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OSTEOMETRICAL ASSESSMENT OF WITHERS HEIGHT AND SEX DETERMINATION OF BYZANTINE CATTLE FROM METACARPALS (THE THEODOSIUS HARBOUR AREA, ISTANBUL)

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ABSTRACT

In this research, a total of 186 metacarpal and 275 metatarsal bones were used from the 4739 bovine bones which were collected from the Yenikapi Metro and Marmaray excavation of the port of Theodosius in Istanbul. The bovine bones were investigated by radiocarbon (14C) dating, and the cattle bones between Early Byzantine (4th-7th centuries) to Late Byzantine (15th century). A total of 16 osteometric measurements were taken from each metapodial. When the withers height was estimated according to the Matolcsi multipliers without regard to the gender differences of the metapodial bones, it was observed that they varied between 120.97 and 123.52 cm on average. The presence of individuals with withers heights ranging from 103.45 to 148.10 cm suggests the existence of improved cattle breeding to obtain larger animals as well as steer cattle. The wide interval scale of the withers heights seen in the Byzantine cattle suggests that Roman animal breeding was still an influence in this period. However, the presence of small-size cattle in the port area of Theodosius also suggests the presence of smaller, local individuals.

KEYWORDS: Withers height, Cattle, Metacarpal, Metatarsal, Theodosius harbour, Byzantine period

1. INTRODUCTION

Cattle skeletal remains have been the most abundant animal bone remains in most sites since the Neolithic Period (De Cupere et al., 2000). Archaeozoological studies show that these animals were used in a multipurpose manner; exploited for meat, milk and labor (Bartosiewicz et al., 1997; Luff, 1993; De Cupere and Waelkens, 2002; Groot, 2005; Koepke and Baten, 2007; Telldahl, 2005). They were probably primarily kept for meat, with other products, such as labor, milk and fertilizer, as secondary uses (Groot, 2008). These animals were probably the first large animal to be used for laboring (Davis, 1987). For this purpose, they would have been mainly trained for their physical strength and appearance (De Cupere, 2001).

Although the domestication of species brought morphological changes, there is no general consensus on the change of size that would be expected (O'Connor, 2008). Environmental impacts such as climate change are also a factor for some species (Davis, 1981), compounded by the significant impact of selective animal breeding in later periods (eg the Roman period) (Groot, 2008). One way of examining the intensity of production and increasing meat needs in past societies is to look at changes in withers height (Groot, 2008), which has been one of the most common ways for describing the size of livestock animals (Reitz and Wing, 2008). Withers heights of cattle has generally been shown to increase through time, particularly in the Roman period (Groot, 2008). Larger size cattle were of great importance both in terms of work force and meat production. Previous research has largely focused on them as a labor force (De Cupere, 2001). However, size is also determinative of weight and thus the potential production of meat from the animals (O'Connor, 2008). Changes in sex ratios of assemblages may also affect the withers height distribution.

Sexual dimorphism in size is observed in most mammals, with males generally being bigger than females (Davis, 1987). This dimorphism provides a great opportunity to estimate the sex ratio from archaeological bone assemblages for livestock animals such as cows and goats (Davis, 1987). However, the existence of steer animals in assemblages makes this problematic (Davis, 1987). Their inclusion makes it very difficult to see dimorphism in these assemblages, however this can be overcome by evaluating the proportional dimensions of the bones (Johnstone, 2004). This is because castration is likely to delay epiphyseal closure in long bones. This allows for extended longitudinal development and thus, the long bones of these animals become comparatively long and thin (Davis, 1987).

Morphological data has been an important tool for archaeologists in defining animal populations. Estimating the shoulder height from an archaeological animal is of great benefit in terms of assessing visual morphology. It is known that the length of the long bones is closely related to the height of an animal. Therefore, one of the most important methods for estimating withers heights is the use of osteometric measurements (O'Connor, 2008).

