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Original Research Article

Establishing the Congruity amongst 2D:4D Ratio, Sex, and Socio-Behavioural Traits in Medical Students of Enugu State University of Science and Technology (ESUT)

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Abstract

The second-to-fourth digit (2D:4D) ratio is a sexually dimorphic trait that has previously been reported to be associated with socio-behavioral characteristics. This study examined the relationship amongst 2D:4D ratio, sex, and socio-behavioral characteristics among undergraduate medical students at Enugu State University of Science and Technology. A quantitative descriptive cross-sectional study design was adopted and a sample size of 120 was calculated using the Taro-Yamane formula. Convenience sampling method was utilized and the majority exhibited positive socio-behavioral characteristics such as emotional control and stress management abilities. There was a significant difference in the personality traits (conscientiousness and openness) between the male and female population at P<0.050. However, there were no significant differences between the left and right digit ratio among the male and female population as *P*>0.050 in each case. Also, there was no significant difference in the level of executive functions (emotional control, inhibition control, and stress intolerance) among the male and female populations as *P*>0.050 in each case. There was a significant negative correlation between the right-hand 2D:4D digit ratio and level of conscientiousness among the population with (r=-0.196) at *P*<0.050. However, no significant association was found between personality traits and executive functions. There was no significant difference between the participants' digit ratio and gender. However, the male right-hand 2D:4D digit ratio was significantly associated with conscientiousness among the population. Additionally, no significant correlation was found between the participant's digit ratios and their executive functions (emotional control, inhibition control, and stress tolerance).

Keywords: 2D:4D Ratio, Socio-behavioral traits, undergraduate medical students, Enugu.

1. INTRODUCTION

Digit ratio refers to the ratio of the lengths of different digits or fingers on a hand. The most studied digit ratio is the 2D:4D ratio, which is calculated by dividing the length of a given hand's index finger by the length of the same hand's ring finger (Bönte *et al*., 2017). The second-to-fourth digit ratio (2D:4D) is a sexually dimorphic trait that has previously been reported to be smaller in males than in females as an indirect method of investigating the putative effects of prenatal exposure to androgens (Mitsui *et al*., 2015). Through androgen receptors found in fetal cartilaginous tissue, this sex difference in digits has been linked to the prenatal hormonal environment (Mitsui *et al*., 2016). Evidence suggests that males have a lower digit ratio than females due to prenatal androgen exposure, with testosterone being the most important androgen, playing an important role in the sexual differentiation of the mammalian brain and having an enduring influence on behavior (Bönte *et al*., 2017). As a result, it is assumed that 2D:4D is negatively related to prenatal androgen and positively related to prenatal estrogen (Manning *et al*., 2017). The sex difference is visible in children as young as two years old and has high serial reliability with aging. However, there is significant individual variation in 2D:4D within each sex, and the sex difference is detectable and moderate in size (Hampson *et al*., 2008).

Men outperform women on spatial tests, including tests of mental rotation, on average, and there are also sex differences in several socio-behavioral features such as cognitive abilities and personality traits. Furthermore, males are more aggressive than females, particularly in terms of physical aggression, but also in terms of verbal aggression (Hampson *et al*., 2008). Individual competitiveness, which describes an individual's general proclivity to enter competitive situations, is a sexually dimorphic behavioral trait that has been linked to a 2D: 4D ratio (Niederle, 2017). Similarly, confidence and risk-taking have been identified as socio-behavioral traits associated with digit ratio across both sexes (Neyse *et al*., 2016; Braas-Garza *et al*., 2018). In addition, the 2D:4D ratio has been linked to impulsivity, problematic and pathological Internet use, video gaming behaviors, and alcohol and nicotine dependence (Canan *et al*., 2017). Better academic performance was linked to a lower 2D:4D ratio. However, because the brain's response to activation of steroid hormones decreases with age (Bönte *et al*., 2015), the relationship between 2D:4D and individual socio-behavioural characteristics can likely be better identified when using samples of young people.

Although there are few studies on the relationship between digit ratio and gender, some studies have looked at differences in socio-behavioral characteristics such as competitiveness, internet use, substance abuse, social interactions, risk-taking, and confidence, among others (Neyse *et al*., 2016; Canan *et al*., 2017; Brañas-Garza *et al*., 2018; Buchholz *et al*., 2019). More evidence is needed however to back up these study findings. Furthermore, as far as can be determined, there has been a scarcity of research on digit ratio and sexual and socio-behavioral differences among individuals in this resource setting. The 2D:4D ratio exhibits genetic and environmental variability, so findings from one population may not be extrapolated to another (Banyeh *et al*., 2021). Hence, this study tends to examine the relationship between the 2D:4D ratio, sex, and socio-behavioral characteristics among undergraduate medical students at Enugu State University of Science and Technology (ESUT). The study focused on the 2D:4D ratio and revealed the practical application of knowledge of anatomy to social sciences such as psychology, sociology, or other studies on personality traits. Also, it contributes to the body of knowledge on the 2D:4D ratio which is necessary for explaining socio-behavioral characteristics among students in the campuses and the findings can be generalized to other similar settings. In addition, this study finding is the first or one of the few available studies on digit ratio in the region, hence, it will give empirical support to similar studies by upcoming researchers.

