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ARAŞTIRMA MAKALESİ / ORIGINAL ARTICLE
FORENSIC ANTHROPOLOGY

Sex determination from hand dimensions: Preliminary study

El ölçümlerinden cinsiyet tespiti: Ön Çalışma

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ABSTRACT

Objective: Sex determinations is one of the important parameters in identification. In decomposed corpses and skeletal remains, sex determination is quite complicated. Therefore, researchers utilize anthropometric methods in such cases. In this study, the usefulness of hand anthropometry for sex determination was questioned by using three different analysis methods and the superiority of the methods was investigated.

Material and Method: Three researchers measured the hand length and width of 221 participants in the study. The measurements were taken using digital calipers, and each participant's hand measurement was recorded twice. Hand index and sectioning point values were calculated based on the measurements. The student's t-test and the Mann-Whitney U test and Fisher-Freeman-Halton exact test were used to compare sex groups. Lastly, discriminant analysis was used to evaluate the sex prediction performance of the measurements. The significance level was assumed as $p<0.05$ in all statistical analyses. SPSS Version 23.0 and the R MVN package were used in the analyses.

Results: In the study, significant differences between sex groups were observed across all measurements (95%) and hand type distribution. Sectioning point values were identified as reliable indicators for sex determination, with hand width demonstrating the highest classification accuracy. Discriminant analysis results indicated that the combined use of hand length and width had higher classification accuracy than using hand index alone.

Conclusion: The study showed that hand size can be used as an alternative method for sex determination. In this regard, it has been found that among different statistical methods, discriminant analysis has a higher efficiency in sex determination.

Keywords: *Identification, hand measurement, sex determination, forensic science*

ÖZET

Amaç: Kimliklendirmede yararlanılan önemli parametrelerden biri cinsiyettir. Cinsiyet tespitini; çürümüş, parçalanmış cesetler ve iskelet kalıntılarında oldukça komplikedir. Bu nedenle araştırmacılar bu tür durumlarda antropometrik yöntemlerden faydalanmaktadır. Bu çalışmada, üç farklı analiz yöntemi kullanılarak el antropometrisinin cinsiyet belirlemedeki kullanılabilirliği sorgulanmış ve yöntemlerin birbirlerine göre üstünlükleri araştırılmıştır.

Materyal ve Metod: Çalışmaya katılan 221 katılımcının el uzunluğu ve genişliği üç araştırmacı tarafından ölçüldü. Ölçümler dijital kumpas kullanılarak yapıldı ve her katılımcının el ölçümü iki kez alındı. Ölçümler ile el indeksi ve ayrım noktası değerleri hesaplandı. Cinsiyet gruplarını karşılaştırmak için student's t-testi ve Mann-Whitney U testi ve Fisher-Freeman-Halton exact testi kullanıldı. Son olarak, ölçümlerin cinsiyet tahmin performansını değerlendirmek için diskriminant analizi yapıldı. Tüm istatistiksel analizlerde anlamlılık düzeyi $p<0.05$ olarak kabul edildi. Analizlerde SPSS Version 23.0 ve R MVN paketi kullanıldı.

Bulgular: Çalışmada, cinsiyet grupları arasında tüm ölçümlerde (%95) ve el tipi dağılımında anlamlı farklılıklar gözlenmiştir. Ayrım noktası değerleri cinsiyet belirleme için güvenilir göstergeler olarak tanımlanmış ve el genişliği en yüksek sınıflandırma doğruluğunu göstermiştir. Diskriminant analizi sonuçları, el uzunluğu ve genişliğinin birlikte kullanımının tek başına el indeksi kullanımından daha yüksek sınıflandırma doğruluğuna sahip olduğunu göstermiştir.

Sonuç: Çalışmada el boyutlarının cinsiyet tespitinde kullanılabilecek alternatif bir yöntem olabileceği gösterdi. Ayrıca çalışmada kullanılan farklı istatistiksel yöntemler arasında diskriminant analizinin cinsiyet belirlemede daha yüksek bir etkinliğe sahip olduğu belirlendi.

Anahtar Kelimeler: *Kimliklendirme, el ölçümü, cinsiyet tayini, adli tıp*

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INTRODUCTION

Forensic anthropology is a subfield of forensic science focused on identifying skeletal remains and assessing traumatic lesions. Parameters such as age, gender, fingerprints, medical and dental characteristics are used to identify individuals during criminal investigations (1-3).