Withers heights of archaeological animals can be estimated using different formulas (Forest, 1998; Reitz and Wing, 2008). However, these different shoulder height formulas do not give similar results when used on archaeological bones (Bartosiewicz, 1995, Reitz and Wing, 2008). It has been noted that there are some problems in relation to the ratio of the forelimb and hindlimb for the calculation of shoulder height (Peters, 1998). It has been reported that some pre/early historical animals and modern animals (e.g. horses) do not have similar leg ratios and this may have affected the calculations of withers heights (Johnstone, 2004). However, the withers height is an important factor in terms of defining animal populations. This is because the withers height enables a direct comparison of the measurements from different skeletal elements and provides an idea of the height of the living animal without relying on simple bone measurements. When measurements obtained from different bones are converted to the withers height, it allows them to be evaluated as a single example (O'Connor, 2008).

In cattle, the withers heights (Boessneck, 1956; Fock, 1966; Matolcsi, 1970) and sex ratio (Boessneck, 1956; Higham, 1969; Howard, 1963; Kostov and Tsandev, 2014; Matolcsi, 1970; Nobis, 1954; Telldahl et al., 2012; Zalkin, 1960) estimations have generally been undertaken by using metapodial measurements. The formulas represent a relationship between a specific bone lengths - which were obtained by using analogue data from modern specimens - and their withers height (O'Connor, 2008). The measurements are combined with a number of different multiplier such as that presented by von den Driesch and Boessneck (1974).

In this study, the sex ratio and withers height estimations were calculated from cattle metapodial bones of the Byzantine period [between Early Byzantine (4th-7th centuries) to Late Byzantine (15th century)] Yenikapi Theodosius harbor area (Onar et al., 2008a), which is now the main station of the Metro Rail System and Marmaray tube crossing. The size change between Byzantine cattle and the cattle remains from different periods was evaluated and as a result the influence of selective cattle breeding in the

Byzantine period was revealed. In our previous research (Onar et al., 2015), the study of pathologies indicates that these animals were used for labour. This study presents the sex structure and withers heights of these animals. By this, the effects of production and aims on gender and withers height which were preferred during the Byzantine period according to the labour and meat demands could be understood. In order to contribute this outcome, the differentiation in cattle dimensions during the Roman period and its reflections of such applications during the Byzantine period were tried to be determined osteometrically.

2. MATERIALS AND METHODS

In this research, cattle metapodial bones which were recovered from the Istanbul Yenikapi Metro and Marmaray excavation of the Theodosius Harbor were investigated. The excavation began in 2004 and was completed in 2013. Post-excavation work on what was recovered ongoing. The lengths of 186 metacarpals and 275 metatarsals from the total of 4739 bovine bones that were recovered (Onar et al., 2015) were measured. Sixteen osteometric measurements were obtained from each metapodial (von den Driesch, 1976).

Osteometric measurements of the metapodia

GL: Greatest length
Bp: Width of proximal end
Dp: Depth of proximal end
SD: Smallest width of diaphysis in the medio-lateral axis
d: Mid-shaft width of diaphysis
e: Mid-shaft depth of diaphysis in the dorso-palmar axis
Bd: Width of distal end
Be: Greatest width of metaphysis in the medio-lateral axis
De: Greatest depth of metaphysis in the dorso-palmar axis
Dd: Depth of distal end
DIM: Antero-posterior diameter of the internal trochlea of the medial condyle
DEM: Antero-posterior diameter of the external trochlea of the medial condyle
DIL: Antero-posterior diameter of the internal trochlea of the lateral condyle
DEL: Antero-posterior diameter of the external trochlea of the lateral condyle
WCM: Medio-lateral width of the medial condyle
WCL: Medio-lateral width of the lateral condyle