2. METHODS

2.1 Sample Size

A quantitative descriptive cross-sectional study design was adopted to determine the relationship between 2D:4D ratio, sex, and socio-behavioral characteristics among undergraduate medical students in ESUT. A sample size of 120 was calculated using the Taro-Yamane formula. A quantitative design was adopted so that the relationship between the variables (2D:4D ratio, sex, socio-behavioral features) can be tested statistically and the variables can also be quantified via mathematical models (Goertzen, 2017). The data sets are large and the findings are representative of the population, conclusions drawn from quantitative design studies can be applied to the population of ESUT and other comparable settings. As such, similar studies can be repeated so that the results can be compared. A cross-sectional design was chosen as data from ESUT medical students based on the sample size determined can be collected and analyzed at a specific point in time. In addition, the study is descriptive and will offer the privilege of describing the pattern of 2D: 4D ratio among the students.

2.2 Study Population

The study population was made up of undergraduate medical students from ESUT. The estimated total population of ESUT undergraduate medical students is around 1815. Inclusion and exclusion criteria specify who may or may not be included in the study sample. The inclusion criteria consistently, reliably, uniformly, and objectively identify the study population. Exclusion criteria include factors or characteristics that preclude the recruited population from participating in the study (Garg, 2016). In this present study, all undergraduate medical students of ESUT who were available in medicine, nursing, anatomy and medical laboratory science departments at the time of data collection were eligible to be included in the study. However, those unwilling to participate in the study were excluded.

2.3 Sample Size Determination

The study sample size is the number of people chosen from the target population to represent the entire population. To ensure that the findings are generalizable to the population, the sample size must be estimated ethically and scientifically that prevents waste of resources and time (Bhalerao & Kadam, 2010). The minimum sample size will be determined by the Taro Yamane formula

$$n=\frac{N}{1+\{N\{e^2\}\}}$$

Where n = desired sample size.
N = total population
1 = constant
e = level of precision = 0.1

N = N (ESUT Nursing, MedLab, Anatomy and Medicine)

N = 1815

$$n=\frac{1815}{1+\{11815\{0.1^2\}\}}$$

$$n=\frac{1815}{1+\{1815\{0.01\}\}}$$

$$n=\frac{1815}{1+\{18.15\}}$$

$$n=\frac{1815}{\{19.15\}}$$

n= 95

An attrition rate of 26% was given for poorly completed questionnaires or non-response.

n=95 + 25 =120

Therefore, 120 undergraduate students were recruited to participate in the study.

2.4 Sampling Method

Sampling is a technique for selecting individual members or a subset of the population to make statistical inferences and estimate population characteristics (Berndt, 2020). A convenience sampling technique was utilized to select respondents from ESUT. The convenience sampling technique is based on the principle of accessibility and convenience (Setia, 2016). Thus, at each visit, participants who were available at the time of data collection were recruited to participate in the study.

2.5 Inclusion and Exclusion Criteria

The following inclusion criteria were established: the research was concentrated on 200-level and 300-level students of the departments of Anatomy, Nursing Science, Medical lab science, and Medicine. The following criteria were grounds for exclusion from the study: respondents should not be 100-level, 400-level, and 500-level students of any of the departments.

2.6 The Instrument for Data Collection

The study instrument is a validated standardized questionnaire following a review of pertinent pieces of literature and consultations with experts in the field of anatomy and biostatistics (Hampson *et al*., 2008; Mitsui *et al*., 2015; Bönte *et al*., 2017). The instrument consists of three parts, the first part consists of question items to assess the respondents' sociodemographic characteristics.

The second section includes questions about the dimensions of the 2D:4D ratio, which will be evaluated objectively by the researcher. The 2D:4D ratio is calculated by comparing the lengths of the index and ring fingers (Bönte *et al*., 2017). The lengths of the second (index) and fourth (ring) digits are measured on the ventral surface of the hand using digital vernier calipers from the fingertip to the midpoint of the basal crease. These values are divided to get the 2D:4D ratio. To ensure reliability, two or more measurements are usually taken (Jeevanandam, 2016). All measurements will be taken by two observers who are not aware of the participants' identities to confirm the results (Mitsui *et al*., 2015). The mean of the multiple measurements for the right and/or left hand is taken and divided to calculate the 2D:4D ratio for the right and left hands separately. According to some, the right digit ratio is more differentiated and sensitive to prenatal testosterone exposure, whereas others report an averaged 2D:4D ratio across both hands (Jeevanandam, 2016). The measurements will be taken down to the nearest 0.5 mm (Mitsui *et al*., 2015).