Identification refers to the process of determining the distinctive characteristics of living and deceased individuals. In cases where the body is intact, identification can be accomplished with relative ease with internal and external gender data. However, the process becomes more complex with decomposed corpses, skeletons, and skeletal remains (4). In such cases, anthropometric methods are applied for identification purposes.

The use of anthropometry in identification was first introduced by Bertillon (2,5). Studies have demonstrated that anthropometric measurements vary significantly across different population groups, including among sex groups within the same population (3,6-10). In the field of identification studies pertaining to skeletal remains, sex determination is commonly achieved through the utilization of measurements taken from the pelvis, skull, and long bones (11,12). In the context of natural disasters, plane crashes, explosions, and similar events, especially in cases where only hand remains are found at the scene, these fragments are important as forensic medicine data (13).

Studies conducted to demonstrate the usability of hand measurements in sex determination show that hand measurements can be used in sex determination, although they use different methods (3, 6-10, 13-17).

In this pilot study, three different methods were used to analyze the data with the objective of determining the most successful method in sex determination. Using hand length (HL), hand width (HW), and hand index (HI) values, hand type distribution by sex and sectioning point by sex were calculated. In the last phase of the study, discriminant analysis was performed, and the data obtained from the results of these three analyses were discussed. Furthermore, the secondary purpose of this study is to collect data on hand measurement values in a small sample group in Türkiye.

MATERIAL AND METHOD

Minimum sample size was calculated as 207 participants to evaluate the association between gender and hand type using Pearson chi-square test where the effect size is Cohen's medium effect size w=0.30 with the type I error as α=0,05 and the power of 95% (18).

The study was a pilot study conducted with hand measurements of 221 participants who volunteered from a total of 430 Term I and II students studying at Baskent University Faculty of Medicine and Faculty of Dentistry. The age spectrum ranged from 18 to 30, with a median age of 20.

The participants' dominant hands were identified, and subsequent measurements were obtained from their non-dominant (passive) hands. During the measurement process, considerations were given to ensure the absence of deformities, amputations, or injuries in the participants' hands, as well as the absence of deformations or chronic diseases in the individuals' vertebral structures, arms, and legs.

Using predefined anatomical points, three researchers systematically measured hand length (HL) and hand width (HW) twice using precise digital calipers.

These specified points are defined as follows: HL represents the location where the apex of the middle finger intersects the midpoint of the line formed by the radial and ulnar prominences, while HW signifies the measurement of the distance between the distal ends of the 2nd and 5th metacarpal bones, obtained with the fingers closed.

Statistical Analysis

The statistical analyses were conducted using IBM SPSS Statistics for Windows, Version 23.0 (Armonk, NY: IBM Corp. Released 2015), along with R4.0.4 (19) and R Studio (20). In all statistical analyses, the significance level was set at $p<0.05$.

During statistical analysis, measurements originally recorded in millimeters were converted to centimeters. The Hand Index was computed using the formula "Hand Index = (Hand width/Hand length) × 100," as established by Martin and Saller (21). To determine the sectioning point value distinguishing

Table 1. Intra observer reliability

	Observer 1	Observer 2	Observer 3
Hand Length	0.993 (0.978-0.997)	0.980 (0.953-0.992)	0.974 (0.937-0.989)
Hand Width	0.980 (0.954-0.991)	0.946 (0.875-0.977)	0.965 (0.895-0.987)

between men and women for HL, HW, and HI, the formula "Sectioning point for measurement = (Mean male value + Mean female value) / 2" was applied.

To assess differences in hand measurements between sex groups, the "student's t test" was conducted and mean±standard deviation was presented as descriptive statistics when parametric test assumptions were satisfied. In cases where these assumptions were not met, descriptive statistics were presented as the median (minimum value – maximum value) and the Mann-Whitney U test was used for evaluating group differences in terms of numerical measurements. The Kolmogorov-Smirnov normality test was applied to assess the normality of numerical variable distributions. Additionally, Levene's test was conducted to evaluate the homogeneity of group variances.

The Fisher-Freeman-Halton Exact test was employed to assess the association between hand type categorized based on HI and sex, with frequencies and percentages are presented as descriptive statistics. The evaluation of the correlation between body mass index (BMI) and hand measurements was conducted using the Spearman correlation coefficient, encompassing both an overall assessment and a sex-specific analysis.

