sex difference was observed too within the civil course students. However, there was no significant difference in 2D:4D between sexes in the uniformed course group.

Differences in 2D:4D were also assessed between the two study courses, uniformed and civil, within each sex separately. Significant difference in mean 2D:4D between the uniformed and civil courses were observed in females but not in males. The female uniformed students had significantly lower (i.e., more mas-

Table 1. Means and standard deviations (SD) of digit ratio according to sex and course type

	Male	Female	t
All students	(N = 106)	(N = 92)	
Right 2D:4D	0.97 (0.03)	0.99 (0.03)	3.29**
Left 2D:4D	0.98 (0.03)	0.99 (0.03)	2.66**
Average 2D:4D	0.98 (0.03)	0.99 (0.03)	3.25**
Civil course	(N = 56)	(N = 50)	
Right 2D:4D	0.97 (0.03)	0.99 (0.03)	4.32**
Left 2D:4D	0.98 (0.03)	1.00 (0.03)	3.32*
Average 2D:4D	0.97 (0.03)	1.00 (0.03)	4.21**
Uniformed course	(N = 50)	(N = 42)	
Right 2D:4D	0.97 (0.04)	0.97 (0.03)	0.43
Left 2D:4D	0.98 (0.03)	0.99 (0.03)	0.48
Average 2D:4D	0.98 (0.03)	0.98 (0.03)	0.54
	Uniformed course	Civil course	t
Male	(N = 50)	(N = 56)	
Right 2D:4D	0.97 (0.04)	0.97 (0.03)	0.27
Left 2D:4D	0.98 (0.03)	0.98 (0.03)	0.47
Average 2D:4D	0.98 (0.03)	0.97 (0.03)	0.38
Female	(N = 42)	(N = 50)	
Right 2D:4D	0.97 (0.03)	0.99 (0.03)	3.30**
Left 2D:4D	0.99 (0.03)	1.00 (0.03)	2.18*
Average 2D:4D	0.98 (0.03)	1.00 (0.03)	2.95**

Statistically significant at *$p< 0.01$; ** $p< 0.001$.

Table 2. Results of analysis of covariance where 2D:4D was dependent variable, course type was (uniformed vs. civil) independent variable and height, BMI and age were covariates

	Right hand Wald's χ^2 (p)	Left hand Wald's χ^2 (p)	Average Wald's χ^2 (p)
Males			
Age	0.62 (0.431)	0.00 (0.997)	0.11 (0.740)
Height	0.98 (0.322)	0.01 (0.931)	0.46 (0.499)
BMI	1.83 (0.176)	0.34 (0.560)	1.17 (0.279)
Course type	0.11 (0.737)	0.18 (0.673)	0.14 (0.711)
Females			
Age	0.00 (0.957)	0.22 (0.642)	0.05 (0.831)
Height	10.17 (0.001)	4.84 (0.028)	8.36 (0.004)
BMI	0.64 (0.422)	0.88 (0.349)	0.00 (0.958)
Course type	11.72 (0.001)	4.71 (0.030)	9.02 (0.003)

culine) values of left (t = 3.30, $p<0.01$), right (t = 2.18, $p<0.01$) and the average 2D:4D of both hands (t = 2.95, $p<0.001$) compared to the female civil students (Table 1).

As significant differences in age and height were observed between female cadets and civil students, analysis of covariance (ANCOVA) was performed separately for boys and girls to see whether the results, as shown in table 1, changed after controlling for age, height and BMI. The results of ANCOVA are presented in Table 2.

In each analysis of covariance for each sex, 2D:4D was dependent variable, type of study course (uniformed or civil) was independent variable, and age and height were covariates. In males, no significant effect of course type was observed on 2D:4D in any hand (R/L) or on average for both hands (A) after adjusting for age, height and BMI (Wald's ^{2} R=0.11, p=0.737; L=0.18, p=0.673, A=0.14, p=0.711, respectively). However, among the females, significant difference in right (R), left (L) and average (A) 2D:4D existed between the uniformed and civil

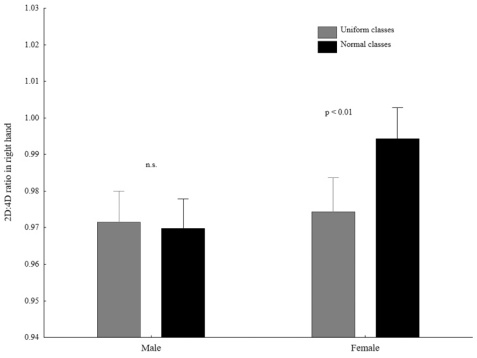

Fig. 1. Comparison of means (± S.E) of 2D:4D of right hand according to course type (uniformed vs civil) and sex. Differences in groups were assessed by Tukey's post-hoc HSD test

