

Is digit ratio (2D:4D) associated with a religious profession? An exploratory study on male Polish seminary students

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ABSTRACT: Human females demonstrate higher religiosity than men in populations. Digit ratio (2D:4D), being a putative indicator of prenatal testosterone, is associated in varying degrees with characters that show sexual dimorphism. A small number of studies have indicated that religiosity may be associated with the biological basis of sex differences in humans. The objective of the present study was to ascertain whether 2D:4D in religiously oriented seminary students is different from individuals in other occupations. The study followed a cross-sectional design. Male participants of the study included 13 seminary students, 18 military chaplains and 91 control students from study courses relating to civil occupations. Lengths of second (2D) and fourth (4D) digits and their ratio (2D:4D) for each hand, height and weight were the variables and 2D:4D was the outcome measure. The results demonstrated that the seminary students had significantly higher 2D:4D than both the military chaplains and civil students. The military chaplains had the lowest 2D:4D. The study also revealed that the choice of religious occupation, and for that matter, religiosity, could be linked with the prenatal hormonal environment, particularly lower intrauterine testosterone compared to oestrogen.

KEY WORDS: prenatal testosterone, foetal androgen, 2D:4D, digit ratio; occupation, religiosity.

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Introduction

Digit ratio (2D:4D), more specifically, the ratio of the lengths of the second (index) to the fourth (ring) finger is considered to be a proxy marker of androgen exposure during an early period of prenatal development (Manning 2011). Compared to female, male foetus gets exposed to relatively higher levels of prenatal testosterone (PT) responsible for lengthening the 4th finger, whereas, prenatal oestrogen (PE), which is higher in case of female foetus, slows down the growth of the 4th digit. This phenomenon results in the sex difference in 2D:4D; males tend to have longer 4th digits relative to the 2nd than do females, i.e. male 2D:4D < female 2D:4D at the population level (Manning et al. 1998; Cohen-Bendahan et al. 2005). The sex difference in 2D:4D can be identified at the end of the first trimester (Malas et al. 2006; Galis et al. 2010). The 2D:4D reflects this relative concentration of PT and PE in a narrow developmental window during foetal growth (Zheng, Cohn 2011). During this brief phase of prenatal development, this relative balance of intrauterine sex hormones plays significant role in the “organisational” development of brain which, in turn, leave an enduring influence on behavioural and personality characteristics, which, particularly, show sexual dimorphism in the population (Manning 2011; Hines et al. 2015). Although, there was evidence showing a lack of association between 2D:4D and prenatal hormones (Hikey et al. 2010; Nave et al. 2021), it was confirmed via animal models (Zheng, Cohn 2011; Auger et al. 2013). On average, males show lower 2D:4D than females at the population level and this sexual dimorphism is established during the end of the first trimester of foetal development (Malas et

al. 2006; Galis et al. 2010). After this period, the ratio remains almost unchanged for the rest life and remains stable even during puberty (McIntyre et al. 2005). The 2D:4D was linked with several physical and behavioural traits in humans (Manning 2008; 2011). Nevertheless, in congruence with the role of prenatal androgens to manipulate behaviour through brain “organisation”, several behavioural traits having sex variation, such as, assertiveness and risk-taking behaviour, also showed clear associations with higher PT level (Manning, Taylor 2001; Manning et al. 2010; Apicella et al. 2008). All these characteristics, on the other hand, showed association with lower 2D:4D (Garbarino et al. 2011; Hönekopp 2011). Lower 2D:4D was also shown to be associated with the choice of participation in specific types of sports, especially, those with relatively higher risk profiles, such as contact sports, among Polish men and women (Koziel et al. 2016; Kociuba et al. 2017; Tomaszewska, Lubońska 2022) and also with ‘male-typical’ jobs in a range of occupations among women (Manning et al. 2010; Kociuba et al. 2016; Koziel et al. 2018).

