Al-Rafidain J Med Sci. 2023;5(Suppl 1):S23-28.
DOI: https://doi.org/10.54133/ajms.v5i1S.301

AJMS

Online ISSN (2789-3219)

Research Article

Gender Determination Using Hand Parameters: A Cross-Sectional Analytical Study in Iraq

Mohammed Hussein Assi*

Department of Human Anatomy, College of Medicine, Mustansiriyah University, Baghdad, Iraq

Received: 14 September 2023; Revised: 19 October 2023; Accepted: 23 October 2023

Abstract

Background: Hand parameters have been suggested to be useful indicators for gender identification. ***Objective***: To detect gender from hand parameters in a sample of Iraqi individuals. ***Methods***: Hand parameters (hand length, width, hand index, index and ring lengths, and index to ring ratio) of 100 participants were measured using traditional techniques. The data were tested statistically using appropriate statistical methods. ***Results***: Females display a higher 2D/4D ratio compared to males. In contrast, males show a higher hand index compared to females. The study proposes a 2D/4D cutoff point of 0.9722, where a ratio < 0.9722 was regarded as male and a ratio ≥ 0.9722 was regarded as female. Alternatively, a hand index (HI) cutoff point was 40.2154, where an HI > 40.215 was regarded as male and an HI ≤ 40.215 was regarded as female. Consequently, the study verifies that hand parameters can be used for gender determination in medical legal examinations. ***Conclusion***: Hand parameters may be valuable indicators of sexual dimorphism in medico-legal examination and may have a great implication in cases of natural disasters and wars when an isolated hand is subjected to examination.

Keywords: Anthropometry, 2D to 4D ratio, Gender determination, Hand index, Iraqi people.

تحديد جنس الأشخاص باستخدام معلمات اليد: دراسة تحليلية مقطعية في العراق

الخلاصة

الخلفية: هناك فرضية في أن تكون قياسات اليد مؤشرات مفيدة لتحديد نوع الجنس. **الهدف**: الكشف عن الجنس من معلمات اليد في عينة من الأفراد العراقيين. **الطرق**: تم قياس معلمات اليد (طول اليد والعرض ومؤشر اليد وأطوال اطوال اصبعي السبابة والبنصر ونسبة طول اصبع السبابة الى البنصر) ل 100 مشارك باستخدام التقنيات التقليدية. تم اختبار البيانات إحصائيا باستخدام الأساليب الإحصائية المناسبة. **النتائج**: تظهر الإناث نسبة 2D/4Dأعلى مقارنة بالذكور. في المقابل، يظهر الذكور مؤشر يد أعلى مقارنة بالإناث. ظهر في الدراسة نقطة فاصلة 2D/4Dتبلغ 0.9722، حيث تم اعتبار نسبة > 0.9722 ذكرا ونسبة ≤ 0.9722 أنثى. بدلا من ذلك، كانت نقطة قطع مؤشر اليد40.2154 (HI) ، حيث تم اعتبار HI > 40.215 ذكرا و HI ≤ 40.215 تم اعتبارها أنثى. وبالتالي، يتبين من نتائج الدراسة أنه يمكن استخدام معلمات اليد لتحديد الجنس في الفحوصات القانونية الطبية. **الأستنتاج**: قد تكون معلمات اليد مؤشرات في الفحص الطبي الشرعي وقد يكون لها تأثير كبير في حالات الكوارث الطبيعية والحروب عندما تخضع يد معزولة للفحص.

* ***Corresponding author***: Mohammed H. Assi, Department of Human Anatomy, College of Medicine, Mustansiriyah University, Baghdad, Iraq; Email: drmha1975@uomustansiriyah.edu.iq

Article citation: Assi MH. Gender determination using hand parameters: A cross-sectional analytical study in Iraq. *Al-Rafidain J Med Sci*. 2023;5(Suppl 1):S23-28. doi: https://doi.org/10.54133/ajms.v5i1S.301