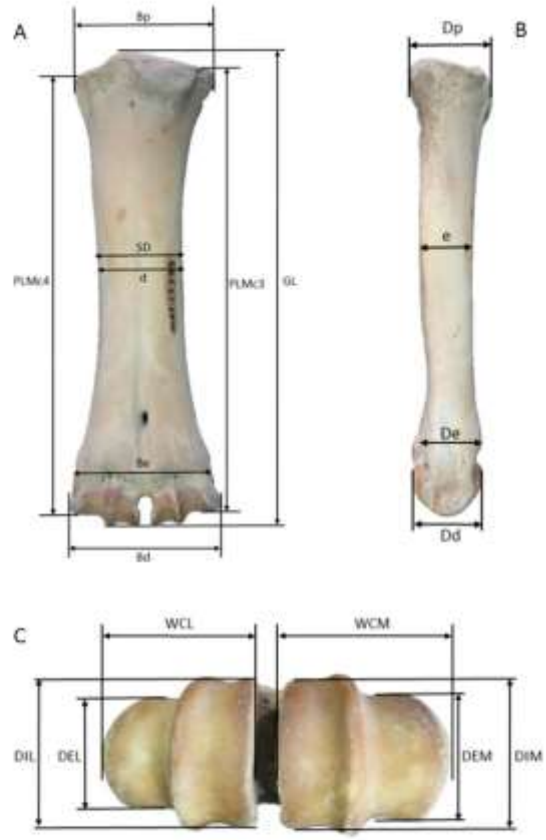

Figure 1. Osteometric measurements of the cattle metacarpal. A.Dorsal view, B. Lateral view, C. Distal view

The index calculations were undertaken using these osteometric measurements.

Indeks 1(Slenderness index) = SD/GL*100 (Berteaux and Guintard, 1995; Davis, 2000; Guintard, 1998, Howard, 1963; Onar et al., 2008b; Pazvant et al., 2015)

Indeks 2= Bp/GL*100 (Nobis, 1954; Zalkin, 1960)

Indeks 3= Bd/GL*100 (Howard, 1963)

Nobis's (1954) index scale was used for the assessment of sex from the metapodial bones with the aim of separating male, female and steers. Withers heights were then the estimated using metapodial multipliers from a number of researchers (Boessneck, 1956; Fock, 1966; Matolcsi, 1970; Zalkin, 1960), as noted by von den Driesch and Boessneck (1974).

3. RESULTS

The sixteen osteometric measurements that were obtained from the metapodial bones are presented in Tables 1 and 2. The measurements are grouped by sex based on the Nobis's index calculation scale Bp/GL*100 (index 1) value (Tables 3 and 4).

It was observed that the difference in GL (Greatest Length) measurements of the metacarpal bones between male, and female and steer animals was not statisically significant. However, the difference between female and steers was statistically significant at P <0.05 (Table 1). The same result was found for the estimation of withers heights (which were obtained from the GL measurements), which were calculated using four different multipliers (Matolsci, 1970; Boessneck, 1956; Fock, 1966 and Zalkin, 1960). There were also some statistical significances between the sexes (female, male, and steer) in terms of other osteometric measurements (SD, d, Bd, DEM, WCM, and WCL) of the metapodial bones. There was a significant difference (P<0.05) between female and steer animals while there were no significant differences observed between male and steer individuals.

According to the calculation of the Nobis index (Bp/Gl*100), one male individual was identified from the metatarsals. For this reason, males could not be properly compared. The difference between the mean values of the metatarsals of females and steers was significant at P <0.05 level when a Student-T test was applied (Table 2). A similar result was found for the withers height estimations which were calculated using the metatarsal GL measurements using 4 different multipliers (Matolsci, 1970; Boessneck, 1956; Fock, 1966 and Zalkin, 1960).

Overall, there were significant differences in measurements according to sex for both the metacarpal and metatarsal (P<0.05). However, the difference between female and steer individuals was essential, as there was only on measurable male metatarsal bone.

