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Reliability of the Sternal Index as a sex indicator in medieval skeletal remains from Northeastern Bulgaria

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ABSTRACT

The aim of the present study is to assess the applicability of the Hyrtl's law for sex determination in medieval skeletal remains from Bulgaria. According to the Hyrtl's law, the sternal index is less than 50% in males and more than 50% in females. The study was performed on osteological material from medieval necropolises in Northeastern Bulgaria. Sex was previously determined by standard anthropological features. A total of 76 sterna (47 male and 29 female) were included in the present study. The lengths of manubrium and mesosternum were measured and the sternal index was calculated. In the present study, Hyrtl's law was obeyed by 46.8% of male and 79.3% of female specimens. Although the sternal index showed an obvious statistically significant sexual difference, there was a considerable overlapping among the male and female values. Therefore, the Hyrtl's law could not be considered as a helpful and reliable indicator for sex determination in medieval skeletal remains from Bulgaria.

Key words: sternum, sex determination, sternal index, Hyrtl's law

Introduction

The sternum as a sex and age indicator has been studied by various authors. Wenzel (1788) was the first to describe a sexual difference in the ratio between the lengths of the manubrium and the mesosternum. Wenzel noted that the length of manubrium is almost equal in both sexes, but the length of mesosternum is proportionally greater in the male sterna than the female ones. This statement was supported by Hyrtl (1878), Strauch (1881), and Dwight (1890). Hyrtl's law was formulated as "the manubrium of the female sternum exceeds half the length of the body, while the body in the male sternum is, at least, twice as long as the manubrium"; and therefore, the Sternal Index (manubrio-corporis index) is less than 50% in males and more than 50% in females. Although this law is considered as a rule, there are many more recent studies, conducted in different population groups, which have proved its unreliability in sex estimation (Jit et al., 1980; Dahiphale et al., 2002; Hunnargi et al., 2009; Ramadan et al., 2010; Bongiovanni & Spradley, 2012).

The aim of the present study is to assess the applicability

of the Hyrtl's law for sex determination in medieval skeletal remains from Bulgaria.

Materials and Methods

The study was performed on osteological material from medieval necropolises in Northeastern Bulgaria. Sex was previously determined by standard anthropological features of the skull and bones of the postcranial skeleton. A total of 76 sterna (47 male and 29 female) were included in the present study. The lengths of manubrium and mesosternum were measured according to the definitions by Martin and Saller (1957). The sternal index was calculated, as it is derived by dividing the length of manubrium by the length of mesosternum and multiplying it by 100. Standard descriptive statistics were calculated. The independent-sample t-test was used to determine the statistical significance of the sexual differences in the sternal features. Hyrtl's law was applied and the number of male and female sterna obeying the law was analyzed.

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Results

The results of the descriptive statistics are presented in Table 1. Both lengths showed significantly higher values in male sterna than in female ones.

The mean value of sternal index was higher in female sterna. Although the sternal index showed an obvious statistically significant sexual difference, there was considerable overlapping among the male and female values. In this study 80.9% of male and 100% of female sterna lied within the range of overlapping zone.

Concerning the Hyrtl's law applicability, in the present study 46.8% of male and 79.3% of female sterna obeyed the Hyrtl's law.

Discussion

The skeleton remains revealed in archaeological excavations are often limited or fragmented, which makes every single bone of great importance for determination of the sex and age. However, it should be noticed that sexual dimorphism in bones is population-specific, which means that one method for sex determination could be applicable to one group, but without good results in other one. Many researchers have studied the sternum in order to prove its usage as an indicator of sex in different populations (Dwight, 1881, 1890; Ashley, 1956; Narayan & Varma 1958; Rother et al., 1975; Jit et al., 1980; Stewart & McCormick, 1983; Teige, 1983; McCormick et al., 1985; Mall et al., 1991; Dahiphale et al., 2002; Gautam et al., 2003; Torwalt & Hoppa, 2005; Hunnargi et al., 2009; Osunwoke et al., 2010; Ramadan et al., 2010; Bongiovanni & Spradley, 2012). Analyzing sternal measurements in different population groups, Bongiovanni and Spradley (2012) concluded that, in general, the sterna from East African and Indian populations are smaller than the sterna from European and American (US and Canadian) populations.

Our results showed that both lengths of manubrium and mesosternum demonstrate significant sexual differences, which endorses most of the previous studies conducted on dry sterna (Jit et al., 1980; Dahiphale et al., 2002; Selthofer et al., 2006; Macaluso, 2010; Singh et al., 2010; Adhvaryu et al., 2013; Singh & Pathak, 2013; Kaneriya et al., 2013), radiographs (Stewart & McCormick, 1983; Torwalt & Hoppa, 2005) or CT scans (Ramadan et al., 2010; Franklin et al., 2012). As a whole, the length of mesosternum showed bigger differences in comparison with the other population groups, especially with Indian ones, in which the mesosternum is much shorter (Jit et al., 1980; Dahiphale et al., 2002; Gautam et al., 2003; Hunnargi et al., 2009), while the means of the manubrium length were comparatively nearer to these of the other studies. The absolute difference between the lengths of mesosternum in the male and female sterna was 19.4 mm. The mean difference between the lengths of manubrium in both sexes was 6.4 mm, which is much greater than the differences reported by Strauch (1881) and Dwight (1890), who found that the variation in the length of manubrium is very slight.