INTRODUCTION

Earlier in 1888, Frank Baker was the first to demonstrate sexual differences in the relative lengths of the index (2D) and the ring (4D) fingers, and subsequently, the 2D/4D ratio exhibits a sexual dimorphism between males and females [1]. It has been found that in males, the index finger (2D) is a little shorter than the ring finger (4D), so the 2D/4D ratio is quite lower than one (2D/4D <1). While in females, the ring finger (4D) is

slightly shorter than (or just equal) to the index (2D), and the 2D/4D ratio in females is greater than or equal to one (2D/4D ≥1) [2]. Several studies reveal that this sexual dimorphism in the 2D/4D ratio becomes apparent by the age of two years, seems to have existed prenatally during the 2nd trimester, and was thought to be due to the direct effect of sex hormones (estrogen and androgen) on the relative growth rate of the digits, particularly the index and ring fingers [3,4]. The 2D/4D ratio shows a negative correlation to prenatal androgens and a positive correlation to estrogens. This provisional assumption is partly confirmed by the lower digit ratio in girls with congenital adrenal hyperplasia (characterized by overproduction of androgens), a higher ratio in males with androgen insensitivity syndrome, and in males with Klinefelter syndrome (characterized by low androgens), who show a mean 2D/4D ratio similar to normal females [5]. The 2D/4D ratio can simply be computed by dividing the index finger length by the little finger length. Measuring finger lengths can be executed using one of two methods (the direct or indirect method). In the direct method, the finger length is normally measured on the palm side of the hand, from the midpoint of the proximal finger skin crease to the finger's tip [6]. In the indirect method, a photocopy or scanned photo is used to measure the finger length [7]. Several studies have used other hand parameters, like hand length and width, hand index (hand width/hand length×100), palm length and palm index (hand width/palm length×100), and others [8,9]. It has been found that there is a scarcity of studies on the subject of sexual dimorphism from hand parameters in the Iraqi population, and this has encouraged the author to perform this study. So, the research aim is to verify sexual dimorphism using hand parameters, namely index to ring finger ratio (2D/4D ratio) and hand index (HI), in a sample of adult Iraqi individuals.

METHODS

Study design

The study is observational cross-sectional in design and was conducted in the Department of Human Anatomy at Mustansiriyah Medical College, Baghdad, Iraq. It has been approved by the local ethical committee of Al-Mustansiriyah Medical College, and informed consent was obtained from all participants. The study includes 100 healthy adults (50 males and 50 females) aged 18–48 who attended a private GP clinic in Baghdad during the period from February to July 2023.

Inclusion criteria

Adults, both male and female, who are at least 18 years old and willing to participate in the study.

Exclusion criteria

Individuals with a history of trauma, disease or surgery affecting the hand or fingers were excluded from the study.

Outcome measurement

Techniques for calculating hand dimensions were performed according to the approaches suggested by Weiner and Lourie [10]. These measurements are recorded in centimeters using a sliding caliper. To overcome interobserver variations, the same person recorded all measurements. The hand of the participant was positioned on the ground with the palm directed superiorly and the digits extended and close to each other. The length of the hand was measured as the distance from the wrist skin crease to the tip of the middle finger. The width of the hand was measured as the distance from the lateral point of the head of the 2nd metacarpal bone to the medial point of the head of the 5th metacarpal bone. The index length (2D) was measured as the distance from the metacarpal-phalangeal skin crease of the index finger to its tip. The ring length (4D) was measured as the distance from the metacarpal-phalangeal skin crease of the ring finger to its tip. The hand index was computed using the following formula: HI = (HW/HL) * 100, where HI is the hand index, HW is the hand width, and HL is the hand length. The 2D/4D ration was computed by dividing the 2D length by the 4D length.

Statistical analysis

Statistical analyses were performed using SPSS "Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA)" version 26 for Windows. Continuous data were represented as mean±SD. For the normally distributed variables, inter- and intra-group comparisons were executed using ANOVA and t-tests. *A p*-value l*ess* than 0.05 was considered statistically significant [11,12]. An average mean value for the 2D/4D digit ratio and for the hand index of both genders was taken for sex discrimination, and it was termed a "sectioning point" and "cut-off points" were derived using discriminant analysis. Sectioning point = (mean male value + mean female value)/2 [13].

RESULTS

In male participants, the length of the right index finger (right 2D) ranges from 6 to 9 cm (7.56±0.767). The length of the left index finger (left 2D) ranges from 6–9.5 cm (7.670± 0.746). The length of the right ring finger (right 4D) ranges from 6.5–9 cm (7.98±0.699). The length of the left ring finger (left 4D) ranges from 6.5–9 cm (7.930± 0.7144). The right 2D/4D ratio range is 0.86–1.07 (0.947±0.04). The left 2D/4D ratio ranges from 0.87 to 1.13 (0.968± 0.050) (Table 1) (Figure 1).