The linear discriminant analysis method was employed to assess the sex prediction success of using HL and HW together or combined as HI. In examining the assumption of multivariate normality of the linear discriminant analysis, the bivariate normal distribution adequacy of HL and HW measurements was tested using the Henze-Zirkler multivariate normality test (22); the univariate normal distribution adequacy of HI was examined using the Kolmogorov-Smirnov normality test. The assumption of homoscedasticity, one of the assumptions of linear discriminant analysis, was assessed with Box's M test. Additionally, the presence of multicollinearity was evaluated using Variance Inflation Factors (VIF).

During the study, conducted amidst the Covid-19 epidemic, it was unfeasible to re-engage the same participants. Consequently, the evaluation of reliability (intra-observer reliability) was limited to the assessment of reliability between two measurements taken by each observer from the same participant. For the assessment of intra-observer reliability, intra-class correlation coefficients (ICC) (3,1) were computed, utilizing 23 measurements (69 in total) of HL and HW (refer to Table 1) (23) which indicates that there was a high level of intra-observer reliability for all measurements.

RESULTS

The study was carried out by hand measurements of 221 voluntary students enrolled at Baskent University. Within the participating volunteers, there were 140 females (63.3%), and 81 males (36.7%). The age spectrum ranged from 18 to 30, with a median age of 20.

Given the non-normal distribution of height and weight measurements among the study volunteers, medians were reported. The BMI median stood at 21.48 (15.05-35.91), with height at 172 cm (151-191) and weight at 63 kg (44-107). Examining the Spearman correlation coefficient across all participants revealed a medium to low correlation between BMI and hand measurements (HL=0.316; HW=0.451; HI=0.321) (24). In sex-specific analyses, no significant relationship emerged between BMI and hand measurements in men. For women, there was a low level of significance between BMI and HW and HI (p=0.237 and p=0.219, respectively).

Upon a comprehensive examination of the distribution of HL, HW, and HI means across sex groups in Table 2, a statistically significant difference was observed at the 95% confidence level (p<0.001, p<0.001, p<0.001, respectively).

Table 2. Distribution of measurements by sex

Variables	Sex	Descriptive statistics	p
Hand Length	Female	16.8±0.7	<0.001[a]
	Male	18.3±0.6	
Hand Width	Female	6.3 (8.3-7.4)	<0.001[b]
	Male	7.5 (8.9-8.4)	
Hand Index	Female	43.7±2.2	<0.001[a]
	Male	45.3±1.98	

a. Student's t-test; b. Mann-Whitney U test

Table 3. Distribution of hand types by sex

Hand Types*	**Female**		**Male**		**Total**	
	n	**%**	**n**	**%**	**n**	**%**
Hyperdolichocheir	17	%7.7	0	%0.0	17	%7.7
Dolichocheir	61	%27.6	20	9%	81	%36.7
Mesocheir	52	%23.5	46	%20.8	98	%44.3
Brachycheir	10	%4.5	14	%6.3	24	%10.9
Hyperbrachycheir	0	%0.0	1	%0.5	1	%0.5
Total	**140**	**%63.3**	**81**	**%36.7**	**221**	**100%**

*: Martin and Saller Standard Hand Index range (21) 1. hyperdolichocheir (≤40.9), 2. Dolichocheir (41.0-43.9), 3. Mesocheir (44.0-46.9), 4. brachycheir (47.0-49.9), 5. hyperbrachycheir (≥50.0)

Hand types were ascertained through the computation of the Hand Index (HI) by using the methodology established by Martin and Saller (2, 21). The distribution of hand types by sex was determined (Table 3).

Utilizing the Fisher-Freeman-Halton Exact test ($p<0.001$) to determine whether a statistically significant difference existed in the distribution of hand types by sex, it was established that the hand type distribution significantly differed between sex groups.

In the utilization of hand anthropometry for sex determination, an additional method involves establishing the sectioning point value (2,9,25). In this regard, measurements of HL, HW, and the calculated HI value were conducted to determine the sectioning point for both sexes. For HL (Female 16.82-Male 18.35), SP=17.58 cm; for HW (Female 7.35-Male 8.31), SP=7.83 cm; and for HI (Female 43.72-Male 45.30), SP=44.51. Evaluating the classification performances in the sectioning point analysis,

1. HL sectioning point value accurately classified the sample overall by 86%; females with a rate of 85.7%, males with a rate of 86.4%,
2. HW sectioning point value accurately classified the overall sample by 89.6%; females with a rate of 89.2%, males with a rate of 90.1%,
3. HI sectioning point value accurately classified the sample overall by 63.8%; females with a rate of 63.6% and males with a rate of 64.2%.