The personality trait questionnaire was developed for assessing measures in individuals on the Big Five Factors (dimensions) of personality (α=0.553 [10 items]). The Big 5 personality traits were measured on a 7-option scale, ranging from strongly disagree (1) to strongly agree (7). The digit ratios were derived from the ratio of second and fourth digit ratios (2D:4D) for both right and left hands. Executive function in this study was described by emotional control, inhibition control, and stress tolerance. Emotional control (EC) was defined as a student's ability to manage and control their emotions to achieve a goal or complete a task. Inhibition control (INC) was defined as the extent to which the students can control their attention, behavior, thoughts, and/or emotions, while Stress tolerance (ST) was defined as the extent to which the students are relaxed and composed when faced with stressful situations or difficulties. Personality traits used in the framework were defined as Extraversion (includes being extraverted and enthusiastic or reserved and quiet), Agreeableness (includes being critical and quarrelsome or sympathetic and warm), Conscientiousness (includes dependable and self-disciplined or disorganized and careless), Emotional stability (includes being anxious and easily upset or calm and emotionally stable), and Openness (includes openness to experiences and complex or conventional and uncreative).

2.7 Data Collection

Following ethical approval, the letter was presented to the class representatives at each point of data collection from the group of students. Then, the research objectives, significance, and procedures were explained verbally to the students, and those who gave verbal consent were asked to sign the informed consent form. Five research assistants who are anatomy students were recruited and trained on the research ethics, purpose, and data collection process. The study participants were required to fill in their sociodemographic characteristics while the quantitative and objective assessment of the digit ratios were carried out by the researcher or research assistants, thus, the researcher or research assistants will assist in completing the section on the digit ratio. Filling the instruments lasted for an estimated 15 minutes. The data collection process lasted for a month.

2.8 Data Management and Analysis

The reliability of the scale items for emotional control (EC; α=0.246 [4 items]), inhibition control (IC; α=0.188 [4 items]), and stress tolerance (ST; α=0.488 [4 items]) were deemed inadequate. Each item was measured on a five-point Likert scale, ranging from ''strongly disagree'' (1) to ''strongly agree'' (5). The personality trait questionnaire was developed for assessing measures in individuals on the Big Five Factors (dimensions) of personality (α=0.553 [10 items]). The Big 5 personality traits were measured on a 7-option scale, ranging from strongly disagree (1) to strongly agree (7). To test these proposed hypotheses, data was collected and analyzed using Statistics Package for Social Science – (IBM® Amos V26.0.0, USA) which combined correlation tests with a series of interrelated dependence relationships.

3. RESULTS

The descriptive characteristics of the studied population are presented in Table 1. The study highlights the associations' digit ratios using executive functions, personality traits, and socio-academic characteristics. The hypothesized relationships were tested using correlation path analysis presented in Fig. 2.

Table 1: Study demographic characteristics of participants in the survey

Description		**Sex**		**Total (n=120)**
		Male (n=52)	**Female (n=52)**	
Sociodemographic				
Discipline	Anatomy	18 (34.6)	35 (51.5)	53 (44.2)
	Med Lab	16 (30.8)	9 (13.2)	25 (20.8)
	Medicine	10 (19.2)	4 (5.9)	14 (11.7)
	Nursing	8 (15.4)	20 (29.4)	28 (23.3)
Age	20 – 22 years	24 (46.2)	47 (69.1)	71 (59.2)
	23 and above	28 (53.8)	21 (30.9)	49 (40.8)
Relationship status	No relationship	49 (94.2)	62 (91.2)	111 (92.5)
	In a relationship	3 (5.8)	6 (8.8)	9 (7.5)
Employment status	Not employed	36 (69.2)	55 (80.9)	91 (75.8)
	Self-employed	16 (30.8)	13 (19.1)	29 (24.2)

Note: *n=distribution*

Table 1 presents the sociodemographic characteristics of the respondents, larger proportion 53(44.2%) were in the anatomy department while the remaining were in medical laboratory science 25(20.8%), medicine 14(11.7%), nursing 28(23.3%); as regards the participants' age, more than half 71(59.2%) were between 20-22 years; majority 111(92.5%) were not in any relationship; on employment, majority 91(75.8%) were unemployed; males 52(50%) and females 52(50%) were equally represented in the study population.