Table 1: Descriptive statistics of participants

	Min-Max	Mean±SD	Variance
Males			
Right 2D length	6.0-9.0	7.56±0.77	6.0
Right 4D length	6.5-9.0	7.98±0.7	6.5
Right 2D/4D ratio	0.86-1.07	0.947±0.04	0.86
Left 2D length	6.0-9.5	7.67±0.75	6.0
Left 4D length	6.5-9.0	7.93±0.71	6.5
Left 2D/4D ratio	0.87-1.13	0.97±0.05	0.87
Right hand length	16.5-22.5	19.02±1.02	1.03
Right hand width	7.0-9.0	8.12±0.56	0.312
Right HI	34.09-50.3	42.77±3.35	11.207
Left hand length	16.5-22.0	19.12±1.02	1.048
Left hand width	7.0-9.0	8.16±0.54	0.290
Left HI	34.09-50.3	42.76±3.25	10.556
Females			
Right 2D length	6.0-8.5	7.29±0.63	6.0
Right 4D length	6.0-8.5	7.17±0.7	6.0
Right 2D/4D ratio	0.92-1.17	1.02±0.04	0.92
Left 2D length	6.0-8.5	7.27±0.67	6.0
Left 4D length	6.0-8.5	7.18±0.67	6.0
Left 2D/4D ratio	0.93-1.08	1.01±0.03	0.93
Right hand length	15.0-20.0	17.99.24	1.552
Right hand width	6.0-8.0	7.22±0.69	0.481
Right HI	31.58-51.61	40.25±4.47	19.999
Left hand length	6.0-8.5	7.284±0.68	0.461
Left hand width	15.5-21.0	18.12±1.23	1.508
Left HI	31.25-51.61	40.32±4.32	18.661

2D: Index (2nd Digit), 4D: Ring (4th Digit), HI: Hand Index, SD: Standard Deviation

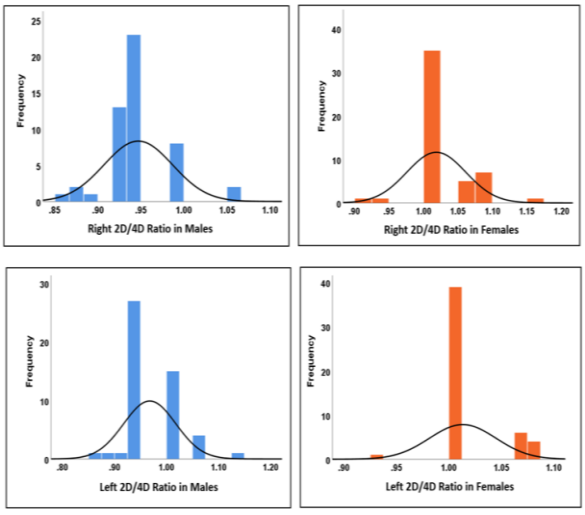

Figure 1: Simple histograms showing normal distributions of the right 2D/4D ratio in males (top left) and in females (top right), the left 2D/4D ratio in males (bottom left) and in females (bottom right).

In females, the length of the right index finger (right 2D) ranges from 6–8.5 cm (7.29±0.632). The length of the left index finger (left 2D) ranges from 6–8.5 cm (7.27±0.672). The length of the right ring finger (right 4D) ranges from 6–8.5 cm (7.17±0.697). The length of the left ring finger (left 4D) ranges from 6–8.5 cm (7.180±0.6758). The right 2D/4D ratio range is 0.92-1.17 (1.019±0.043). The left 2D/4D ratio ranges from 0.93 to 1.08 (1.013±0.0317) (Table 1 and Figure 1). In males, the length of the right hand (HL) ranges from 16.5-22.5 cm (19.022±1.015). The width of the right hand (HW) ranges from 7-9 cm (8.12 ±0.558). The right-hand index (HI) ranges from 34.09 to 50.30 (42.774±3.348). The length of the left hand (HL) ranges from 16.50 to 22.00 cm (18.116±1.228). The width of the left hand (HW) ranges from 7-9 cm (8.160±0.538). The left-hand index (HI) range is 34.09–50.30 (42.758±3.249) (Table 1 and Figure 2).