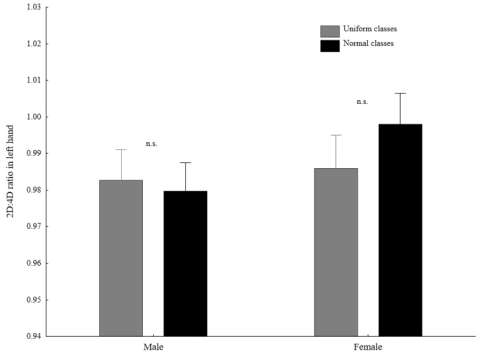

Fig. 2. Comparison of means (±S.E) of 2D:4D of Left hand according to course type (uniformed vs civil) and sex. Differences in groups were assessed by Tukey's post-hoc HSD test

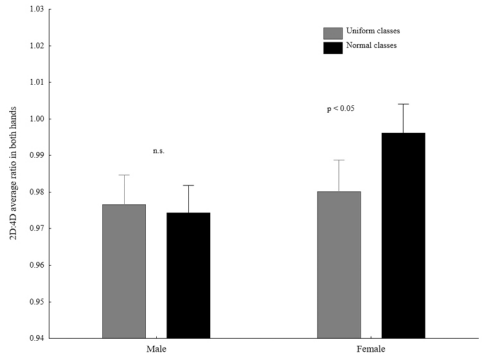

Fig. 3. Comparison of means (±S.E) of average 2D:4D of both hands according to course type (uniformed vs civil) and sex. Differences in groups were assessed by Tukey's post-hoc HSD test

courses even after controlling for age and height (Wald's χ^2 R=11.72, p=0.0006, L=4.71, p= 0.03, A=9.02; p=0.0027, respectively). It was worth noting that the difference in 2D:4D between the courses was relatively more prominent in right hand in females.

Figures 1, 2 and 3 also demonstrate the differences in mean (±SE) 2D:4D between the uniformed and civil groups assessed by Tukey's post-hoc analysis of variance. The differences in right -, and the average 2D:4D between the uniformed and civil course students were only evident in females but not in males. Female uniformed students always showed lower 2D:4D than their civil course counterparts. But the uniformed boys had no significant difference with the civil course boys. However in this post-hoc analysis the difference in left 2D:4D in females were also not significant.

Discussion

Prenatal testosterone (PT) has definite 'organisational' effects on brain during its early development and thus determines behaviour in the later life to a great extent (Zheng and Cohn 2011). Behaviours that were more prevalent in males, such as, assertiveness and risk-taking attitude, were very often suggested to be associated with higher PT (Manning 2002; Manning and Taylor 2001). Even females exposed to higher intrauterine androgen, demonstrated behaviours that were found more in males, during their infancy, relative to those having a lower exposure (Hines 2000). Even in case of occupational choices, women exposed to higher PT (low 2D:4D) were more likely to work in male dominated occupations, while women with low PT exposure (higher 2D:4D) were more likely to work in occupations that are female dominated (Manning et al. 2010, Kozieł et al. 2018). Uniformed services in Poland are certainly male dominated as around the World; females occupy only about 6% of the Polish Armed Forces (Information procured from the Ministry of Defence, Poland) and about 15% of police forces (ENP 2017). In the present study, females were found to comprise <20% of the total enrollments in the uniformed course, clearly showing male dominance.

The present study investigated whether 2D:4D ratio differed between uniformed- and civil course students and also the sex variation in such difference. The results of this study, in general, supported the theory of sex difference in 2D:4D in the general population. Among all participants of this study, males showed significantly lower mean 2D:4D compared to the females. When only the civil course students were taken into account, the same kind of sex difference prevailed – the females showed significantly higher mean value. However, there was no significant difference

in digit ratio between males and females within the uniformed course students. In other words, the usually expected sex difference in 2D:4D was absent among the uniformed course students. However, the comparison of 2D:4D between the two courses revealed different results for each sex. The females under uniformed course showed lower 2D:4D than the females in civil course. The male uniformed students had similar or almost same 2D:4D values with the male civil course students with no significant differences in between. In brief, the 2D:4D difference between the cohorts of two courses was evident and statistically significant only in female sex, but not in males.