One broad dimension of human behaviour that shows considerable sexual dimorphism across culture is ‘religiosity’ (Schmitt, Fuller 2015). Greater affiliation to religion in females than males across cultures were reported several times in scientific literature (Roth and Kroll 2007; Voas et al. 2013). In many religions, females tend to be more involved in a variety of religious practices and to report stronger religious beliefs, commitment, salience, and spirituality than males (Hoffmen 2019). Most theories used the universally similar gender specific socialization and also the sex oriented biological differences between male and

female in order to explain such gender difference in religiousness (Trzebiatowska 2012; Hoffmann 2019). However, one theory suggested that sexual dimorphism in risk preferences might also be attributed to the association of gender and religiousness in a broader extent. In general, males, compared to females, tend to prefer risks and this translates into less frequent religious behaviours, such as attendance and prayer, and a diminished sense of importance of religion in life (Miller, Hoffmann 1995). However, a growing body of evidence has indicated that religiosity not only has psychosocial, but also a physiological basis. For instance, data from large national surveys among older U.S. adults revealed that higher baseline levels of testosterone and dehydroepiandrosterone was clear predictors of religiousness whether measured by attendance at services or network connections to clergy (Das 2018).

As mentioned above, 2D:4D, being a marker of PT and sexually dimorphic, has been linked with several other sexually dimorphic characters in humans. Thus, one might expect that it would also correlate with religiosity and other associated personality characters, as the former also shows a distinct sex difference. However, studies showing associations of 2D:4D with such characteristics are hitherto limited. For example, development of 'paranormal' and 'superstitious' beliefs, both suggested to rely upon a common underlying factor (see Lindeman, Aarnio 2006), were reported to be associated with high 2D:4D (Rogers et al. 2017; Voracek 2009). Besides, higher religiousness was associated with lower risk-taking behaviour (Pitel et al. 2012). On the other hand, risk taking was linked with both testosterone (Apicella et al. 2008; Sapienza et al. 2009;

Stark 2002) and 2D:4D (Garbarino et al. 2011; Hönekopp 2011). The 2D:4D in males was positively associated with beliefs in superstitions and the paranormal (Voracek 2009), but not in females. On the other hand, Richards (2017) could not replicate similar associations and Ellis et al. (2016) reported no association between 2D:4D and religiosity. Another recent study (Richards et al. 2018) pointed out that high 2D:4D may be relatively-specifically associated with increased religious affiliation in young and highly-educated females. However, in this study, the association with religious affiliation was observed in females but not males and the correlations with trait measures were all non-significant. Moreover, this study was a conglomeration of two studies, of which, only one found a significant association.

Therefore, the previous studies provided mixed evidence regarding the plausible connection between 2D:4D and religious attitude and/or choice for a relatively more religious life, albeit, collateral evidence indicated a possible link. It is worth mentioning here that Polish students undertaking military courses showed lower 2D:4D than civil students in previous studies. The former two groups represented two contrasting occupations based on risk profiles; the military chaplains involving higher involvement with and exposure to risk related to a war front, whenever required, whereby, the seminary students were the religious leaders always serving in the ambit of a religious institution and living in a religious way. In a previous study, Polish students who chose military services as a future career path showed lower 2D:4D than those who preferred civil jobs (Kociuba et al. 2016). Hence, in this present study, it was hypothesised that

seminary students would show a higher 2D:4D than male military chaplains and civil course students. The aim of this study was thus to assess the association of 2D:4D with a religiously oriented occupation in contrast to others.

Material and methods

Participants and settings

This cross sectional study included 122 Polish male participants, 13 of whom were seminary students (students of theological seminary) as the experimental group with a mean (SD) age of 24.2 (2.7) years. They were included from the Metropolitan Higher Theological Seminary in Wrocław (MHTS). The second group consisted of 18 military chaplains (mean age 33.5; SD 3.6 years). Another 91 males as a control group were included from the students undertaking civil study courses (mean age 29.9, SD 4.9, years) at the General Kuściuszko Military Academy of Land Forces (GKMALF) in Wrocław. All participants were apparently and reportedly healthy and devoid of any abnormality or deformity in hands and fingers, in particular. Before inclusion, it was ensured if they were not compelled by any circumstance to choose the occupation, especially, for the clerks and chaplains. The seminary students, belonging to the MHTS, Wrocław, had chosen this opportunity for a religious occupation and were admitted in that institute. These students came from small towns and villages of South-Western Poland. They had to live in a hostel located within a closed campus and their daytime is strictly scheduled beginning and ending with common prayers in the seminary chapel. They took meals together and slept in shared rooms. They required obtaining

permission of the authority to go out of the seminary campus. On the other hand, the military chaplains were recruited during their officer's course that took place in Academy of Land Forces in Wrocław. All chaplains were graduates from several different civil theological seminaries. After the completion of the course they were commissioned and delegated to military units as members of the clerics.