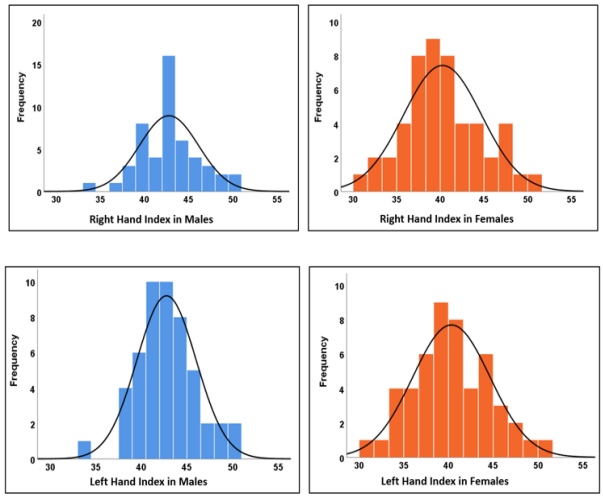

Figure 2: Simple histograms show normal distribution of right hand index in males (top left), right hand index in females (top right), left hand index in males (bottom left) and left hand index in females (bottom right).

In females, the length of the right hand (HL) ranges from 15.0–20.0 cm (17.996±1.246). The width of the right hand (HW) ranges from 6–8 cm (7.22 ± 0.693). The right-hand index (HI) range is 31.58–51.61 (40.254±4.472). The length of the left hand (HL) ranges from 15.50–21.00 cm (19.122±1.239). The width of the left hand (HW) ranges from 6–8.5 cm (7.278±0.67). The left-hand index (HI) range is 31.25–51.61 (40.322±4.32) (Table 1 and Figure 2). The analysis of variance and covariance (ANOVA test) confirmed that there were statistically significant differences in all hand and digit dimensions between males and females ($p< 0.005$). A t-test further confirms these findings; the test reveals that the right and left HI are greater in males than in females (42.774 *vs*. 40.254, $p=0.002$ for the right HI, 42.758 *vs*. 40.322, $p=0.002$ for the left HI). In regard to the 2D/4D ratio, it has been found that the right and left 2D/4D ratios were greater in females than males (1.019 *vs*. 0.947, $p<0.001$ for the right side, 1.0132 *vs*. 0.968, $p<0.001$ for the left side) (Figure 3).

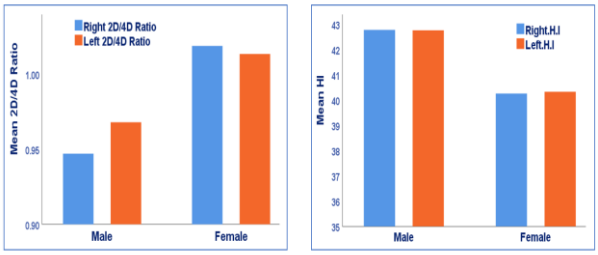

Figure 3: Clustered bars: means of 2D/4D ratios and HI by gender.

Paired sample *t*-tests were conducted to compare right and left hand HI and 2D/4D ratios. The tests revealed no significant differences between right and left hands (p=0.780 for HI and 0.163 for the 2D/4D ratio) (Figure 4).

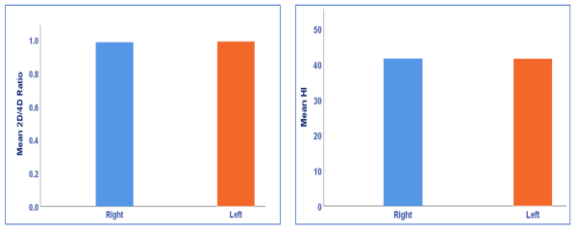

Figure 4: Clustered bars: means of 2D/4D ratios and HI by laterality.

The analysis of variance and covariance (ANOVA test) confirmed that there was no significant difference in all hand dimensions in relation to age (p>0.05) (Figure 5). Based on the mean 2D/4D ratio for both genders, a "sectioning point" for the 2D/4D ratio was computed to classify female and male hands. Using trial and error, a "cut-off point" of 0.972 was obtained to ascertain the sexual dimorphism of the ratio.

