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Comparison of Second and Fourth Digit Lengths in Individuals with Autism Spectrum Disorder and Controls among the Hausa Population of Kano, Nigeria

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ABSTRACT
Globally, there has been a rise in autism spectrum disorder (ASD), impacting nearly one in every 160 children. However, its prevalence in many low- and middle-income countries remains uncertain. Although ASD has been connected to various bodily characteristics, its link to digits has been scarcely explored, particularly among the Hausa population. This study aimed to compare 2D and 4D digits between individuals with ASD and controls in the Hausa population of Kano State, Nigeria. The study was a cross-sectional comparative study, and using convenience sampling, 48 students aged 8 to 19 years (24 with ASD and 24 controls) participated in the study. Direct anthropometric measurements of the second (2D) and fourth digits (4D) of both hands were taken, and the digit ratios were calculated accordingly. Normality of data distribution was assessed with the Shapiro-Wilk test, while independent sample t-tests and Mann-Whitney U tests were used to compare means between groups. Results showed that although ASD participants generally had higher mean 2D and 4D lengths of both hands, no significant differences were observed in the 2D:4D ratios between ASD and control groups overall. However, when stratified by sex using independent sample t-tests and Mann-Whitney U tests, males with ASD exhibited a significantly greater right 2D length compared to controls (P = 0.030). No significant sexual dimorphism was found within the digit parameters of either group. This study suggests that while digit lengths may differ in males with ASD, the 2D:4D digit ratio may not be a distinguishing marker for ASD in this population.

Keywords: Autism spectrum disorder, Digit ratio (2D:4D), Hausa population, neurotypical controls, anthropometry

INTRODUCTION
The term anthropometry is taken up from the Greek word "Anthropos", which means "human" and "metron" meaning "measure". Thus, anthropometry refers to the different bodily measurements of the human individual[1]. It is the study of the measurement of the human dimensions of bone, muscle, and fat tissue[2].

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by impairments in social and communication abilities and patterns of repetitive and stereotypical behaviors[3]. Autism is called a "spectrum" disorder since the types and intensity of symptoms experienced by individuals differ greatly. The wide range of symptoms associated with ASD makes its diagnosis a difficult task. ASD affects people of all ethnic, racial, and socioeconomic backgrounds[4]. Despite the fact that ASD is a lifelong illness, studies have shown that early detection and appropriate medical care can enhance a person's long-term outcomes[5].

The second-to-fourth digit ratio (2D:4D) is a biological marker that can be defined as the ratio of the length of the second digit (index) to the length of the fourth digit (ring finger) of the same hand. 2D:4D is constant throughout life[6] and represents an indirect, retrospective, and non-invasive measure that correlates negatively with intrauterine exposure to testosterone, which means a lower 2D:4D is the result of increased levels of fetal testosterone[7]. It has been reported that digit ratio correlates with a wide number of traits and conditions, ranging in almost every field of medicine, with particular regard to sex hormone-dependent conditions, prostate cancer[8], osteoarthritis[9], and obesity[10]. Scholars have also investigated the association between the 2D:4D ratio and behavioral features, like aggression[11], stuttering[12], visuo-spatial ability[13], handedness[14], schizotypal personality[15], and sporting ability[16].

The 2D:4D ratio has also been suggested as a predictor of disease predisposition. More specifically, the 2D:4D digit ratio might be a useful predictor of fertility, differentiation pattern of the central nervous system (CNS), and the expression of particular adult-onset diseases, such as immune dysfunction, myocardial infarction, and breast cancer[17].

World Health Organization[18] revealed epidemiological statistics indicating that ASD affects one in every 160 children worldwide and its incidence in many low and middle-income countries remains unknown. Given the paucity of data on digit anthropometry in individuals with ASD within the Hausa ethnic group, this study aimed to compare second and fourth digit lengths and 2D:4D ratios between individuals with ASD and neurotypical controls in Kano State, Nigeria.

