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Applicability of current soft tissue thickness tables in forensic anthropological facial reconstruction studies in Turkey

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Abstract: As rapid changes and developments are achieved in the contemporary world, the phenomenon of "crime" is also developing. In response, forensic anthropology as a part of the multi-disciplanary forensic sciences, provide precious contributions to law enforcement. One of the most important contributions forensic anthropology provides to the identification researches is the "Facial Reconstruction". The purpose of this study is to compare Kirman (Turkish), Lebedinskaya (Russian) and Lebedinskaya (Kazakh) Soft Tissue Thickness (STT) tables versus the STTs of a test group which is derived from the Turkish population, provide contribution in increasing the accuracy of facial reconstruction practices, and test the applicability three STT tables on the Turkish population.

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INTRODUCTION

As rapid changes and developments are achieved in the contemporary world, the phenomenon of "crime" is also developing. The decisive and concrete contributions of science to the crime investigations led to the evolvement of multi-disciplinary forensic sciences which today assist in unveiling all kinds of crimes and identifying criminals.

Anthropology, which primarily focuses on "human", has become an important part of the forensic sciences, since crime involves human action in its nature, and both perpetrator and victim are human as well. This new discipline, which is named as "Forensic Anthropology", aims to provide precious contributions to the crime investigations.

Basically, forensic anthropology tries to provide knowledge about the unidentified individuals -that are generally victim of homicide- by determining basic morphological features of the body or skeleton such as sex, age, height and race. In addition, it assists in reconstructing the soft tissue structure on the skull that would help in reaching a picture of the unidentified person during his ante-mortem life (Tug et. al., 2002). In this respect, forensic anthropological studies focus on skeletons and bodies that are burned, mostly putrefied or completely unidentifiable.

One of the most important contributions forensic anthropology provides to the identification researches is the "Facial Reconstruction". The face is the most important part of our features because of the role it plays in communication. Forensic facial reconstruction is the scientific art of visualizing a face on the skull for personal identification (El-Mehallawi and Soliman, 2011). It is based on re-structuring the soft tissue and facial features on a cranium with special techniques (Fernandes et.al., 2012). The identity of the victim provides invaluable information in enhancing an efficient investigation and finding the murderer in most of the homicide cases. Furthermore, identified bodies of the victims could be delivered to his/her family for interment which has an important place in almost every religious belief. The production of a three-dimensional plastic face on an unknown human skull has been practiced sporadically since the latter part of the last century. In recent years, the technique has been revived and applied to forensic science cases (El-Mehallawi and Soliman, 2011).

Supposing that personal identifiers (such as fingerprints, dental records, ID card, driving license, passport, etc..) or personal belongings were not found with the dead body or special techniques such as photographical comparison, superimposition, erythrocyte enzymes and DNA samples does not help in the identification efforts, facial reconstruction should be considered necessary as a last resource (Kirman, 1999, Fernandes et.al., 2012).

Facial reconstruction in general is a technique which determines the facial features of an unidentified person in pursuance of cranial measurements. This process includes covering the cranium with clay (or similar material) with a series of anatomic principles in accordance with soft tissue thickness databases (Aka and Dökmez, 2003; El-Mehallawi and Soliman, 2011). Fernandes et.al. (2012) mention that there are different databases of soft tissue thicknesses published in the scientific literature. From a different point of view, Taylor (2001) defined facial reconstruction as a method of "forensic art" that is applied in identifying the unknown skeletons.

Facial reconstruction enables the restoration of the contours of the soft tissues over the skull, producing a face and increasing the probability of facial recognition. The reliability of this technique depends on analyzing the values of aforementioned soft tissue thickness observed in a given population. To produce facial reconstruction, information on the thickness of the soft tissues that cover the bony structures of skull and face are vital (Fernandes et.al., 2012).