These findings indicate that in the context of sex classification by relying only on a single variable, HW is the most reliable variable, achieving an accuracy of 89.6%.

In the subsequent phase of the investigation, the efficacy of hand measurements in sex determination was assessed through discriminant analysis. In the joint evaluation of HL and HW, the assessment of multivariate normality assumption was performed using the Henze-Zirkler normality test within sex groups, yielding p-values of 0.175 for women and 0.767 for men. The homoscedasticity assumption was meticulously examined utilizing Box's M test, yielding a p-value of 0.165 (26). Additionally, an assessment of multicollinearity was conducted through a thorough analysis of variance inflation factor (VIF), with all values observed to be below the threshold of 5. Consequently, all essential prerequisites for discriminant analysis were met.

Table 4. Discriminant analysis by sex

Function and Variables	Function and Coefficients	Standard Coefficients	Group Centroid	Group Centroid Cutoff point	Correct Classification Rate (LOO)
Hand Length* **Hand Width*** **Constant Value***	0.783 1.651 -26.314	0.525 0.643	F: -1.019 M: 1.761	F≤0.371<M	91,90%
Hand Index** **Constant Value ****	0.474 -20.986	1.000	F: -0.275 M: 0.475	F≤0.1<M	63,80%

Note: LOO: Results obtained with the leave-one-out validity method.
*: 1. Discriminant function (number of significant dimensions 1)
D_1=(-26.314)+0.783xHand length (HL)1.651xHand Width (HW)
**: 2. Discriminant function (number of significant dimensions 1)
D_2=(-20.986)+0.474xHand Index (HI)

Given that the hand index (HI) is a ratio derived from HL and HW measurements, its individual efficacy in sex classification was meticulously scrutinized. The normality assumption underwent a rigorous examination through the Kolmogorov-Smirnov normality test with Lilliefors correction (p>0,05). Furthermore, the evaluation of homoscedasticity was conducted using Box's M test, resulting in a p-value of 0.321 (26).

Table 4 provides the discriminant function (DF) equations formulated through the joint utilization of HL and HW (bivariate) and the exclusive application of HI (univariate). The derived functions represent the mathematical expressions employed in the discriminant analysis for sex classification. These,

DF1= constant value + (HL coefficient x HL) + (HW coefficient x HW),

DF2= constant value + (HI coefficient x HI).

Sex can be determined by comparing the discriminant value associated with each observation against the predefined group centroid cutoff point specific to the relevant discriminant function.

Group centroid cutoff points were established as follows:

- For the first discriminant function (bivariate function of HL and HW), it was established as Female ≤ 0.371 < Male, yielding a correct classification rate of 91.9%.
- In accordance with the second discriminant function (HI univariate function), it was established as Female ≤ 0.1 < Male, yielding a correct classification rate of 63.8%.

In order to demonstrate the usability of the method through an example by placing the HL, HW, and HI values of an individual with an unknown sex into our formula derived from discriminant analysis, the sample with measurement values of HL 15.99 cm, HW 6.49 cm and HI 40.59 (%) is placed in the discriminant functions. The results are as follows,

DF1 = -26.314+0.783x15.99+1.651x6.49= -3.08,

DF2 = -20.986 +0.474x40.59 = -1.75.

Through meticulous computation, it was ascertained that the categorization of the individual was determined as "Female". This conclusion is supported by the -3.08 value derived from the joint consideration of HL and HW, and the -1.75 value obtained from the HI function alone—both of which are below their respective group centroid cutoff values.

The standardized coefficients provided in Table 4 represent the standardized canonical discriminant function coefficients, offering insights into the relative significance of independent variables in the classification process. In our investigation, employing HL and HW together in the bivariate discriminant function revealed that the HW value exhibited a more substantial contribution to the classification compared to HL.