Table 2: Mean, standard deviation, and p-value for sex differences between measurement items

	Sex		**Total**	**T-test Analysis**		
Variables	**Male Mean (SD)**	**Female Mean (SD)**	**Mean (SD)**	**Df**	**t**	**p-value**
Digit ratio						
2D:4D Left Hand	0.96(0.03)	0.96(0.05)	0.96 (0.04)	118	0.095	0.924
2D:4D Right Hand	0.96 (0.03)	0.96 (0.06)	0.96 (0.05)	118	-0.906	0.367
Executive Functions						
Emotional Control (EC)	3.26 (0.59)	3.29 (0.63)	3.28 (0.61)	118	-0.273	0.785
Inhibition Control (IC)	2.94 (0.71)	3.08 (0.57)	3.02 (0.63)	118	-1.200	0.233
Stress Tolerance (ST)	3.23 (0.52)	3.35 (0.75)	3.29 (0.66)	118	-0.985	0.327
Personality Traits						
Extraversion	3.81 (1.07)	4.07 (1.10)	3.96 (1.09)	118	-1.331	0.186
Agreeableness	4.69 (1.06)	4.43 (1.05)	4.54 (1.06)	118	1.368	0.174
Conscientiousness	5.30 (0.76)	4.26 (0.96)	4.71 (1.01)	118	6.392	**0.000****
Emotional Stability	4.19 (0.83)	4.14 (1.01)	4.16 (0.94)	118	0.304	0.762
Openness	5.03 (0.88)	4.14 (0.94)	4.53 (1.01)	118	5.266	**0.000****

Note: SD – Standard deviation, N = 120, * signifies p<0.05, ** signifies p<0.01

Table 2 presents the mean, standard deviation, and p-value for sex differences between measurement items;

There was a significant difference in the level of conscientiousness and openness between the male and female populations with (t=6.392, P=0.000) and (5.266, P=0.000) respectively at P< 0.050. The level of conscientiousness was significantly higher among the male 5.30(0.76) as compared to the females 4.26(0.96). Also, the rate of openness was significantly higher among the male population 5.03(0.88) as compared to the female 4.14(0.94).

However, there was no significant difference in the degree of some of the personality traits (Extraversion, Agreeableness, and Emotional Stability) between the male and female gender as P> 0.050 in each case. Also, there were no significant differences between the left and right digit ratio among the male and female population as P> .050 in each case. Thus, the digit ratio differs not with respect to gender. Likewise, there was no significant difference in the level of executive functions (emotional control, inhibition control, and stress intolerance) among the male and female populations as P> 0.050 in each case.

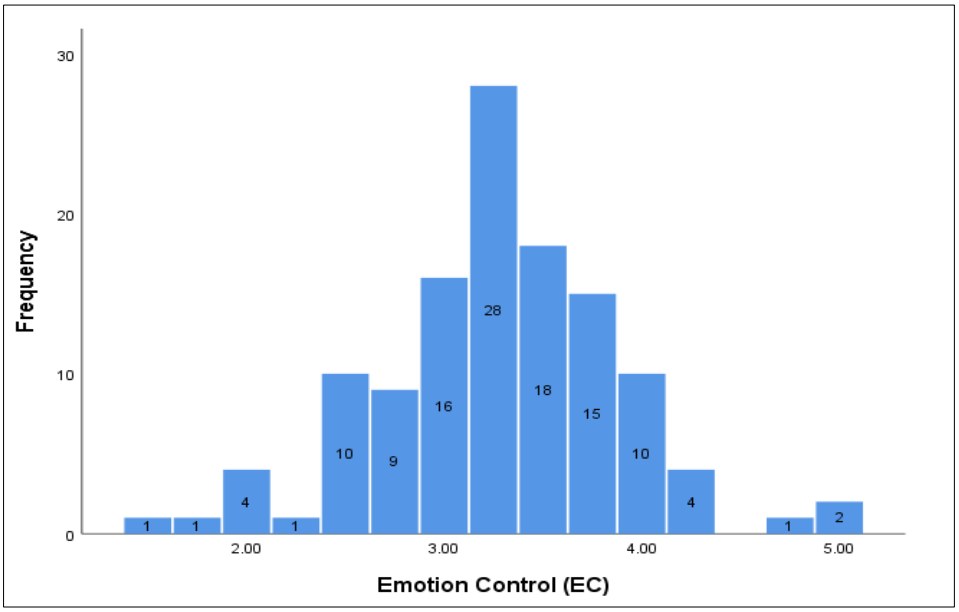

Figure 1: The distribution of the population for Emotion Control

More of the population for emotional control had scores between 2.5 and 4 and several others between 1.5 and 2 suggestive of the population having a balanced control over their emotions when completing a task.