There are many studies revealing differences in the thickness of facial soft tissue between ethnic groups. For instance soft tissue thickness tables on certain populations such as North American Blacks, Whites and Hispanics, South Africans, African Zulus, Egyptians, Europeans, Australians, Portuguese, Japanese, Caucasians, White Americans, and Black Americans can be easily found in the scientific literature (Fernandes, et.al., 2012, 211.e2).

Currently, there are three prevalent facial reconstruction methods. These include a morphoscopic method using an "anatomical approach" of reconstructing the musculature, fat and skin (generally known as the Russian method), a "morphometric method" which rests heavily on the use of average facial soft tissue depth measurements that have been gathered by previous researchers over various anatomical sites of the skull and jaws (known as the American method) and a combination of both (El-Mehallawi and Soliman, 2011).

As results obtained from the measurement of live tissues are more feasible and applicable in the construction of faces, many other methods have been employed including lateral cephalometric radiographs, computed tomographic scanning (CT) ultrasonics (US) and magnetic resonance image (MRI) (El-Mehallawi and Soliman, 2011).

The purpose of this study is to compare Kirman's (Turkish), Lebedinskaya's (Russian) and Lebedinskaya's (Kazakh) Soft Tissue Thickness (STT) tables versus the STTs of a test group which is derived from the Turkish population, provide contribution in increasing the accuracy of facial reconstruction practices, and test the applicability of the abovementioned three STT tables on the Turkish population.

MATERIAL AND METHOD

The universe of the study is composed of 25-50 years old male and female patients that visited a radiology imaging center in Ankara (Turkey) for cranial examination. The subjects were weighed and measured for height. To ensure average body weight, body mass index (BMI) was calculated according to the equation: Weight (in kilograms) divided by Height (in meters) squared (Eisenberg et.al., 1956). The BMI can be used as an indicator for tracking body size throughout the life cycle (Malhotra et.al., 2016). In addition to weight, height and BMI, hometown and age of the selected individuals were also recorded to the registry, and then their cranial magnetic resonance images were taken for assessment.

In order to avoid possible geographical and climatic factors that could bias the accuracy of the study, the individuals are selected from different cities of Turkey. Other important factors that could affect the consistency of our study were facial surgeries and similar facial anomalies on the face. In that sense, the individuals that previously had plastic surgeries with sequels on bones and the ones that had facial anomalies were removed from the test group.

As a result of this initial assessment, our test group, which is consisted of 131 patients from 48 different cities, has been formed. Acquisition was made with 'Siemens Symphony 1.5 Tesla' MRI device with head coil. Images were acquired with T1 weighted spin echo sequence which the subcutaneous fat layer was most marked, on midsagital, axial and coronal cranial plans. Chosen images were transferred in DICOM format to 'DICOM Works' (version 1.3.5) software and evaluated with appropriate window level for bones and soft tissue discrimination.

All datum were measured by a radiologist with computer aid. The landmarks where measurements had been taken were metopion, glabella, nasion, rhinion, superior labial sulcus, superior labial margin, inferior labial margin, inferior labial sulcus, pogonion, menton, superciliary, maxilla, nose side point, zygion, zygomatic arcus posterior, supracanine, middle of corpus mandibula, margin of corpus mandibula, middle of ramus mandibula, between alae nasi and gonion.

All patients were categorized in accordance with their body types as thin, normal and fat. The "Body Mass Index" (Eisenberg et al., 1956) was used to determine the body types of the individuals. Since STTs of a fat and a thin person can not be the same, determining the body types is considered very important while preparing a STT table. Within this context, the body mass indexes of the individuals were carefully calculated.

Table-1: The Body Mass Index (BMI) (Eisenberg et al., 1956).

$BMI\ (kg/m^2) = \frac{m\ (kg.)}{L^2\ (m^2)}$		
	MALE	FEMALE
THIN	… – 20,7	… – 19,1
NORMAL	20,8 – 27,8	19,2 – 27,3
FAT	27,9 – 45,4	27,4 – 44,8

The data obtained from the MRI of the patients were classified with respect to sex and body types, and have been statistically assessed with SPSS (version 13.00) software by using correlation analysis and t-test.