Table 1. Osteometric measurements of the metacarpus

Metacarpus		**Osteometric measurements (mm)**															
Sex	**Statistical**	**GL**	**Bp**	**Dp**	**SD**	**d**	**e**	**Bd**	**Be**	**De**	**Dd**	**DIM**	**DEM**	**DIL**	**DEL**	**WCM**	**WCL**
Female	N	133	132	132	132	132	133	130	130	131	129	132	132	128	130	131	128
	Mean	196.54[a]	53.80[a]	32.87[a]	29.14[a]	29.31[a]	22.05[a]	55.04[a]	50.85[a]	27.46[a]	29.67[a]	27.48[a]	24.54[a]	27.90[a]	22.39[a]	26.30[a]	25.54[a]
	SD	13.60	4.49	3.27	2.94	3.02	1.95	4.88	4.50	2.12	2.53	2.43	2.13	2.45	1.98	2.42	2.30
	Minimum	171.56	44.94	27.54	24.28	22.37	18.26	47.46	41.03	22.92	23.97	20.96	19.72	22.43	18.44	22.19	21.88
	Maximum	241.62	65.55	49.51	40.16	41.01	29.48	70.57	66.73	32.99	38.40	34.07	31.32	35.18	27.94	33.20	32.97
Male	N	20	19	20	20	20	20	17	19	20	18	17	17	18	19	16	18
	Mean	201.36[ab]	64.10[b]	38.63[b]	36.54[b]	36.83[b]	25.37[b]	66.76[b]	59.65[b]	30.75[b]	33.99[b]	31.49[b]	28.40[b]	32.12[b]	25.43[b]	32.55[b]	31.35[b]
	SD	9.38	3.77	3.03	2.54	2.53	1.75	3.67	2.88	1.96	2.04	2.15	1.71	2.17	1.81	2.18	2.05
	Minimum	179.46	55.39	31.72	31.81	31.99	22.48	57.30	53.59	27.29	29.29	27.81	25.12	27.94	21.77	27.58	26.33
	Maximum	225.54	73.34	45.34	41.14	41.40	29.02	74.04	65.56	35.40	38.32	35.38	31.29	35.79	29.20	36.33	35.56
Ox?	N	33	33	33	33	33	33	32	32	32	32	33	33	31	32	33	30
	Mean	205.35[b]	62.58[b]	37.56[b]	34.30[c]	34.58[c]	24.53[b]	62.97[c]	57.74[b]	30.15[b]	33.29[b]	31.01[b]	27.29[c]	31.58[b]	25.15[b]	30.19[c]	29.24[c]
	SD	10.53	3.00	2.69	2.34	2.36	1.50	2.87	3.28	1.89	2.08	1.80	1.56	1.90	1.52	1.57	1.55
	Minimum	185.84	56.55	30.05	30.26	30.76	20.55	56.58	52.04	26.49	27.80	26.65	24.24	26.86	21.53	26.77	26.14
	Maximum	233.90	70.12	43.14	41.72	41.90	27.86	69.25	67.19	33.67	37.81	34.34	30.53	35.40	29.04	34.09	32.32
Total	N	186	184	185	185	185	186	179	181	183	179	182	182	177	181	180	176
	Mean	198.62	56.44	34.33	30.86	31.06	22.85	57.57	52.99	28.29	30.75	28.49	25.40	28.97	23.20	27.57	26.77
	SD	13.13	5.94	3.90	3.94	4.02	2.25	6.15	5.40	2.45	2.97	2.83	2.45	2.91	2.28	3.12	2.99
	Minimum	171.56	44.94	27.54	24.28	22.37	18.26	47.46	41.03	22.92	23.97	20.96	19.72	22.43	18.44	22.19	21.88
	Maximum	241.62	73.34	49.51	41.72	41.90	29.48	74.04	67.19	35.40	38.40	35.38	31.32	35.79	29.20	36.33	35.56

[a,b,c]: Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 2. Osteometric measurements of the metatarsus