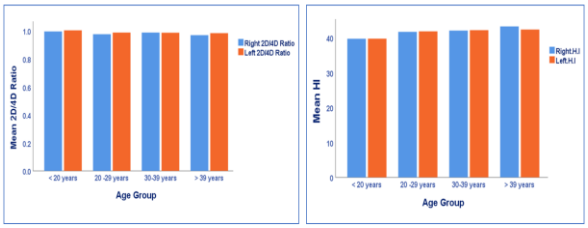

Figure 5: Clustered bars - means of 2D/4D ratios and HI by age group.

The right 2D/4D ratio precisely determines gender in 80% males and 96% females, while the left 2D/4D ratio determines gender in 60% males and 98% females, and when applied to all cases, 2D/4D ratios <0.972 were regarded as males and those ≥0.972 were regarded as females (Table 2). Based on the mean HI for both genders, a "sectioning point" for the HI was computed to classify male and female hands. Using trial and error, a "cut-off point" of 40.215 was obtained to ascertain sexual dimorphism in the HI. Right HI precisely verifies gender in 66% males and 68% females, while left HI determines gender in 62 males and 66 females, and when applied to all cases, HI >40.215 was regarded as males and those≤ 40.215 were regarded as females (Table 2).

Table 2: Discriminant Analysis- 2D/4D Ratios and HI

Variable	Gender	Predicted group membership (%)		Correct classification (%)
		Male	Female	
Right 2D/4D ratio	Male	80	20	88
	Female	4	96	
Left 2D/4D ratio	Male	60	40	79
	Female	2	98	
Right HI	Male	66	34	67
	Female	32	68	
Left HI	Male	62	38	64
	Female	34	66	

2D: Index length (2nd Digit), 4D: Ring length (4th Digit), HI: Hand Index

DISCUSSION

Human remnant identification is a crucial part of medicolegal examination. It is not rare to find a peripheral component of a human, like a foot or hand, in natural catastrophes and wars where the body is disarticulated, obscuring victim identity. When a separate hand is conveyed for examination, hand somatometric and osteologic examination and imaging radiology can assist in the identification of the victim's primary indicators, such as gender, age, and physique [12]. Due to the paucity of literature investigating sexual dimorphism from hand parameters in Iraq, the present research has been performed to study the sexual dimorphism of the 2D/4D ratio and hand index in a sample of adult Iraqi individuals. The present study records a mean right 2D/4D ratio of 0.95 in males and 1.02 in females and a mean left 2D/4D ratio of 0.97 in males and 1.01 in females. These readings are quite consistent with the pattern found in most previous studies [13,7,15-17] (Table 3).

Table 3: Comparisons of 2D/4D digit ratios described among different countries

Country	No.		M	F	Authors
Iraq (current study)	100	Right 2D/4D	0.95	1.02	-
		Left 2D/4D	0.97	1.01	
Iraq (previous study)	161	Right 2D/4D	0.98	1.0	Al-Salihi *et al.*, 2011
		Left 2D/4D	-	-	
Saudi Arabia	560	Right 2D/4D	0.98	0.98	Almasry *et al.*, 2011
		Left 2D/4D	0.97	0.99	
Egypt	250	Right 2D/4D	0.97	0.99	Aboul-Hagag *et al.*, 2011
		Left 2D/4D	0.97	0.99	
India	141	Right 2D/4D	0.97	1.01	Sangeeta and Kapoor 2016
		Left 2D/4D	0.97	1.01	
USA	51	Right 2D/4D	0.95	0.98	Smedley *et al.*, 2014
		Left 2D/4D	-	-	

2D: Index length (2nd Digit); 4D: Ring length (4th Digit)