In the assessment of the applicability of HL, HW, and HI measurements for sex determination, the classification accuracy table (Table 5) was generated based on the results of discriminant analysis. Upon careful consideration of both the correct classification rates derived from the "Leave-one-out" method

Table 5. Classification accuracy table

1) Hand Length Hand Width		Prediction		
		Female	**Male**	**Total**
Original	**Female**	129 (%92.1)	11 (%7.9)	140 (100%)
	Male	7 (%8.6)	74 (%91.4)	81 (100%)
2) Hand Index		**Prediction**		
		Female	**Male**	**Total**
Original	**Female**	89 (%63.6)	51 (%36.4)	140 (100%)
	Male	29 (%35.8)	52 (%64.2)	81 (100%)

Note:
1. Fisher Discriminant Function:
C_{female}= -349.330+31.075*Hand lenght+23.778*Hand width
C_{male}=-423.505+33.251* Hand length +28.368* Hand width
2. Fisher Discriminant Function:
C_{female}= -215.179+9.812*Hand index
C_{male}= -230.977+10.167* Hand index

Table 6. HL-HW Measurements and HI Values in Other Studies

Studies	Sex	n	HL Mean (mm)	p	HW Mean (mm)	p	HI Mean (mm)	p	Methods
Mandahawi et al. (Jordan) (34)	Male	115	191.2±1.5	<0.001	104.2±10.94	<0.001	-	-	-
	Female	120	171.3±10.2	0.006	93.9±5.63	<0.001	-	-	
Kanchan et al. (North India) (17)	Male	120	199±9	<0.001	79.0±4	<0.001	40.0±1.5	<0.001	Sectioning Point
	Female	100	179±9	<0.001	71.0±3	<0.001	39.5±1.9	<0.001	
Kanchan et al. (South India) (17)	Male	110	199±9	<0.001	80.0±4	<0.001	40.5±1.6	<0.001	Sectioning Point
	Female	170	179±8	<0.001	71.0±3	<0.001	39.7±1.7	<0.001	
Esomonu et al. (Nigeria) (35)	Male	150	190.9±0.7	<0.001	84.3±0.3	0.003	-	-	Hand Types Analyses
	Female	150	176.9±0.7	<0.001	75.8±0.3	<0.001	-	-	
Aboul-Hagag et al. (Egypt) (32)	Male	250	194.95±9.21	<0.001	81.43±3.96	0.001	41.8±1.4	<0.001	Sectioning Point
	Female	250	181.66±9.13	<0.001	71.73±4.07	<0.001	39.5±1.6	<0.001	
Karadayı et al. (Türkiye) (9)	Male	255	192.02±9.5	<0.001	83.41±5.0	0.539	-	-	Sectioning Point & Discriminant Analysis
	Female	155	178.51±7.6	<0.001	75.55±3.8	<0.001	-	-	
Cakit et al. (Türkiye) (37)	Male	92	102.89±5.49	<0.001	77.75±4.71	<0.001	-	-	-
	Female	73	90.08±4.58	<0.001	68.95±3.16	<0.001	-	-	
Dey & Kapoor. (India) (2)	Male	91	192.1±11.3	<0.001	81.7±3.7	0.012	42.63±1.4	<0.001	Hand Types Analyses & Sectioning Point
	Female	91	173.4±10.4	<0.001	74.7±3.8	0.026	43.21±2.63	0.141	
Varu et al. (India) (27)	Male	100	178.0±9.8	<0.001	80.9±6.0	0.003	-	-	Linear Regression Analysis
	Female	100	165.7±8.7	0.019	71.5±4.3	<0.001	-	-	
Bayraktar & Özşahin, (Türkiye) (38)	Male	49	183.9±0.8	0.547	87.5±7.7	<0.001	-	-	Hand Types Analyses
	Female	92	169.7±2.01	0.020	76.3±12.1	0.035	-	-	
Uzun et al. (Türkiye) (39)	Male	112	182.6±13.3	0.526	77.4±11.2	<0.001	-	-	Logistic Regression Analysis
	Female	288	168.6±13.5	0.689	71.2±11.9	0.003	-	-	
Taştan ÖA. (Türkiye) (40)	Male	141	186.18±8.27	0.005	84.35±4.21	0.019	-	-	-
	Female	159	170.08±7.5	0.028	74.64±3.58	0.011	-	-	
Sah & Jeelani. (Nepal) (10)	Male	171	178.5±8.6	<0.001	78.5±5.2	<0.001	43.99±2.1	<0.001	Sectioning Point
	Female	229	169.7±5.6	0.035	68.9±4.5	<0.001	40.61±2.4	<0.001	
Zahor S. (Tanzania) (36)	Male	192	197.66±10.62	<0.001	95.03±5.74	<0.001	48.11±2.32	<0.001	Hand Types Analyses & Sectioning Point
	Female	192	181.39±9.75	<0.001	88.3±0.54	<0.001	48.98±2.61	<0.001	
Kumar et al. (South India) (33)	Male	150	179.8±10.4	0.001	80.9±5.6	<0.001	45.03±2.66	0.383	Sectioning Point
	Female	150	167.4±9.8	0.425	72.6±5.7	0.121	43.38±2.73	0.269	
Yaşar et al. (Türkiye)	Male	81	183.5±5.86		83.1±3.55		45.3±1.98		
	Female	140	168.2±7.14		73.5±4.08		43.7±2.18		