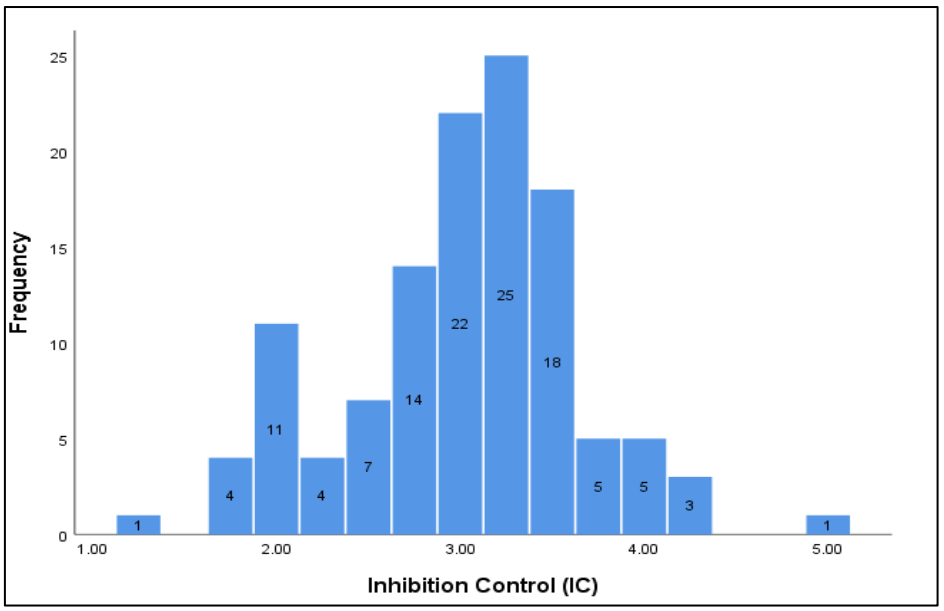

Figure 2: The distribution of the population for Inhibition Control

More of the population for inhibition control had scores between 2 and 3.5 and several others between 3.5 and 4 suggestive of the population being more impulsive in terms of the ability to control their attention, behavior, and thoughts.

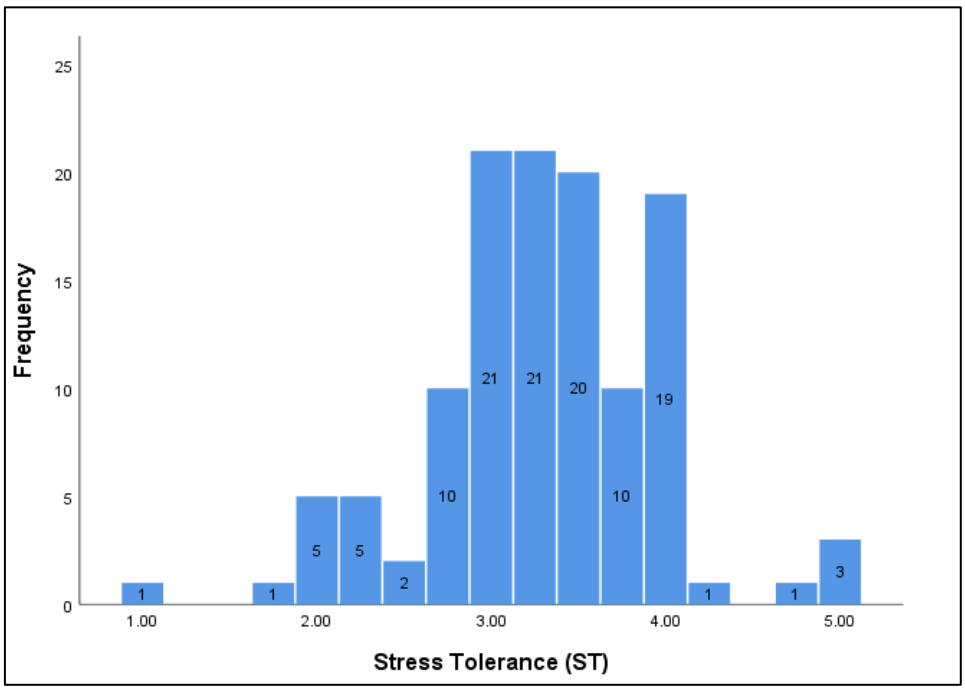

Figure 3: The distribution of the population for Stress Tolerance

More of the population for inhibition control had scores between 2.8 and 4 and several others between 1.8 and 2.5 suggestive of the population being more relaxed and composed when faced with stressful situations or difficulties.