In view of the relatively more challenging and physically demanding nature of the uniformed course, a lower value of 2D:4D was expected among its students compared to the civil course students, irrespective of sex. However, the uniformed males did not have lower 2D:4D than the civil course males. Such phenomenon was, however, also previously reported in 2D:4D literature. In a study from Austria, 2D:4D was not lower (more masculine) among the male firefighters than in males from general population (Vorachek et al. 2010). Besides, the present study revealed that the association of low 2D:4D with the uniformed course was only observed among the females, but not in males. In Jamaican children, the association of low 2D:4D with endurance-linked running was reported to be the strongest in females (Trivers et al. 2013). Contrastingly, the male Indian swimmers, but not the female, showed significantly lower 2D:4D ratio (Sudhakar et al. 2013). Coming straight to the domain of choice and attitudes relating to 2D:4D values, and more particularly, in the Polish population, the results of some recent studies are worth citing here. Kociuba et al. (2016) showed similar results among the adult Polish males and females, where the females who chose a highly challenging military course showed a lower mean 2D:4D than the females who picked up a civil course in the same military academy. As in the present study, the males in those two courses, however, did not show such difference. Also, within the military course, the sex difference in digit ratio was absent, but not within the civil course (Kociuba et al. 2016). Another study, again among the Polish participants, showed that the female Police officers, but not males, had significantly lower 2D:4D in right hand and also in average of two hands compared to the general females (Koziel et al. 2018). The present study thus not only demonstrated a similar pattern of association of 2D:4D with the voluntary choice of study / training course for a challenging and riskier job, but also indicated that such association could also be revealed even at a younger age.

Military service, undoubtedly, bears higher risk of life and injuries relative to civil jobs, except a few. Thus, individuals aversive to risk, generally, are not expected to choose such a preference voluntarily. However, among the predictors of risk taking behaviour, intra-uterine sex hormone exposure was also suggested to be one biological factor for attitudes such as risk aversion in later life (Apicella et al. 2008). The link between such behaviours with androgen was implicated by the fact that men were more risk-seeking than women across a variety of contexts (Wang et al. 2009; Stenstrom et al. 2011). Even within females, sublingual administration of testosterone induced

riskier financial choices (van Honk et al. 2004). A study showed that the MBA students with higher testosterone levels were more likely to choose a career in finance than a career in a less risky field after graduation (Sapienza et al. 2009).

As an established indicator of higher PT exposure, a lower right-hand 2D:4D was also linked with self-reported risk taking attitude in men and women (Hönekopp 2011; Bönte et al. 2016; Stenstrom et al. 2011). A recent study also demonstrated that males and females with lower 2D:4D preferred to choose riskier lotteries in incentivized experiments. However, 2D:4D was not associated with self-reported risk attitude (Brañas-Garza et al. 2017). Risk aversion, on the other hand, was considered to be sex-biased and found more in women than men in economic experiments (Daruvala 2007; Ball et al. 2010). This may have some implication to the observed sex differences in career choice in large scale surveys. Association of higher 2D:4D with a dislike or aversion for higher risk was also found even within one sex, as both men and women with lower 2D:4D, compared to their same sex counterparts, chose relatively riskier options (Garbarino et al. 2011). Voluntary participation in relatively high risk sports was also associated with lower 2D:4D in polish females independent of their physical ability (Kociuba et al. 2017). Therefore the linkage of higher risk taking and lower risk aversion with lower level of PT could also be a plausible explanation for the association of low 2D:4D with the selection or choice of uniformed course in the present study. Besides, it was also recommended that second to fourth digit ratio can be used as a tool in career choice (Gwunireama et al. 2013).

In a large population survey it was shown that lower 2D:4D in women was associated with higher involvement in 'male-typical' jobs, suggesting that women exposed to high PT, represented by relatively low 2D:4D, were more likely to be found working in such occupations, and vice versa (Manning et al. 2010). A lower 2D:4D was found to be associated with more enterprising careers among women (Weiss et al. 2007). Low 2D:4D was found in individuals engaged in male-dominated occupations and this phenomenon was particularly prominent among females, indicating that PT might have a stronger relationship with occupational choice in women (Govier 2003; Manning et al. 2010). In another study, financial risk-taking preferences were positively correlated with testosterone levels among female students, but not among males (Sapienza et al. 2009).