MATERIALS AND METHODS

Study location

The study was conducted at the Usman International School, Kano, for the already diagnosed ASD subjects, and Danyalo Nursery, Primary and Secondary School, Kano, for the subjects with normal psychomotor development.

Study population

Registered students aged 8–19 years with Autism Spectrum Disorder from Usman International School were recruited into the study. The ASD diagnosis was documented in the school records and had been previously established at an appropriate hospital using standard diagnostic protocols. The diagnosis was made by qualified healthcare professionals through clinical and medical assessments. Only students with no prior history of developmental defects or injury to the digits were included. The control group consisted of students with normal psychomotor development from Danyalo Schools who had no history of developmental defects or digit injuries.

Sampling technique and sample size determination

Using a convenience sampling technique, a total of 48 students (24 ASD and 24 normal) with a total of 18 and 6 for males and females, respectively, for each group were recruited from the named schools that participated in the study.

The sample size for this study was determined by the availability of eligible participants. All registered students aged 8–19 years with a documented diagnosis of autism spectrum disorder (ASD) who met the inclusion criteria at Usman International School during the study period were recruited. The number of participants available and willing to participate at the time of data collection determined the final sample size. A corresponding number of age-matched control subjects with normal psychomotor development were recruited from Danyalo Schools.

Ethical considerations

Ethical approval was obtained from Aminu Kano Teaching Hospital, Kano (AKTH/MAC/SUB/12A/P-3/VI/3669) and the Ethics Committee, Kano State of Nigeria, Ministry of Health (NHREC/17/03/2018). Approval was obtained from the Centre before the study. Informed consent and assent were obtained from participants' parents/guardians and participants, respectively, before the study. The study was carried out in accordance with the Helsinki Declaration[27].

Anthropometry: digits, lengths, and digit ratio

The finger length was measured (Figure 1) using a stainless steel digital vernier caliper (Neiko 01407A, New York, USA). Measurements were taken from both the right and left hands. The digit lengths (index and ring) were measured from the proximal crease to the tip of the digit[21]. Each digit was measured twice, and the mean value was recorded. All measurements were performed by a single investigator, and repeated measurements ensured intra-observer reliability. During measurement, the hand was placed flat on a table with the palm facing upward and the fingers fully extended and relaxed (Figure 1).

Figure 1: Technique for the digit length measurements

Statistical analysis

The data were expressed as mean ± standard deviation. Normality of the data was assessed using the Shapiro–Wilk test. A P-value < 0.05 was considered to indicate non-normally distributed data. Independent sample *t*-test (for normally distributed data) or Mann–Whitney U test (for non-normally distributed data) was used to compare the differences in the digit parameters. SPSS version 20 (IBM

Corporation, for Windows) was used for the data analysis. P-value < 0.05 was set as the level of significance. The Left 2D and Left 2D:4D ratios were not normally distributed and were analyzed using the Mann–Whitney U test. In contrast, other digit variables were normally distributed and were therefore analyzed using independent t-tests.

RESULTS

Table 1 presents the distribution and normality tests for the digit parameters of ASD and control subjects in the Hausa population of Kano State, Nigeria. The table shows that some variables, such as right 2D, right 4D, and the right 2D:4D ratio, as well as left 4D, were normally distributed, whereas others were not.

Table 1: Distribution of the Digit Parameters of the Study Participants (n = 48)

	Shapiro-Wilk	
Variables	**Statistic**	***P* - value**
Right 2D (mm)	0.98	0.59
Right 4D (mm)	0.98	0.44
Right 2D:4D ratio	0.97	0.28
Left 2D (mm)	0.95	0.03
Left 4D (mm)	0.97	0.28
Left 2D:4D ratio	0.65	<0.001

2D; second digit length, 4D; fourth digit length

Table 2 shows the descriptive statistics of age and digit parameters of subjects with ASD and controls of the Hausa population of Kano State, Nigeria. The mean age of the subjects was 14.71±3.10 and 14.54±2.83 for ASD and control subjects, respectively. In this study, the mean values of all digit anthropometrics were higher in the ASD group, except for the left digit ratio**,** which was higher in the control group. The right digit ratio was the same in both groups.