Table 3: Correlations with digit ratio

Variables	2D:4D Left	2D:4D Right	Male Left	Male Right	Female Left	Female Right
Executive Functions						
Emotional Control (EC)	-0.114	-0.084	-0.210	-0.221	-0.067	-0.039
Inhibition Control (IC)	-0.075	-0.051	-0.206	-0.257	0.008	0.029
Stress Tolerance (ST)	-0.132	-0.006	-0.101	-0.043	-0.142	-0.005
Personality Traits						
Extraversion	0.077	-0.115	-0.212	0.018	0.232	-0.190
Agreeableness	0.074	-0.036	-0.012	0.100	0.122	-0.078
Conscientiousness	0.046	**-0.196***	-0.166	**-0.317***	0.139	-0.139
Emotional Stability	-0.044	-0.099	-0.247	-0.173	0.044	-0.075
Openness	0.096	0.034	0.116	0.049	0.097	0.130

Note: * signifies p<0.05, ** signifies p<0.01

Table 3 presents the correlation between the executive functions and digit ratio; there was a significant negative correlation between the right-hand 2D:4D digit ratio and level of conscientiousness among the population with (r=-0.196) at P< 0.050. There was a significant negative correlation between the male right-hand 2D:4D digit ratio and their level of conscientiousness with (r=-0.317) at P< 0.050.

However, no significant correlation was found between the participant's digit ratios and their executive functions (emotional control, inhibition control, stress tolerance) as P> 0.050 in each case. Also, the participants' digit ratio was not significantly correlated to some of the personality traits such as extraversion, agreeableness, emotional stability, and openness as P> 0.050 in each case.

Table 4: Correlations with executive function

Variables	Emotional Control (EC)	Inhibition Control (IC)	Stress Tolerance (ST)
Personality Traits			
Extraversion	-0.025	0.047	-0.012
Agreeableness	-0.103	-0.006	-0.091
Conscientiousness	-0.122	-0.138	-0.067
Emotional Stability	-0.093	-0.068	-0.175
Openness	-0.122	0.099	0.072

Note: * signifies p<0.05, ** signifies p<0.01

Table 4 presents the correlation between the personality traits and executive functions, the null hypothesis is rejected as there was no significant correlation between the executive functions (Stress Tolerance (ST), Emotional Control (EC), and Inhibition Control (IC)) and personality traits ((Extraversion, Agreeableness, Conscientiousness, Emotional stability, and Openness) and executive functions as P > 0.050 in each case.

3.1 Hypotheses

Hypothesis 1 - 3 examine the association between the right digit ratio and executive function (EC, IC, and ST), while hypotheses 4 – 6 examine the association between the left digit ratio and executive function (EC, IC, and ST); none of the executive functions were significantly associated with right or left digit ratio. Therefore, we reject hypotheses 1 through 6. Further analysis with sex as a mediating factor, also showed that the female right digit ratio was not significantly associated with executive function. Also, the study results indicate that the whole participants as well as the male right digit ratio was significantly associated with conscientiousness (rho = -0.196, p<0.05; rho = -0.317, p<0.05).