Necessary permission was obtained from the authority of GKMALF and MHTS for conducting the study. Informed consents from all participants were also obtained during study. Ethical guidelines as per Helsinki Declaration were adhered to (Goodyear et al. 2007). Permission was granted to measure the seminary students for only one day during the lessons. On the day, 13 students agreed to participate in the study. Military chaplains, as other professional soldiers, were subject to periodical tests of physical fitness at their institute (GKMALF), where they were measured on this occasion.

Anthropometry

Measurements of height with a stadiometer to the nearest 1 mm and body weight with a standardized digital scale to the nearest 1g were recorded. During measurement the subjects wore light garments. The lengths of the second and fourth digits of each hand were measured to the nearest 0.1 mm by trained physical anthropologists (MK and TK) using a digital caliper (TESA SHOP-CAL). The finger lengths were recorded 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. While measuring, the participant was asked to rest the hand on a flat table surface with

the ventral surface facing upward. The digits, except the thumb, were kept fully extended but relaxed and touching each others laterally (Manning et al. 1998). Another variable, right minus left hand 2D:4D difference (D_{R-L}), is considered to be an alternative marker of PT, and thus, is a sex dependent character in adults. It is also a measure of “directional asymmetry”. Larger or rightward biased D_{R-L} values are, generally, expected in women compared to men (Rogers et al. 2017). In the present study, D_{R-L} was also calculated and tested for its association, if any, with religiosity.

Statistics

Descriptive statistics of mean and standard deviation were calculated for 2D:4D of each hand and for the average of two hands. As the sample size of the study appeared to be low and there was no option to increase the number of seminary student participants, we attempted to check if the sample was statistically sufficient. As it was difficult to obtain a sufficient sample from among the religious students due to some reservations against permitting for such studies, we calculated *a priori* the minimum number of experimental subjects for the analyses to be carried out. For one-way ANOVA with 3 groups, with RMSSE fixed on 0.25, error type-I at 0.05, power of test 0.80, the estimated required sample size was 79. Our number in ANOVA was 122 for all individuals. Therefore, we expected a fair statistical result from a small sample size. One-way analysis of variance was employed to observe the significance of difference in 2D:4D between the groups. Analyses of covariance (ANCOVA) with generalized linear model (GLM) were conducted to test the differences in 2D:4D between the groups, allowing for

age, height and BMI. These covariates were included in the model as controls as there is evidence that these might be correlated with 2D:4D in European – (Manning et al. 2021) and in Polish populations (Tomaszewska, Lubońska 2022). Differences in mean (\pm SE) 2D:4D between the groups were assessed by Tukey’s post-hoc test for unequal sample size. The differences were also presented by appropriate diagrams (Fig. 1). All the statistical analyses were performed by Statistica 13.1 software (Dell Inc. 2016).

Results

Table 1 Shows the descriptive statistics of mean and corresponding standard deviation (SD) for 2D:4D between the study groups. The mean (SD) 2D:4D in right hand ($F=4.20$, $p<0.05$) and for average of both hands ($F=3.67$, $p<0.05$) differed significantly between the groups, whereas for left hand differences were not significant. Differences were also not significant for D_{R-L} . The military chaplains showed the lowest and the seminary students the highest, while the civil students showed intermediate values.

Table 2 presents the results of ANCOVA performed to assess the significance of difference in 2D:4D among the three study groups after controlling for the independent effects of age, BMI and body height. The groups differed in respect of the right hand – ($F=8.09$, $p<0.05$) and also for both hands – ($F=7.64$, $p<0.05$) 2D:4D, allowing for age, height and BMI. No significant effect of any of these confounding variables on digit ratio was observed for any hand. Also, the D_{R-L} did not exhibit any significant difference. Figure 1 also demonstrates the differences between groups in each hand and for the average 2D:4D of both hands together.