Table 3 shows the sexual dimorphism of the digit lengths (2D and 4D) and 2D:4D ratios in ASD and control subjects of the Hausa population of Kano State. From the table, it was observed that no significant difference was observed in the digit parameters for both case and control groups, which can be due to the small female sample size.

Table 4 shows the comparison of the digit parameters between ASD and control subjects of the Hausa population of Kano State. No significant difference was observed between the ASD and control subjects about the digit parameters (2D, 4D, and 2D:4D ratios of both hands).

Table 5 presents a comparison of digit parameters between ASD and control subjects in the Hausa population of Kano State, by gender. Among male participants, a significant difference was observed only in the right 2D (P = 0.030), which was higher in participants with ASD than in controls. For the female participants, no significant difference was observed in all the digits between the two groups.

DISCUSSION

This study explored differences in digit lengths (2D, 4D) and the 2D:4D ratio between individuals with autism spectrum disorder (ASD) and neurotypical controls among the Hausa population of Kano State, Nigeria. The 2D:4D digit ratio has been suggested as a potential marker of prenatal hormonal exposure and central nervous system development, with prior studies indicating its association with ASD traits [17,22].
In the present study, no statistically significant differences were observed in 2D, 4D, or 2D:4D ratios between the ASD and control groups overall, although participants with ASD generally exhibited slightly longer digits. This finding aligns with some earlier studies but contrasts with others that reported significantly lower 2D:4D ratios in individuals with ASD[2324]. A possible explanation for this discrepancy is the age range of participants in this study (8–19 years), as digit ratios can vary slightly with age[25]. Ethnic, geographical, and environmental factors may also contribute to differences in findings across populations due to variations in prenatal hormone exposure.
When stratified by sex, a significant difference was observed in the right second digit (2D) length among males, with ASD participants having longer digits. No statistically demonstrable sexual dimorphism was observed in 2D:4D ratios. This is consistent with the findings[26], who also reported shorter 2D lengths in typically developing boys compared to those with ASD. However, in our study, this difference was limited to the right hand. In contrast, other studies[2423] reported lower 2D:4D ratios in individuals with ASD. Differences in study populations, including age, ethnicity, and methodological approaches, may account for these inconsistencies.
Overall, while it may warrant further investigation, the 2D:4D ratio alone does not appear to be a reliable marker for ASD in the Hausa population. Further research with larger and more diverse samples is recommended to validate these findings.

CONCLUSION

This study found no significant differences in overall 2D, 4D, or 2D:4D ratios between individuals with autism spectrum disorder and neurotypical controls among the Hausa population of Kano State, Nigeria. However, a significantly longer right second digit was observed among males with ASD, which warrants further investigation in larger, more diverse populations.

Table 2: Descriptive Statistics of Age and Digit Parameters of Subjects with ASD and the Normal Hausa Population of Kano State

	ASD			Normal		
Variables	**Min**	**Max**	**Mean±SD**	**Min**	**Max**	**Mean±SD**
Age (Year)	9.00	19.00	14.71±3.10	8.00	19.00	14.54±2.83
Right 2D (mm)	49.09	80.20	66.99±6.86	44.66	75.25	63.17±7.77
Right 4D (mm)	59.11	81.99	68.77±7.13	46.01	82.45	64.97±9.03
Right 2D:4D ratio	0.83	1.11	0.98±0.06	0.89	1.14	0.98±0.06
Left 2D (mm)	48.21	80.21	67.00±7.82	43.23	98.43	64.68±10.65
Left 4D (mm)	56.65	83.22	69.71±7.75	47.80	80.35	66.67±8.12
Left 2D:4D ratio	0.77	1.10	0.96±0.06	0.85	1.55	0.97±0.13

Min; Minimum, Max; Maximum, SD; standard deviation,2D; second digit, 4D; fourth digit, ASD; Autism Spectrum Disorder