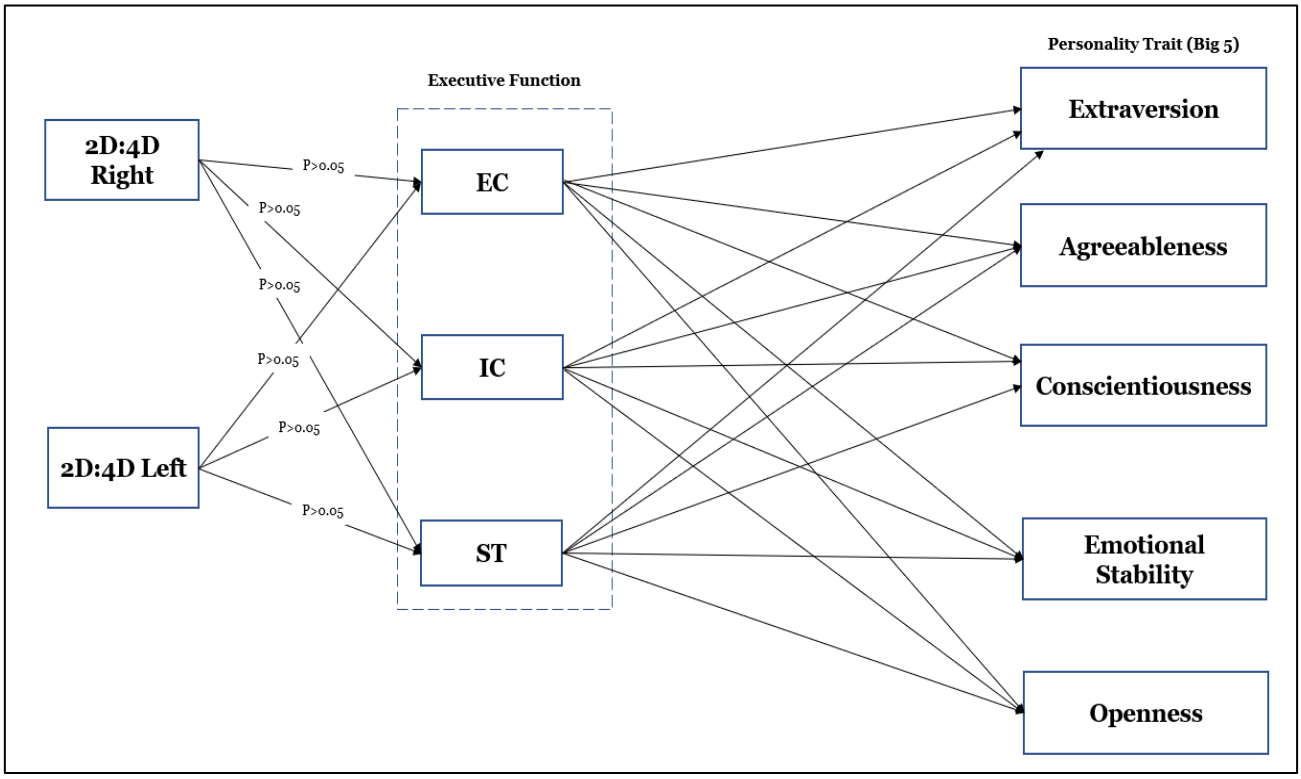

Figure 4: Correlation analysis

Hypothesis 7 – 11 examines the association between the executive function of emotion control and personality traits (Extraversion, Agreeableness, Conscientiousness, Emotional stability, and Openness). The analyses showed that no such relationship exists amongst the variables (P>0.05). Thus, the study rejects all four hypotheses.

Hypothesis 12 – 16 examines the association between the executive function of inhibition control and personality traits (Extraversion, Agreeableness, Conscientiousness, Emotional stability, and Openness. The analyses showed that no such relationship exists amongst the variables (P>0.05). Thus, the study rejects hypothesis 12 through 16.

Hypothesis 17 – 21 examines the association between the executive function of stress tolerance and personality traits (Extraversion, Agreeableness, Conscientiousness, Emotional stability, and Openness). The analyses showed that no such relationship exists amongst the variables (P>0.05). Thus, the study rejects all four hypotheses.

4. DISCUSSION

The second-to-fourth digit ratio (2D:4D) has previously been reported to be an indirect method of investigating the putative effects of prenatal exposure to androgens and associated with certain socio-behavioral characteristics (Mitsui *et al*., 2015). This study investigated the relationship amongst 2D:4D ratio, sex, and socio-behavioral characteristics among a sample of undergraduate students in ESUT. A larger proportion (44.2%), were in the anatomy department. Others were in nursing (23.3%), MLS (20.8%), and medicine (11.7%). The majority were aged between 20-22 years (59.2%), single (92.5%), and unemployed 91(75.8%). Male to female ratio was 1:1.

4.1 Association amongst Gender, Personality Traits, Digit Ratio, and Executive Function

There was a significant difference in the personality traits (conscientiousness and openness) between the male and female populations with (*P*=0.000) and (*P*=0.000) respectively at P< 0.050. The level of conscientiousness was significantly higher among the male 5.30(0.76) as compared to the females 4.26(0.96). Also, the rate of openness was significantly higher among the male population 5.03(0.88) as compared to the female 4.14(0.94). This finding is keeping in view with Mitsui *et al*. (2016) who found a significant association between gender and certain personality traits such as choice of activities, cognition, and other school behaviors. However, there was no significant difference in the degree of some of the personality traits (Extraversion, Agreeableness, and Emotional Stability) between the male and female gender as P> 0.050 in each case.

In contrast to these findings, Manning *et al*., (2013) found that digit ratios were associated with emotional stability (anxiety) and extraversion (aggression). Also, Hampson and Sankar, (2012) found out females' digit ratio was significantly related to assertiveness in females. The reason for these differences may be because the digit ratio of the females in this population is similar to the male population (Manning *et al*., 2013).

There were no significant differences between the left and right digit ratio among the male and female population as P> .050 in each case. Thus, the digit ratio differs not significantly with respect to gender. This finding is in contrast to what has been reported across several studies including both old and recent pieces of evidence (Xie *et al*., 2017; Bönte *et al*., 2017; Butovskaya *et al*., 2021). However, the reason for the differences may be that there is an ample body of evidence suggesting that some females are exposed to increased prenatal testosterone levels due to congenital adrenal hyperplasia (CAH) and thus, have lower 2D:4D values than normal controls (Buchholz *et al*., 2019).