RESULTS

DISPERSION OF AGE AND SEX

Table-2: Test Group's Sexual Dispersion According to Age.

Age	MALE		FEMALE	
	n	%	*n*	%
25-30	22	32,84	25	39,06
31-35	5	7,46	13	20,31
36-40	16	23,88	12	18,75
41-45	5	7,46	8	12,50
46-50	19	28,36	6	9,38
TOTAL	67	100	64	100

Having determined the STTs of the test group, it was seen that 35,87% of the individuals were 25-30 years old, whereas 13,74% are 31-35, 21,37% are 36-40, 9,92% are 41-45 and 19,08 are 46-50 years old. 51,14% of the test group were male while on the contrary 48,86% were female.

DISPERSION OF BODY TYPE

Taking "Body Mass Index" (Eisenberg et al., 1956) into consideration, it was found out that 22,90% of the test group were thin, 49,61% were normal and 27,49% were fat by means of body type.

Table-3: Test Group's Dispersion of Body Type.

Body Type	MALE		FEMALE	
	n	%	*n*	%
THIN	15	22,40	15	23,43
NORMAL	35	52,23	30	46,88
FAT	17	25,37	19	29,69
TOTAL	67	100	64	100

SOFT TISSUE THICKNESSES (STTs)

Mean, standard deviation, minimum and maximum values of the STTs of the test group is depicted in Table-4.

In conjunction with Table-4, a statistically positive correlation was found in males for the following points:

- Metopion and zygomatic arc-posterior,
- Glabella and inferior labial sulcus, superciliary, supracanine,
- Inferior labial sulcus and superciliary, supra canine, between alae nasi,
- Menton and superciliary, supracanine, gonion,
- Superciliary and supracanine, corpus mandible margin, gonion, between alae nasi,
- Zygion and supracanine,
- Supracanine and gonion,
- Gonion and between alae nasi.

In conjunction with Table-4, a Statistically positive correlation was found in females for the following points:

- Glabella and superciliary, maxilla, zygion, zugomatic arc-posterior, between alae nasi,
- Nasion and supracanine,
- Superior labial sulcus and between alae nasi, corpus mandible margin, gonion,
- Inferior labial margin and supracanine,
- Inferior labial sulcus and maxilla, zygion,
- Maxilla and zygion, middle of corpus mandible, between alae nasi,
- Nose side point and middle of ramus mandible,
- Zygion and middle of corpus mandible, between alae nasi,
- Middle of corpus mandible and between alae nasi.

Table-4: Test Groups's STTs.

Point on the Cranium	**Male (n:67)**				**Female (n: 64)**			
	Mean	**SD**	**Min.**	**Max.**	**Mean**	**SD**	**Min.**	**Max.**
Metopion	4,18	1,36	1,86	7,43	4,17	0,91	2,05	6,08
Glabella	5,00	1,58	2,10	8,82	4,79	1,28	2,75	7,28
Nasion	4,84	1,46	2,17	8,79	4,69	1,40	2,45	7,26
Rhinion	2,81	0,82	1,58	5,55	2,54	0,82	1,07	5,49
Superior Labial Sulcus	11,49	2,03	7,16	16,81	9,50	1,79	5,64	13,16
Superior labial margin	11,29	1,54	7,51	15,42	9,38	1,87	3,79	13,32
Inferior labial margin	11,85	1,85	8,00	16,34	10,62	1,86	7,26	14,08
Inferior Labial Sulcus	10,50	1,55	8,10	13,87	9,53	1,99	5,82	13,09
Pogonion	10,88	2,21	5,00	16,82	9,98	1,89	5,79	14,81
Menton	6,66	1,84	3,39	11,08	6,29	1,96	2,96	10,72
Superciliary	4,89	1,65	2,00	9,02	4,64	1,39	2,15	7,10
Maxilla	12,72	3,04	5,26	17,33	13,40	3,00	6,17	18,11
Nose side point	3,25	0,67	1,98	4,49	3,16	1,03	1,35	5,71
Zygion	9,57	3,80	2,73	18,66	11,25	3,09	5,12	18,13
Zygomatic Arcus, Posterior	5,66	1,70	2,76	10,03	7,56	3,26	2,51	13,48
Supracanine	11,37	2,43	5,19	17,48	10,54	2,61	5,21	17,00
Middle of Corpus Mandible	13,66	1,76	9,50	18,16	14,53	3,25	7,85	21,18
Margin of Corpus Mandible	6,15	0,99	3,70	8,66	6,88	2,12	3,56	13,03
Middle of Ramus Mandible	18,64	2,91	12,49	26,35	18,85	3,23	12,46	26,90
Gonion	5,78	1,69	2,11	10,13	6,39	2,25	3,23	12,40
Between Alae Nasi	33,89	2,32	29,93	40,05	33,08	4,49	21,19	41,29