According to the findings of the present research, females exhibit significantly higher mean 2D/4D ratios for both hands as compared to males. This finding is clearly in accordance with most of the preceding studies [18–20]. This difference was explained by the fact that the digit ratio is negatively correlated with prenatal androgens and positively correlated with prenatal estrogens [5]. Thus, a lower 2D/4D ratio was considered "masculine" and a higher ratio as "feminine". The present study reports a mean right HI of 42.774 in males and 40.254 in females, and a mean left HI of 42.7580 in males and 40.322 in females. This was larger than those reported by Almasry *et al*. (2011) and Kanchan and Rastogi (2009) [7,8]. Another finding this study exposed is that the hand dimensions (hand length, width, and hand index) in males are found to be greater than in females. These findings are parallel to the previous studies that show a male hand dimension is constantly larger than that of a female [8,21-23]. These differences in hand dimensions between males and females may be explained by the late maturity of boys compared to girls; subsequently, the boys have more time for physical growth [7]. With respect to laterality (handedness), the study found no difference between right and left hands in both genders; these findings are similar to those recorded by Krishan and Sharma (2009) and Habib and Kamal (2010) [8,18]. According to the results of the present study, there was no significant relationship between the age of the individual and hand parameters; this was consistent with the study performed by Habib and Kamal (2010) [18] and Farhan *et al*. (2023) [24]. The present study proposes a cutoff value for HI $\leq$ 40.215 (for both hands) to be indicative of female hands, while HI > 40.55 is indicative of male hands. This cutoff value is quite similar to that suggested by Kanchan and Rastogi (2009) [8], but slightly greater than that suggested by Almasry *et al.* (2011) [7]. Again, the study proposes a cutoff value for 2D/4D ratio < 0.972 (for both hands) to be indicative of male hands, while HI $\geq$ 0.972 is indicative of female hands. Once again, this cutoff value is quite similar to that suggested by Aboul-Hagag *et al*. (2011) [14], but slightly greater than that suggested by Almasry et al. (2011) [7]. The present study finds that the right 2D/4D ratio was more sensitive and specific than the left ratio in determining sexual dimorphism. This may be explained by the assumptions of Manning *et al*. (1998) [23] and Hönekopp and Watson (2010) [25], who supposed that the effect of androgen on the 2D/4D ratio is predominantly potent in the right hand.

Conclusion

Hand index (HI) and 2nd to 4th digit ratio may be helpful indicators of sexual dimorphism to be used in medicolegal examinations. It may have a great implication in cases of natural disasters and wars when an isolated hand is subjected to medicolegal examination, particularly when DNA testing is difficult to execute, as it may have some restrictions in respect to costs, skilled personnel, and time constraints.

Conflict of interests

No conflict of interest was declared by the author

Funding source

The author did not receive any source of fund.

Data sharing statement

Supplementary data can be shared with the corresponding author upon reasonable request.

REFERENCES

1. Baker F. Anthropological notes on the human hand. *Am Anthropol*. 1888;1:51-76.
2. Fusar-Poli L, Rodolico A, Sturiale S, Carotenuto B, Natale A, Arillotta D, et al. Second-to-fourth digit ratio (2D:4D) in psychiatric disorders: A systematic review of case-control studies. *Clin Psychopharmacol Neurosci*. 2021;19(1):26-45. doi: 10.9758/cpn.2021.19.1.26.
3. Baxter A, Wood EK, Witczak LR, Bales KL, Higley JD. Sexual dimorphism in Titi Monkeys' digit (2D:4D) ratio is associated with maternal urinary sex hormones during pregnancy. *Dev Psychobiol*. 2020;62(7):979-991. doi: 10.1002/dev.21899.
4. Ernsten L, Körner LM, Schaper ML, Lawrenz J, Richards G, Heil M, et al. The association of prenatal amniotic sex hormones and digit ratio (2D:4D) in children aged 5 to 70 months: A longitudinal study. *PLoS One*. 2023;18(3):e0282253. doi: 10.1371/journal.pone.0282253.
5. de Sanctis V, Soliman AT, Elsedfy H, Soliman N, Elalaily R, Di Maio S. Is the second to fourth digit ratio (2D:4D) a biomarker of sex-steroids activity? *Pediatr Endocrinol Rev*. 2017;14(4):378-386. doi: 10.17458/per.vol14.2017.SSE.SexSteroids.
6. Richards G, Aydin E, Tsompanidis A, Padaigaitė E, Austin T, Allison C, et al. Digit ratio (2D:4D) and maternal testosterone-to-estradiol ratio measured in early pregnancy. *Sci Rep*. 2022;12(1):13586. doi: 10.1038/s41598-022-17247-3.
7. Almasry SM, El Domiaty MA, Algaidi SA, Elbastawisy YM, Safwat MD. Index to ring digit ratio in Saudi Arabia at Almadinah Almonawarah province: a direct and indirect measurement study. *J Anat*. 2011;218(2):202-208. doi: 10.1111/j.1469-7580.2010.01318.x.
8. Kanchan T, Rastogi P. Sex determination from hand dimensions of North and South Indians. *J Forensic Sci*. 2009;54(3):546-550. doi: 10.1111/j.1556-4029.2009.01018.x.
9. Ibrahim MA, Khalifa AM, Hagras AM, Alwakid NI. Sex determination from hand dimensions and index/ring finger length ratio in North Saudi population: Medico-legal view. *Egypt J Forens Sci*. 2016; 6(4):435-444. doi: 10.1016/j.ejfs.2016.11.002.
10. Weiner JS, Lourie JA, (Eds.), Human Biology: A guide to field methods, Blackwell Scientific Publications, Oxford, London, 1969; p.p. 32–33.
11. Daniel W, Cross C, (Eds.), Biostatistics: A foundation for analysis in the health sciences, (11th ed.), Wiley, 2018; p.p. 254.
12. Assi MH, Zghair MA, Al-Hussaini HI. Computed tomographic assessment of normal splenic length in relation to anthropometric parameters: An observational cross-sectional study in Iraq. *Al-Rafidain J Med Sci*. 2023;5:172-176. doi: 10.54133/ajms.v5i.204.
13. Kanchan T, Kumar GP, Menezes RG. Index and ring finger ratio: a new sex determinant in the South-Indian population. *Forensic Sci Int*. 2008;181:53.e1–4. doi: 10.1016/j.forsciint.2008.08.002.