Metatarsus		Osteometric measurements (mm)															
Sex	**Statistical**	**GL**	**Bp**	**Dp**	**SD**	**d**	**e**	**Bd**	**Be**	**De**	**Dd**	**DIM**	**DEM**	**DIL**	**DEL**	**WCM**	**WCL**
Female	N	244	239	237	243	242	243	240	242	233	236	232	239	235	239	237	237
	Mean	230,17[a]	45,59[a]	43,36[a]	26,23[a]	26,62[a]	27,24[a]	53,03[a]	49,94[a]	29,18[a]	30,18[a]	27,39[a]	23,85[a]	28,69[a]	21,74[a]	25,18[a]	24,28[a]
	SD	14,54	4,54	4,09	3,10	3,22	2,70	5,34	4,99	2,59	2,69	2,52	2,12	2,71	2,03	2,64	2,48
	Minimum	194,72	26,12	33,76	20,59	20,91	21,72	43,55	38,42	22,67	23,44	22,00	18,37	22,32	16,58	20,07	18,91
	Maximum	266,04	55,77	53,85	34,87	36,38	34,46	65,00	60,72	36,23	37,55	33,87	30,35	36,54	26,93	32,63	30,08
Male	N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mean	208,12	50,12	46,77	29,25	29,52	28,91	56,58	50,06	28,51	30,79	27,88	25,71	29,21	22,44	26,68	25,97
	SD																
	Minimum	208,12	50,12	46,77	29,25	29,52	28,91	56,58	50,06	28,51	30,79	27,88	25,71	29,21	22,44	26,68	25,97
	Maximum	208,12	50,12	46,77	29,25	29,52	28,91	56,58	50,06	28,51	30,79	27,88	25,71	29,21	22,44	26,68	25,97
Ox?	N	30	30	29	30	30	30	30	29	30	30	29	30	30	30	30	30
	Mean	238,64[b]	53,62[b]	49,53[b]	30,70[b]	31,03[b]	31,73[b]	61,20[b]	56,83[b]	32,16[b]	33,74[b]	30,97[b]	26,49[b]	31,48[b]	24,06[b]	29,11[b]	27,94[b]
	SD	20,97	4,14	5,21	2,94	2,88	2,96	4,73	5,19	3,44	3,14	3,19	2,65	3,80	2,32	2,21	2,15
	Minimum	196,75	44,22	33,07	25,68	26,17	25,78	51,44	47,28	24,04	25,50	23,83	20,27	23,05	19,17	24,32	23,31
	Maximum	270,75	62,68	58,62	36,45	36,96	36,45	69,24	69,16	38,06	38,70	36,51	30,71	37,11	28,69	32,42	31,59
Total	N	275	270	267	274	273	274	271	272	264	267	262	270	266	270	268	268
	Mean	231,01	46,50	44,04	26,73	27,11	27,74	53,95	50,67	29,52	30,58	27,79	24,15	29,00	22,00	25,62	24,69
	SD	15,58	5,15	4,63	3,37	3,46	3,06	5,85	5,43	2,85	2,95	2,82	2,33	2,97	2,19	2,87	2,70
	Minimum	194,72	26,12	33,07	20,59	20,91	21,72	43,55	38,42	22,67	23,44	22,00	18,37	22,32	16,58	20,07	18,91
	Maximum	270,75	62,68	58,62	36,45	36,96	36,45	69,24	69,16	38,06	38,70	36,51	30,71	37,11	28,69	32,63	31,59

[a,b]: Means in the same column with different superscripts are significantly different ($P<0.05$)

The index calculations and estimations of the withers heights are presented in Table 2 and 3, grouped by sex. The sex determination of the metapodial bones was undertaken using the Nobis index (Bp/GL*100) value.

Table 3. Calculation of withers height and indices according to metacarpal measurements

Metacarpus		Withers height				Indices		
Sex	**Statistical**	**Matolcsi 1970**	**Boessneck 1956**	**Fock 1966**	**Zalkin 1960**	**SD/GL*100**	**Bp/GL*100**	**Bd/GL*100**
Female	N	133	133	133	133	132	132	130
	Mean	118.52^{a}	124.02^{a}	117.93^{a}	117.53^{a}	14.84^{a}	27.38^{a}	28.06^{a}
	SD	8.20	8.58	8.16	8.14	1.09	1.27	1.66
	Minimum	103.45	108.25	102.94	102.59	11.90	24.54	23.81
	Maximum	145.70	152.46	144.97	144.49	18.35	29.85	31.99
Male	N	20	20	20	20	20	19	17
	Mean	127.46^{b}	135.12^{b}	125.85^{b}	125.65^{b}	18.14^{b}	31.89^{b}	33.02^{b}
	SD	5.93	6.29	5.86	5.85	0.89	0.85	0.87
	Minimum	113.60	120.42	112.16	111.98	16.74	30.51	31.38
	Maximum	142.77	151.34	140.96	140.74	19.97	33.55	34.69
Ox?	N	33	33	33	33	33	33	32
	Mean	126.91^{b}	133.68^{b}	125.78^{b}	125.47^{b}	16.70^{c}	30.48^{c}	30.63^{c}
	SD	6.51	6.86	6.45	6.44	0.73	0.47	0.95
	Minimum	114.85	120.98	113.83	113.55	14.77	29.76	29.02
	Maximum	144.55	152.27	143.26	142.91	17.88	31.57	32.49
Total	N	186	186	186	186	185	184	179
	Mean	120.97	126.93	120.17	119.81	15.53	28.40	28.99
	SD	8.61	9.29	8.43	8.43	1.53	2.02	2.21
	Minimum	103.45	108.25	102.94	102.59	11.90	24.54	23.81
	Maximum	145.70	152.46	144.97	144.49	19.97	33.55	34.69