The sternal index means and the applicability of the Hyrtl's law recorded by various authors are presented in Table 2. In the Indian populations, the percentage of female sterna obeying the Hyrtl's law is significantly higher than this of male sterna, while the percentage of sterna obeying the Hyrtl's law in the European, African and American samples is similar in both sexes with a slight prevalence of the female ones. Moreover, the male sterna obeying the law in Indian groups show relatively lower percentage in comparison with the other investigated groups, but in the female sterna it is much higher. Our results indicated better sex determination by Hyrtl's law in the female sterna, which is observed by all cited authors, excepting Bongiovanni & Spradley (2012).

Table 1. Descriptive statistics of sternal variables in both sexes.

Variables	Male (n = 47)			Female (n = 29)			p-value
	Mean	SD	Range	Mean	SD	Range	
Length of manubrium	53.7	5.1	45 – 64	47.3	3.6	41 – 55	0.000
Length of mesosternum	107.5	10.9	88 – 134	88.1	8.7	69.5 – 107	0.000
Sternal Index	50.4	6.8	34.5 – 68.5	54.0	5.3	44.0 – 67.1	0.012

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Table 2. Sternal index means and applicability of the Hyrtl's law by various authors.

Author(s)	Sex	Number of specimens	Sternal index mean %	% obeying the Hyrtl's law
Dwight (1890)	♂	142	-	59.1
Americans	♀	86	-	60.4
Bongiovanni & Spradley (2012)	♂	92	48.4	61.0
North American whites and blacks	♀	36	53.7	55.6
Franklin et al. (2012)	♂	93	48.0	-
Western Australians	♀	94	54.3	-
Ashley (1956)	♂	85	-	64.7
Africans	♀	13	-	69.2
Macaluso (2010)	♂	123	49.5	-
Black South Africans	♀	83	54.4	-
Narayan & Verma (1958)	♂	126	54.8	34.1
Indians	♀	27	59.0	81.5
Jit et al. (1980)	♂	312	55.5	31.1
North Indians	♀	88	61.8	88.6
Dahiphale et al. (2002)	♂	96	52.0	52.2
Western Indians	♀	47	63.0	100
Hunnargi et al. (2009)	♂	75	59.2	18.7
Western Indians	♀	40	63.3	95.0
Singh et al. (2010)	♂	252	56.1	-
North Indians	♀	91	61.2	-
Kaneriya et al. (2013)	♂	27	55.0	37.0
Indians	♀	23	63.0	95.7
Adhvaryu et al. (2013)	♂	45	53.7	31.1
Western Indians	♀	55	56.7	81.8
Ramadan et al. (2010)	♂	203	54.1	34.0
Turks	♀	143	59.8	86.0
Ashley (1956)	♂	378	-	52.9
Europeans	♀	171	-	69.3
Present study	♂	47	50.4	46.8
	♀	29	54.0	79.3

The results of Macaluso (2010) and Franklin et al. (2012), which have investigated sterna in a South African population and in a Western Australian population respectively, show that the male and female means of the sternal index correspond to Hyrtl's law. Similar mean values are obtained in American sterna by Bongiovanni and Spradley (2012). All results for the Asian population groups show significant aberration from the Hyrtl's law.

Dwight (1881) noticed that the Hyrtl's law is confirmed

for the "mean" sternum, but not for the individual one. Hunnargi et al. (2009) also concluded that the applicability of Hyrtl's law in sex determination is limited. Our results showed that neither the mean values of the sternal index, nor the individual ones, because of the overlapping range of values, conform to the Hyrtl's law. But yet among the different population groups, the mean values of the sternal index in our study hold an intermediate position. Considerable

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overlapping in the sternal index values in both sexes (over 95%) is observed by Jit et al. (1980), Hunnargi et al. (2009) and Singh et al. (2010), as well as such an overlapping but only in females is established by Dahiphale et al. (2002) and Kaneriya et al. (2013).

It is obvious that the morphology of sternum shows population differences, which suggests the need of more studies in various population groups in order to research its population variability. The population specificity in sternal dimorphism most likely due to a combination of genetic, environmental and socio-cultural factors (Macaluso, 2010).

Conclusion

Our results showed that neither the mean values of the sternal index, nor the individual ones, because of the considerable overlapping in the male and female values, conform to Hyrtl's law. Moreover, the Hyrtl's law was obeyed by 46.8% of male and 79.3% of female specimens. Therefore, it could not be considered as a helpful and reliable indicator for sex determination in medieval skeletal remains from Bulgaria.

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