14. Al-Salihi AR, Selman MO, Wasif HF. The anthropometric ratio of index finger to ring finger (2D:4D) correlation with some seminal fluid analysis parameters. *Iraqi Postgrad Med J*. 2011;10(2):244-248.
15. Aboul-Hagag KE, Mohamed SA, Hilal MA, Mohamed EA. Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians. *Egypt J Forensic Sci*. 2011;2:80-86. doi: 10.1016/j.ejfs.2011.03.001.
16. Dey S, Kapoor AK. Digit ratio (2D:4D) – A forensic marker for sexual dimorphism in North Indian population. *Egypt J Forensic Sci*. 2016;6(4):422-428. doi: 10.1016/j.ejfs.2016.09.003.
17. Smedley KD, McKain KJ, McKain DN. 2D:4D digit ratio predicts depression severity for females but not for males. *Personality Individ Differ*. 2014;70:136-139. doi: 10.1016/j.paid.2014.06.039.
18. Habib SR, Kamal NN. Stature estimation from hand and phalanges lengths of Egyptians. *J Forensic Leg Med*. 2010;17:156-160. doi: 10.1016/j.jflm.2009.12.004.
19. Skorska MN, Coome LA, Peragine DE, Aitken M, Vander Laan DP. An anthropometric study of sexual orientation and gender identity in Thailand. *Sci Rep*. 2021;11(1):18432. doi: 10.1038/s41598-021-97845-9.
20. Holmes L, Watts-Overall TM, Slettevold E, Gruia DC, Raines J, Rieger G. Sexual orientation, sexual Arousal, and finger length ratios in women. *Arch Sex Behav*. 2021;50(8):3419-3432. doi: 10.1007/s10508-021-02095-5.
21. Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a North Indian population. *J Forensic Leg Med*. 2007;14:327-332. doi: 10.1016/j.jcfm.2006.10.008.
22. Rhiu I, Kim W. Estimation of stature from finger and phalange lengths in a Korean adolescent. *J Physiol Anthrop.* 2019;38(1):13. doi: 10.1186/s40101-019-0206-1.
23. Manning JT, Scutt D, Wilson J, Lewis-Jones DI. The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and estrogen. *Hum Reprod*. 1998;13:3000-3004. doi: 10.1093/humrep/13.11.3000.
24. Farhan SS, Al-Imam A, Al-Jewari WM. Stature estimation among Iraqis based on anthropometrics of the hands using multivariable regression. *Al-Rafidain J Med Sci*. 2023;4:92-101. doi: 10.54133/ajms.v4i.120.
25. Hönekopp J, Watson S. Meta-analysis of digit ratio 2D:4D shows greater sex difference in the right hand. *Am J Hum Biol*. 2010; 22(5):619-630. doi: 10.1002/ajhb.21054.