[a,b,c:] Means in the same column with different superscripts are significantly different ($P<0.05$)

Table 4. Calculation of withers height and indices according to metatarsal measurements

Metatarsus		Withers height				Indices		
Sex	**Statistical**	**Matolcsi 1970**	**Boessneck 1956**	**Fock 1966**	**Zalkin 1960**	**SD/GL*100**	**Bp/GL*100**	**Bd/GL*100**
Female	N	244	244	244	244	243	239	240
	Mean	122.68^{a}	129.58^{a}	123.14^{a}	122.91^{a}	11.39^{a}	19.80^{a}	23.04^{a}
	SD	7.75	8.18	7.78	7.76	1.00	1.34	1.60
	Minimum	103.79	109.63	104.18	103.98	9.28	11.57	19.46
	Maximum	141.80	149.78	142.33	142.07	15.54	22.39	27.80
Male	N	1	1	1	1	1	1	1
	Mean	116.96	124.87	115.51	116.13	14.05	24.08	27.19
	SD	-	-	-	-	-	-	-
	Minimum	116.96	124.87	115.51	116.13	14.05	24.08	27.19
	Maximum	116.96	124.87	115.51	116.13	14.05	24.08	27.19
Ox?	N	30	30	30	30	30	30	30
	Mean	130.54^{b}	138.77^{b}	130.06^{b}	130.30^{b}	12.88^{b}	22.50^{b}	25.71^{b}

	SD	11.47	12.19	11.43	11.45	0.89	0.76	1.45
	Minimum	107.62	114.41	107.23	107.43	10.90	20.93	22.57
	Maximum	148.10	157.44	147.56	147.83	14.73	23.66	28.97
Total	N	275	275	275	275	274	270	271
	Mean	123.52	130.57	123.87	123.69	11.56	20.11	23.35
	SD	8.56	9.14	8.51	8.54	1.10	1.56	1.80
	Minimum	103.79	109.63	104.18	103.98	9.28	11.57	19.46
	Maximum	148.10	157.44	147.56	147.83	15.54	24.08	28.97

[a,b]: Means in the same column with different superscripts are significantly different (P<0.05)

When the sex of the metapodial bones was determined according to the Nobis index scale, the calculations from the metacarpal bones found that 71.74% were female, 10.33% were male, and 17.93% were steer, and the calculations from the metatarsal bones found that 88.52% were female, 0.37% were male and 11.11% steer (Table 1 and 2).

When wither heights was calculated there were differences in the resulting estimations depending on the multipliers (Boessneck, 1956; Zalkin, 1960; Fock, 1966; Matolcsi, 1970) and whether metacarpal or metatarsal measurements were used. The averages of the metacarpal estimations ranged between 117.53cm and 118.52cm for females, between 125.65 and 127.46 for males, and between 125.47cm and 126.91cm for steers, depending on the multiplier (Fock, 1966; Matolcsi, 1970; Zalkin, 1960), excluding the formula used by Boessneck (1956). The results of the calculations from the metatarsal (Fock, 1966; Matolcsi, 1970; Zalkin, 1960) were between 122.68 and 123.14 cm for females and between 130.06 and 130.54 for steer, again excluding the formula used by Boessneck (1956). According to the Nobis index scale, there was only one metatarsal which belonged to a male, which had a withers height ranging from 115.51 to 116.96cm. The highest estimations of withers height were obtained by using the Boessneck's (1956) multipliers, which are higher than those multipliers from other researchers (Fock, 1966; Matolcsi, 1970; Zalkin, 1960). This estimation of withers height was also calculated in order to allow comparison with cattle data from other archaeological sites.