Another aspect of the present study was that the 2D:4D difference, wherever visible, was stronger in right hand than the left, both in terms of the absolute differences as well as the level of significance of such differences (Table 1). These findings however substantiated with those of many other studies worldwide as well as in Poland. Higher sexual dimorphism was consistently reported in the right hand than the left in humans (Manning et al. 2011, McFadden and Shubel 2002). Sex difference in 2D:4D was found to be more pronounced in right hand among Chinese Hans (Zhao et al. 2013). The association between masculine 2D:4D and endurance-linked running among the females was particularly associated with right 2D:4D among Jamaican children (Trivers et al. 2013). Manning et al. (2010) also found the association of 'male type' occupation with a lower 2D:4D, more in right

hand rather the left among the British females. Studies on psychological parameters also showed stronger- or even sole association with right 2D:4D (Williams et al. 2000, Csatho et al. 2003a, 2003b). The right 2D:4D was also suggested to be more sensitive to the androgenisation process on the prenatal skeletal development (McFadden and Shubel 2002; Williams et al. 2000; Brown et al. 2002; Szwed et al. 2017). Results similar to the present study were also observed in our previous studies among Polish military cadets (Kociuba et al. 2016) and police persons (Koziel et al. 2018). Hence, the strong differences in right 2D:4D, either between the civil and the uniformed females, or between sex within the uniformed group, further strengthened the theory of right hand bias in 2D:4D associations.

In the present study, within the civil course, the males had significantly lower 2D:4D than the females as expected in the general population. In contrast, however, no sex difference in 2D:4D was observed among the participants of the uniformed course. The results corresponded well with the previous findings by Kociuba et al. (2016) and Koziel et al. (2018) among the Polish military vs. civil cohorts, and policepersons vs. civil individuals, respectively, both studies showing that the sex difference in digit ratio was markedly reduced among the Polish military trainees and police officers, respectively. However, in both of these studies, the civil groups showed the expected sex difference, the males having lower 2D:4D than the females. This absence of sex difference in 2D:4D among the uniformed course students indicated towards some selection forces operating in participation in such a specialised and male dominated course. The results of this study again indicated towards our previously proposed hypothesis of a two-stage selection in case of females who chose challenging, riskier, 'male-biased', physically demanding career like military or police service (see Kociuba et al. 2016, 2017). The hypothesis logically presumed that girls would not have opted to join the uniformed course of study if they did not already have relatively higher physical ability and also prior motivation. Among such females with an assumed higher motivation and risk taking attitude (thus, with a lower 2D:4D similar to the males of the same population), those with even higher endurance, physical strength and fitness would have been admitted in the course. In brief, the females thus enrolled in the uniformed course with 'masculine' physical qualities did not show difference in 2D:4D with their male counterparts. The plausible explanations also could be extended to the phenomenon called 'female-athlete paradox', applied in case of choosing high risk sports by females in most cultures where the females must come across social and psychological prejudices and inhibitions before taking such extraordinary decisions (Dworkin 2001; Krane et al. 2001). As mentioned earlier, among the Polish women, a preference for the high risk martial art in contrast to aerobic exercises was associated with a lower ('masculine') 2D:4D and was explained by higher relative impulsivity and disinhibition as components of sensation seeking behaviour among these females (Kociuba et al. 2017). The presence of a higher psychological threshold of decision making and physical ability to opt for a high risk profession relative to men to overtake the culturally constructed and socially predominant negative perception about the

so called "feminine type" was also implicated by such findings. As mentioned earlier in this article, such physical and psychological qualities were believed to be linked with intrauterine sex hormone exposure and in turn with 2D:4D. That is why the females in the study course for uniformed services showed no difference in 2D:4D with the males in the same course but a lower 2D:4D than the civil course women.

In conclusion, Polish females enrolled in the study course leading to military service, had a low 2D:4D that did not significantly differ with their male peers in the same course. It indicated that the females, who experienced a higher testosterone exposure during their intrauterine development, were more likely to choose not only challenging occupations and high risk sports, but also study courses that led to such occupations. Furthermore, it provided evidence that such prenatal androgen exposure might induce organizational effect on the foetal brain that was reflected in the association of 2D:4D with the choice of study courses even at a younger age. The implication of these findings indicated towards a higher probability of selection of women having lower 2D:4D in typical male dominated professions. Future studies on the development of choice in children adolescents in various social circumstances with reference to 2D:4D may reveal the aetiology of such association.

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Authors' contributions

SK conceived the idea, formulated study design, did data analysis; RC planned and wrote the manuscript; ZI contributed in study design, supervised the field work; MK conducted data collection.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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