Note: p values show the significance between the data in the literature and the data of our study.

and the classification accuracy table in Table 5, it is evident that the utilization of hand measurements (HL and HW) together enhances the discriminant power, yielding a more robust outcome compared to their individual application (Table 4-5).

DISCUSSION

Forensic medicine experts may encounter challenges when determining sex in unidentified, decomposed, or fragmented corpses and skeletal remains. While DNA analysis has become a prevalent technique in forensic sciences, issues such as sample contamination, insufficient sample quantities, high costs, among others necessitate the consideration of alternative methods in complex cases. Anthropometry stands out as one such method, addressing these challenges.

In the literature, studies have been conducted using hand measurements either independently or in conjunction with anthropometric measurements such as height, weight, finger length, foot measurements, and wrist measurements. The analytical methodologies employed across these studies vary (27-31). A consistent finding reveals the existence of sexual dimorphism in hand measurements, as summarized in Table 6. The prevailing trend indicates larger hand measurements in men compared to women, attributed to earlier bone fusion in women than in men (32,33).

Upon thorough analysis of the data presented in Table 6 (2, 9, 10, 17, 27, 32-40), statistically significant differences in HL, HW, and HI values are evident. These differences extend beyond sex groups within the same population, including variations observed between our study's sample group and diverse populations.

The significant disparities between the outcomes of this preliminary study conducted in Türkiye and those of other sampled populations may be attributed to various factors, including altered dietary practices influenced by environmental or climatic conditions, ethnicity, genetics, lifestyle variances, occupational distinctions, and culture. Our findings substantiate that the using of morphological features and measurements of hands for sex determination necessitates the establishment of population-specific standards (41).

The distribution of hand types by sex, as delineated in our study, aligns with the findings reported in the literature. For instance, in a study conducted in India, the findings revealed that 56% of women exhibited dolichocheir hand type, while men exhibited 41.8% dolichocheir and 29.7% mesocheir (2). In a separate study conducted in Turkey, the hand index values were reported as 47.5 for men and 45.7 for women. The findings indicated that the prevalent hand type for men was brachycheir, whereas for women, it was mesocheir (37). In our study, women exhibited varied hand types, comprising 43.57% dolichocheir, 37.14% mesocheir, and 12.14% hyperdolichocheir, while men demonstrated a distribution of hand types, including 56.79% mesocheir, 24.69% dolichocheir, and 17.28% brachycheir. Fisher-Freeman-Halton Exact test ($p<0.001$), which was performed to ascertain the existence of a statistically significant difference in the distribution of hand types by sex, reveals that there is a significant difference in the distribution of hand types between sex groups. Despite the statistical differences in hand types determined between sex groups in our study, considering variables such as the individual's occupation, age, and medical condition, and the differences observed between populations, using this method alone is not considered reliable.

These data suggest potential variations in hand types among different populations and sex groups within the same society. Nevertheless, aligning with existing evidence, to ensure the reliability of sex determination results, employing integrated methods is deemed more suitable than relying solely on individual methods. In accordance with this perspective, our study utilized discriminant analysis methods in addition to sectioning point analysis.