The index values calculated in this research provide information on both the sex (index 2 and 3) and the morphological characteristics of the cattle (index 1). In particular, index 1 (slenderness index) is an indicator of robustness and shows whether an individual has thin or more robust bones relative to its withers height. In general, for the index 1 formula (SD/GL*100) of the metapodial bones, values were lower for all the females compared to males and steers (Table 3 and 4). This shows that the bones of female individuals were thinner and more delicate in structure. The average value of this index for steer was between the average of male and female metatarsal and metacarpal bones. According to the wither height values calculated from the metacarpals, the height of the male and steer individuals are similar. However, the metacarpal slenderness index (index 1) is greater for male individuals than steer. There was not a sufficient number of metatarsal slenderness index (index 1) values for comparison, as there was only one male bone available for measurement. This male individual had a relatively small structure when compared with other female individuals according to the size of the metatarsal. While the epiphyseal fusion of the animal was complete, the animal was possibly still relatively young. Index 3 (Bd/GL*100) allows the sex of individuals to be determined. However, in this research it was found that the difference between male/female/steer was not enough to allow determination of individual sex. As a result, Nobis index scale (Bp/GL*100) was used in this research.

When the withers height was estimated according to the Matolsci multipliers without regard for sex differences in the metapodial, the average of the calculations varied between 120.97cm and 123.52cm. The presence of individuals with a minimum of height ranging between 103.45cm and 148.10cm, suggests the presence of small and large sized cattle. However, the presence of steer animals in this range should not be forgotten. In many archaeozoological studies, the estimations were made according to Boessneck (1956) multipliers, calculations of which are also given in this study (Table 3 and 4).

4. DISCUSSION

The relationship between body size and individual bones is important for evaluating biological parameters of animal populations (Reitz and Wing, 2008). In archaeozoological literature, these evaluations generally use wither heights (Rehazek and Nussbaumer, 2012). The shoulder height calculations are made by using osteometric data due to the close relationship between the lengths of long bones and animal size (O'Connor, 2008). The use of the greatest length measurements of metacarpals and metatarsals, and multipliers for these measurements has been the most common method of calculating withers height (Boessneck, 1956, Fock, 1966, Matolcsi, 1970, Zalkin, 1960). Matolcsi (1970) was the most widely used method among these multipliers (Rehazek and Nussbaumer, 2012). While the relationship between the greatest lengths (GL) and withers heights is clear, the effect of sex, breed, diet and age should not be ignored (Bartosiewicz, 1985).

The epiphyseal fusion of metapodial bones occurs at around 2-2.5 years of age (Habermehl, 1961; Rehazek and Nussbaumer, 2012; Schmid, 1972; Silver, 1963). At this time, metapodials have already reached their greatest length, whilst other skeletal elements are still fusing (Bartosiewicz, 1985; Guilbert and Gregory, 1952). These bones are important for providing information on the morphological characteristics of animal populations (Davis, 1996, 2000, Guintard and Lallemand, 2003), and as an indicator of paleoenvironmental changes (Bourova, 2005). The lengths of these bones are not affected by subsequent training conditions (Watson et al., 2003). The estimation of shoulder height by using the measurements of these bones has an important role in estimating sex ratios in archaeozoological studies (Boessneck, 1956; Higham, 1969; Howard, 1963; Kostov and Tsandev, 2014; Matolcsi 1970; Nobis, 1954; Telldahl et al., 2012; Zalkin, 1960).

In our research, fused metapodials of cattle which were recovered from the port area of Theodosius during the Yenikapi Metro and Marmaray Excavation were used. These metapodial bones did not show any signs of pathology. When the withers heights was estimated according to the Matolcsi multipliers without regard for sex differences, the metapodial average varied between 120.97and 123.52 cm. The presence of individuals with minimum withers heights ranging from 103.45 to 148.10cm suggests the existence of selective cattle breeding with the intention of producing larger size animals besides producing steers. The wide interval scale of the withers heights of cattle in the Byzantine period suggests the influence of selective breeding for larger animals during the Roman period was still present (Groot, 2008; Lauwerier, 1988). The growing demand for meat probably resulted in the importation of large size of bulls (Groot, 2008; Zeuner, 1967; Boessneck et al., 1971; Lauwerier, 1988), and the selective breeding of these cattle to meet the need for labour and urban life, in addition to the breeding of local breeds. Radical changes in the breeding of cattle emerged with the expansion of the Roman Empire in Central and South Eastern Europe (Bökonyi 1974), which continued into the Byzantine period. The practice of castration which has been going on since the Roman period, was also undertaken in the Byzantine period. Steers were identified in the assemblages by the slenderness index (index 1). The presence of these animals is closely related with the fact that the excavation area was a port. The pathological findings (Onar et al., 2015) in the cattle remains of Theodosius port showed that cattle were used for manual labor. In particular, lesion pathologies on the long bones indicate that they had been used for heavy labour for a substantial period of time (Onar et al., 2015). This pathological finding is supported by the presence of castrated individuals among the metapodial bones.