Furthermore, the reason for these estimated differences in findings may be because the samples of the male and female populations were small (120) as compared to other studies (Galis *et al*., 2009; Butovskaya *et al*., 2021). Moreover, the study adopted a convenience sampling technique which can pose a risk of bias in findings. However, this seems to be the first study among a sample of the Nigerian population. Clinical decisions can be made based on the findings of this study while further studies are required to further corroborate these findings.

Thus, based on this study's findings, we can deduce that prenatal androgen exposure may not be associated with the 2D:4D ratio as reported in some studies (Mitsui *et al*., 2016; Xie *et al*., 2017). This is supported by Gooren and Byne (2017) who found out 2D:4D ratio is not a robust predictor of prenatal androgen exposure. However, the digit ratio among the male students (0.96) is similar to what has been estimated to be the average digit ratio among males. Jeevanandam, (2016) found out the usual range of male and female 2D: 4D ratios has been reported to be 0.9470.029 and 0.9650.026, respectively.

A larger proportion had a balanced control over their emotions when completing a task, also, they are more relaxed and composed when faced with stressful situations or difficulties. However, a larger proportion are more impulsive in terms of the ability to control their attention, behavior, and thoughts. However, there was no significant difference in executive functions (emotional control, inhibition control, and stress intolerance) among the male and female populations as P> 0.050 in each case. In contrast to this finding, both Daruvala (2007) and Ball *et al*., (2010) reported that women will make more risk-averse choices than men suggesting a significant association between gender and executive function. The reason for these differences in findings may be due to cultural and environmental factors that would have modified their behaviors.

4.2 The Association between Digit Ratio, Personality Traits, and Executive Function

There was a significant negative correlation between the right-hand 2D:4D digit ratio and level of conscientiousness among the population with (r=-0.196) at P< 0.050. Also, there was a significant negative correlation between the male right-hand 2D:4D digit ratio and their level of conscientiousness with (r=-0.317) at P< 0.050. Conscientiousness has been defined

according to this study as being dependable and self-disciplined or disorganized and careless. This finding is in agreement with the evidence suggesting that the 2D:4D ratio is associated with risk-taking (Brooks & Zank, 2005; Garbarino *et al*., 2011).

However, the participants' digit ratio was not significantly correlated to some of the personality traits such as extraversion, agreeableness, emotional stability, and openness as P> 0.050 in each case. Also, no significant correlation was found between the participant's digit ratios and their executive functions (emotional control, inhibition control, stress tolerance) as P> 0.050 in each case. This finding is in line with the body of pieces of literature suggesting that there are mixed findings as regards the relationship between digit ratio and some socio-behavioral characteristics such as executive functions and personality traits (Apicella *et al*., 2015; Garbarino *et al*., 2011; Braas-Garza *et al*., 2019).

4.3 Association between Personality Traits and Executive Function

There was no significant correlation between the executive functions (Stress Tolerance (ST), Emotional Control (EC) and Inhibition Control (IC)) and personality traits ((Extraversion, Agreeableness, Conscientiousness, Emotional stability, and Openness) and executive functions such as P > 0.050 in each case.

5. CONCLUSION

Conclusively, there was no significant difference between the participants' digit ratio and gender. However, the digit ratio was significantly associated with conscientiousness among the population. Also, male right-hand 2D:4D digit ratio and their level of conscientiousness. Additionally, no significant correlation was found between the participant's digit ratios and their executive functions (emotional control, inhibition control, and stress tolerance). Thus, the 2D:4D digit ratio should be assessed in the developmental process of a child so that certain behavioral characteristics (conscientiousness) are anticipated and modified. The study is the first in Nigeria. Further studies should be conducted utilizing large samples to promote generalizability.

5.1 RECOMMENDATION

This finding revealed the association between the 2D:4D ratio and socio-behavioral characteristics such as conscientiousness. Hence, it is recommended that the 2D:4D ratio be evaluated across several populations so that early discovery of behavioral tendencies can be done and corresponding modifications.

This study showed that the 2D:4D ratio was not significantly different concerning gender in contrast to several bodies of evidence. Thus, further similar studies should be conducted utilizing a broader study setting to promote generalizability to a broad scale. Also, studies should be conducted adopting a random sampling method to reduce the rate of research bias. Studies should be conducted among pediatric populations.

5.2 Limitations

Due to financial limitations and the lack of financing at the time the study was being conducted, a broad population that might have been utilized to generalize the findings was not covered by the researcher. The study is constrained by the use of a single study setting, which may have an impact on how broadly it may be applied. Even when their anonymity was guaranteed, a few respondents still declined to take part in the survey. Finally, non-probabilistic sampling was used because it was challenging to get respondents to agree to take part in the study.

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