Table 1. Descriptive statistics of 2D:4D according to study groups and results of one-way ANOVA

2D:4D	Clergyman (N=13)		Military chaplains (N=18)		Civil students (N=91)		F	p
	Mean	SD	Mean	SD	Mean	SD		
Right	0.993	0.039	0.962	0.036	0.970	0.027	4.20	0.0173
Left	0.995	0.029	0.974	0.030	0.984	0.030	1.90	0.1539
Average	0.994	0.029	0.968	0.030	0.977	0.026	3.67	0.0284
D _{R-L}	-0.013	0.030	-0.003	0.037	-0.013	0.026	0.86	0.4278

Table 2. Results of MANOVA where the DR was dependent variables, groups independent and age, height and BMI covariates

	Right hand		Left hand		Average of both hands		D _{R-L}	
	Wald's χ^2	p	Wald's χ^2	p	Wald's χ^2	p	Wald's χ^2	p
Group	8.09	0.0175	4.32	0.1153	7.64	0.0219	0.54	0.7630
Age	0.50	0.4776	0.49	0.4836	0.63	0.4264	0.04	0.8454
Height	0.02	0.8967	0.32	0.5693	0.06	0.8044	0.59	0.4420
BMI	2.38	0.1229	0.30	0.5819	1.42	0.2340	0.61	0.4360

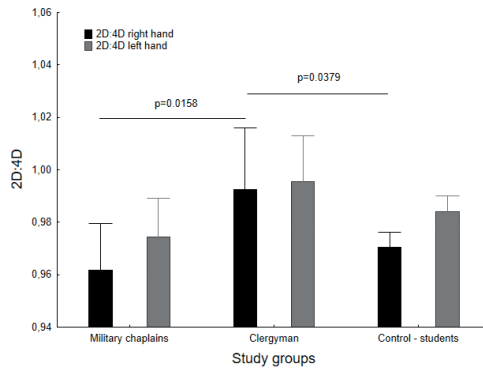


Fig. 1. Mean and 95% CI of 2D:4D for three study groups.

Discussion

The present exploratory study included Polish seminary students, military chaplains and civil course students and assessed the association of 2D:4D with religiously oriented occupation by comparing the values of 2D:4D between

these groups. The objective was to observe whether it differed between groups of participants belonging to religious and non-religious affiliations. The results revealed that the seminary students had significantly higher 2D:4D than both the military chaplains and civil students, whereas, the military chaplains had the

lowest 2D:4D. It has been well known that religious characteristics in humans have gender differences that have been confirmed by recent studies in European populations (Robinson et al. 2018). It indicated that prenatal androgen, particularly, testosterone exposure, might be somehow linked with the choice for a religious life and occupation, such as, a seminary student. However, there was no significant difference in D_{RL} between the groups, similar to the studies by Voracek (2009) and Rogers et al. (2017), where this variable did not show a significant association with superstitious and paranormal beliefs.

Religious, paranormal, and superstitious beliefs could be associated with each other (Orenstein 2001; Ilory 2014). On the other hand, paranormal and superstitious beliefs were reported to be associated with higher 2D:4D in males in one study (Voracek 2009) and in females in another (Rogers et al. 2017). However, a plausible explanation for such associations is still lacking. Religiosity, however, was associated with lower risk-taking behaviour (e.g. Pitel et al. 2012), and 'irreligiosity' was associated with short-sighted risky behaviours that might have a physiological basis, too (Stark 2002). As discussed earlier, Miller and Hoffmann (1995) proposed that one key reason females were reported to be more inclined towards religious affiliations was their lower risk preference or higher average levels of risk aversion relative to males of the same population. In spite of many studies failing to show such association (Roth and Kroll 2007; Freese and Montgomery 2007), a recent replication study on European populations seemed to revive the possible role of risk preference, or at least, of risk behaviour, to account for sex difference in religiosity (Hoffman 2019).

It was shown in several studies that males, relative to females, tend to prefer risk and get more engaged in risk-taking behaviours (Byrnes et al. 1999; Charness and Gneezy 2012; Harris et al. 2006; Niederle 2015). Thus, the risk preference theory of religion advanced the analogical notion that risk preferences might explain why males were also less "religious" than females (Hoffman 2019). Thus the preliminary findings of association of 2D:4D with religiosity or, in present case, with the occupation of seminary students, might correspond with the finding that higher 2D:4D is associated with lower levels of risk-taking behaviour or higher risk aversion (e.g. Hönekopp 2011), compared to military chaplains, who showed significantly lower 2D:4D. However, such an analogy is based on the assumption that a lower risk taking attitude is correlated with higher religiosity (Hoffman 2019; Miller and Hoffmann 1995). In that case, the underlying association between risk preferences and religiosity might have their common association with 2D:4D, and thus, with prenatal androgen exposure and resulting brain organization during foetal development. The origin of religiosity and its variation at the gender and population level could, thus, be comprehended within the theoretical doctrine of intrauterine origin of human behaviour.