Table 3: Sexual Dimorphism of the Digit Parameters in ASD and Normal Subjects of the Hausa Population of Kano State

		Male (n =18)	Female (n = 6)		
Group	**Variables**	**Mean±SD**	**Mean±SD**	**t-value**	***P*- value**
ASD	Right 2D (mm)	68.02±7.12	63.90±5.33	1.30	0.21
	Right 4D (mm)	69.82±7.37	65.61±5.74	1.27	0.22
	Right 2D:4D ratio	0.98±0.07	0.97±0.03	0.06	0.96
	Left 2D (mm)	68.66±7.77	62.04±6.05	1.89	0.07
	Left 4D (mm)	71.34±7.83	64.84±5.44	1.87	0.07
	Left 2D:4D ratio	0.96±0.07	0.96±0.03	0.27	0.79
Normal	Right 2D (mm)	62.28±8.07	65.84±6.70	-0.97	0.34
	Right 4D (mm)	64.70±9.74	65.76±7.19	-0.24	0.81
	Right 2D:4D ratio	0.97±0.06	1.00±0.04	-1.43	0.17
	Left 2D (mm)	64.81±11.75	64.31±7.24	0.01	0.92
	Left 4D (mm)	65.97±8.82	68.75±5.63	-0.72	0.48
	Left 2D:4D ratio	0.98±0.15	0.93±0.06	0.79	0.44

SD; standard deviation, 2D; second digit length, 4D fourth digit length

Table 4: Comparison of the Digit Anthropometry between ASD and Control Subjects of the Hausa Population of Kano State

Group		**ASD (n = 24)**	**Normal (n = 24)**		
Combined	**Variables**	**Mean±SD**	**Mean±SD**	**t/Man U – Value**	***P*-value**
	Right 2D (mm)	66.99±6.86	63.17±7.77	1.81	0.080
	Right 4D (mm)	68.77±7.13	64.97±9.03	1.62	0.110
	Right 2D:4D	0.98±0.06	0.98±0.06	0.00	1.000
	Left 2D (mm)	67.00±7.82	64.68±10.65	217.50	0.146
	Left 4D (mm)	69.71±7.75	66.67±8.12	1.33	0.190
	Left 2D:4D	0.96±0.06	0.97±0.13	234.00	0.266

SD; standard deviation, 2D; second digit length, 4D fourth digit length, ASD; autism spectrum disorder, Mann–Whitney U; Left 2D and Left 2D:4D, t-value; Right 2D, Right 4D, Right 2D:4D, Left 4D where analyzed using t-value

Table 5: Comparison of the Digit Lengths and Ratios between ASD and Control Subjects of the Hausa Population of Kano State

		ASD (n = 18)	Normal (n = 6)		
Sex	**Variables**	**Mean±SD**	**Mean±SD**	**t/Mann U-value**	***P*-Value**
Male	Right 2D/mm	68.02±7.12	62.28±8.07	2.265	0.030
	Right 4D/mm	69.82±7.37	64.70±9.74	1.779	0.084
	Right 2D:4D	0.98±0.07	0.97±0.06	0.463	0.646
	Left 2D/mm	68.66±7.77	64.81±11.75	104.000	0.066
	Left 4D/mm	71.34±7.83	65.97±8.82	1.930	0.062
	Left 2D:4D	0.96±0.07	0.98±0.15	143.000	0.548
Female	Right 2D/mm	63.90±5.33	65.84±6.70	-0.556	0.590
	Right 4D/mm	65.61±5.74	65.76±7.19	-0.040	0.969
	Right 2D:4D	0.97±0.03	1.00±0.04	-1.395	0.193
	Left 2D/mm	62.04±6.05	64.31±7.24	15.000	0.631
	Left 4D/mm	64.84±5.44	68.75±5.63	-1.225	0.249
	Left 2D:4D	0.96±0.03	0.93±0.06	13.000	0.423

SD; standard deviation, 2D; second digit length, 4D fourth digit length, ASD; autism spectrum disorder

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