The selective breeding of larger size cattle in order to obtain a greater meat yield began in the Roman period (Bökönyi, 1974), which caused morphological changes in the animals. The imported large individuals were a result of Roman selective breeding (Boessneck et al., 1971; Groot 2008; Lauwerier, 1988). European cattle, continued to diminish in size during the Neolithic, Bronze and Iron age before the beginning of the Roman period (Boessneck et al., 1971, 1978; Manning et al., 2015). In addition to the effect of selective breeding, withers heights increased due to the presence of steer animals (Groot, 2008; Lauwerier, 1988). This selective breeding of animals was a response to the increased demand for meat (Witcher, 2016). Larger animals were an important way of meeting this growing demand for meat in addition to their use as larger steers for labour (Groot, 2008). Castration is practiced in order to produce working animals and also in order to provide a greater meat yield (Bökonyi, 1974), and it was essential that the draught animals were large to undertake the traction work required (Lauwerier, 1988). In particular, metapodial bones belonging to steers are generally longer and thiner structure in the archaeozoological samples. As a result of the increase in cattle size during Roman period (Bökönyi, 1974; Albarella et al., 2008; Peters, 1998; Witcher, 2016; Kron, 2014; Poulter, 2007) withers heights ranged from 120 to 140cm for Roman cattle, and 135 to 140cm for Roman steer (Bökönyi, 1974). We see the influence of the Roman tradition in the Byzantine Empire. They grew larger cattle in order to increase their effectiveness as labour animals, as shown by the presence of a withers height estimation of 148.10cm, and a metacarpal bone which is 23.99cm in length. As a result of these finding, steers used for labour were important part of everyday life in Constantinople, including in the Theodosius port area.

The presence of female individuals up to 145.70 cm in height from the port area of Theodosius might suggest the possibility that different cattle breed genotypes affected the distribution of withers heights, in addition to the presence of large steer individuals. This was similar to the assessment of metatarsal bones in the medieval and post medieval periods (Albarella, 1997), where it was observed that some of the long metatarsal bones of individuals had a smaller distal tip width (BD). However, we also see the presence of relatively small sized individuals. Individuals with the withers heights of 108.7 cm have been recorded in Early Byzantine from settlements outside of Constantinople (Poulter, 2007). However, we have not yet achieved a proper understanding of the height distribution of Byzantine cattle. A good understanding of the withers heights of the cattle in this assemblage, including those not used for labour, was possible by examining a sufficiently large number of bones. The presence of small size cattle (in particular, those females with a withers height of around 103cm) revealed by this work suggests the presence of individuals from smaller, local cattle populations. The "Native Black" breed (with a withers height of 100-110 cm) (Yılmaz et al., 2012) is still in this region and many other regions of Anatolia today. Given the presence of cattle with small wither heights, similar breeds could be considered to have been present at Constantinople and its surroundings. However, for a proper assessment of this, a genetic study of the relevant populations would be required.

In conclusion, we can see that cattle - which were frequently mentioned in Byzantine texts regarding diet (Dalby, 2004) – played an important role in both the workforce and meat supply, with both small and large withers heights found. The evaluation of the metapodial bones suggests that large steers and cattle were present. In this result we see the influence of the Western Roman Empire, in the East during the Byzantine period. Small indigenous breeds were also present as demonstrated by the range of withers heights, however the Roman period influence of larger sized cattle had a considerable effect on the osteometric measurements of the assemblage.

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