Studies have also identified that occupational choices could be linked with PT exposure represented by 2D:4D measures. In a study on the Polish population, it was shown that individuals who chose study courses leading to military jobs (high risk) had lower 2D:4D compared to their civil courses (low risk) peers (Kociuba et al. 2016). Similarly, individuals choosing to become a police officer had lower 2D:4D than those preferring civil professions

(Koziel et al. 2018). Even the voluntary selection of high risk sport, such as judo, as compared to low risk ones, such as aerobic exercises, was associated with relatively lower 2D:4D (Kociuba et al. 2017). In brief, the findings of these studies together indicated that the choice of careers based on their respective risk profiles, or elements associated with those jobs, may be correlated with prenatal androgen environment, and therefore, pointing to 2D:4D value. Perhaps, one of the most important findings of this present study was that the seminary students not only showed higher 2D:4D values than the military chaplains, but also than with the civil courses students. This indicated that individuals with a higher religious orientation, or at least with higher religiosity, may constitute a distinct group with higher 2D:4D within the population. This relatively higher ('feminine') digit ratio among seminary students is probably linked through broader associations between higher risk aversion, and 'femininity'. However, it is too premature to conclude on this issue without further detailed analyses using objective measures of risk taking and religiosity along with 2D:4D.

As stated earlier, hitherto there has been only one study (Richards et al. 2018) available on the online database regarding the association of 2D:4D with self-reported religious affiliation, general religiosity, spirituality, religious fundamentalism, and religious commitment among the university students and in the general population. Females who were affiliated with organised religions had higher digit ratios compared to agnostic or atheist females. No other measure of religiosity was related to 2D:4D in either of the two study groups (Richards et al. 2018). In this context, the present study is novel and needs further confirmation based on

a larger sample and precise measures of religiosity. The small sample of the seminary students was an acute limitation of our study, albeit, it narrowly fulfilled statistical requirements. However, from another point of the findings, the reliability of the study, perhaps, increased as there was a significantly clear distinction of the seminary students from both military chaplains, as well as from another set of the general population. Besides, it is worth mentioning here that the development of religiosity since childhood may also be influenced by parental belief patterns and also by the cultural environment. Therefore, some consideration of cultural/societal influences on the development of religious beliefs would be very useful in further studies in order to evaluate the chance that the effects of PT are overwritten by the much larger effects of cultural upbringing of an individual. Besides, parental/societal influences regarding paranormal/superstitious beliefs may be much less pervasive than those relating to religion. This could potentially explain why 2D:4D effects relating to the former have been observed but there is currently much less evidence for the latter. However, before attempting to draw some conclusion on the outcome of the study this is worth reminding that the first study by Voracek (2009) which had reported a link between paranormal belief and 2D:4D is not highly confirmative and the attempt of Rogers et al (2017) could not satisfactorily replicate it. It is also not clear whether we should consider paranormal behaviour in the same way that we do for religiosity in the context of their plausible associations with 2D:4D. Furthermore, as regards religiosity, Richards (2017) could not replicate similar associations and Ellis et al. (2016) reported no association between 2D:4D and religiosity.

To conclude, our study, in congruence with that of Richards et al. (2018) indicated that the individuals with higher digit ratio might relatively be more disposed to religious life, in males. However, every conclusion drawn from this study should be treated with caution in view of the inherent limitations of the study, such as the participants' religiosity was not measured in this study. Only the choice of study course was perceived as a proxy to religious inclination. As stated above, particularly, the low sample of one participant group. Besides, the study included only male participants. Data on religiosity of females might provide further insights into the plausible association of religiousness and prenatal condition. However, the most crucial limitation of this study, perhaps, was the small sample of seminary students. Finally, although the risk preference theory has been popular in religious studies, its efficacy to explain religious differences in terms of biological differences between females and males has been controversial (Stark 2002; Miller, Stark 2002; Sullin 2006). Studies on religiosity relating to testosterone and digit ratio across cultures in varied social contexts would add to the knowledge of prenatal origin of human behaviours.

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Conflicts of interest

The authors do not have competing interests.

Authors' contributions

MK collected part of data and build the database, wrote Material section of the draft, TK collected data of clergymen, wrote part of draft, RC interpreted the results and wrote the final manuscript, ZI interpreted the results and edited final manuscript, AR interpreted the results and edited final manuscript, SK conceptualised, designed and supervised the study, analysed data and edited the final manuscript for intellectual contents.

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