When evaluating the sectioning point value and examining sample studies conducted on this subject across diverse populations, it becomes evident that the sectioning point value holds significance in sex determination. In a study conducted in Nepal, the HI sectioning point value was determined as 42.30, with the success rate of the HI sectioning point reaching 79.90% in women and 72.5% in men (10). In another study conducted in India, the HL sectioning point value was determined as 17.36 cm, the HW sectioning point value was 7.67 cm, and the HI sectioning point value was 44.20. Examination of the success rates of hand measurements in sex determination revealed that HL was 73% in women and 77% in men, HW was 77.3% in women and 84% in men, and HI was 66.6% in women and 66% in men (33). Consistent outcomes are observed in various studies on this topic (2,17,32,36). In our study, while the accurate sex classification rates based on the HL and HW sectioning point values exceed those of other studies, the classification rates derived from the HI sectioning point align with the data in the literature (Table 6).

Other methodologies utilized in the literature for sex determination through hand measurements include regression and discriminant analysis. For instance, in a study conducted in India, the accuracy of sex classification based on hand measurements, regardless of sex, yielded a correct classification rate of 83.8% for HL, and 65% for HW (42). In a separate study conducted in Mauritius, it was reported that sex determination was achieved at an accuracy rate of 90.4% based on HL and HW measurements (43). In a Korean study, the overall correct classification rate for the sample, regardless of sex, was not provided. However, accurate classification rates were recorded as 76.6% in women and 75.4% in men for HL, and 85.7% in women and 83.2% in men for HW (44). In a study conducted in Turkey, sex classification based on a single variable revealed that HW was the most reliable variable (83.4%), whereas the HL demonstrated the least reliability in sex classification (79.3%). In the same study, it was noted that the most accurate sex classification within discriminant functions employing multiple variables occurred in the binary model of HL and HWW (hand-wrist width) (9). In our study, upon thorough examination of the classification accuracy table (Table 4-5) resulting from the discriminant analysis of HL, HW, and HI values for sex determination, it becomes apparent that the combined application of HL and HW (91.9%) yields a higher degree of success compared to the sole use of HI (63.8%)."

Upon reviewing the studies on this subject, it becomes evident that many studies use only one or two statistical methods. In studies with two different analytical approaches, the success rates of these methods remain undisclosed. In contrast, our study incorporates a more comprehensive approach, using three different statistical methods for sex determination.

The originality of our study is underscored by its systematic comparison of different analysis methods for sex determination through hand measurements, all conducted within the scope of the single study.

CONCLUSION AND RECOMMENDATIONS

In our country, situated within a seismic zone and frequently susceptible to earthquake disasters, the identification of dismembered and decomposed victims extracted from rubble presents a significant challenge. Morphological and metric methodologies are predominantly used for sex determination, a crucial parameter in the identification process, due to their repeatability and objectivity. Although the study results suggest the feasibility of sex determination through hand measurements, it is advisable to supplement the available data with additional sex determination methods, where feasible, to enhance the overall reliability of the identification procedures.

In this study, various statistical methods were used for sex determination based on hand measurements, and their respective success rates were evaluated. Calculations conducted through sectioning point and discriminant analysis revealed that discriminant analysis exhibited greater efficacy in sex determination using hand measurements.

Notwithstanding this outcome, the sole reliance on discriminant analysis for sex determination through hand measurements is constrained by its applicability only to the hand limb. Enhancing the overall reliability of the methodology would be prudent by incorporating complementary anthropometric methods and employing different statistical analyses. Furthermore, although the assessment of hand length in anthropometric measurements is considered reliable for postmortem sex determination, the measurements, including our study, were obtained from living individuals. Therefore, it is useful to be careful when using these measurements in cases where there are significant changes in individuals after death.

The data derived from this study suggests the necessity for further research aimed at establishing standardized measurement values on a country-specific basis.

Contribution to the Field

This study confirms the substantial variation in hand measurements across different populations. Our preliminary study, conducted to scrutinize the reliability of methods by using different statistical analyses within a methodological framework, aims to contribute to the establishment of a database encompassing population-specific standard values that derived from the determined method, thereby contributing to the forensic sciences.

Ethical Aspects of the Research

This study was approved by Baskent University Institutional Review Board (Project no: KA19/435) on 20/09/2023 and supported Baskent University Research Fund.

The study was conducted in accordance with the ethical standards of the National Research Ethics Board and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Informed written consent for voluntary participation was obtained from each participant involved in the study.

Ethics approval and consent to participate: *The study was approved by the Baskent University Institutional Review Board Ethics Committee (date and number 20.09.2023 / KA19/435*

Competing interests: *No competing interests are declared by the authors.*

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