Table-5: Statistical Comparison of Test Group and Kirman's Values

Point on the Cranium	MALE		FEMALE	
	Difference between Test Group and Kirman's Mean Values	**t-test value**	**Difference between Test Group and Kirman's Mean Values**	**t-test value**
Metopion	-0,05	-0,22	0,10	0,60
Glabella	-0,04	-0,17	0,01	0,05
Nasion	0,10	0,43	0,03	0,13
Rhinion	0,07	0,52	0,15	1,24
Superior Labial Sulcus	-0,13	-0,33	0,14	0,49
Superior Labial Margin	-0,08	-0,25	-0,10	-0,32
Inferior Labial Margin	0,02	0,06	-0,06	-0,19
Inferior Labial Sulcus	0,02	0,08	-0,51	-1,51
Pogonion	-0,02	-0,06	0,22	0,61
Menton	0,06	0,22	-0,07	-0,24
Superciliary	0,03	0,10	0,10	0,46
Maxilla	-0,28	-0,60	0,34	0,80
Nose Side Point	-0,02	-0,10	0,09	0,57
Zygion	-0,52	-0,85	0,22	0,42
Zygomatic Arcus Posterior	0,06	0,20	0,22	0,42
Supracanine	0,05	0,12	0,15	0,36
Middle of Corpus Mandible	-0,08	-0,22	0,26	0,53
Corpus Mandible Margin	-0,01	-0,04	0,11	0,29
Middle of Ramus Mandible	0,04	0,08	0,13	0,26
Gonion	0,06	0,21	0,24	0,64
Between Alae Nasi	-0,01	-0,03	0,37	0,56

Table-6: Statistical Comparison of Test Group and Lebedinskaya (Russian)'s Values.

Point on the Cranium	MALE		FEMALE	
	Difference between Test Group and Lebedinskaya (Russian)'s Mean Values	**t-test value**	**Difference between Test Group and Lebedinskaya (Russian)'s Mean Values**	**t-test value**
Metopion	-1,12	-5,77	-1,13	-8,26
Glabella	-0,80	-3,77	-1,21	-6,80
Nasion	-0,76	-3,60	-0,81	-4,13
Rhinion	-0,99	-7,14	-1,16	-9,25
Superior Labial Sulcus	-0,01	-0,03	-1,10	-4,09
Superior Labial Margin	-1,11	-3,79	-1,52	-5,20
Inferior Labial Margin	-1,95	-6,39	-1,68	-5,83
Inferior Labial Sulcus	-1,00	-3,99	-1,57	-5,66
Pogonion	-0,72	-2,09	-12,82	-43,94
Superciliary	-0,91	-3,91	-1,26	-6,35
Maxilla	0,32	0,70	-0,80	-1,78
Nose Side Point	-0,65	-5,08	-0,64	-4,31
Zygion	4,47	9,40	5,85	14,73
Supracanine	0,87	2,59	0,84	2,42
Middle of Corpus Mandible	1,66	3,94	0,73	1,51
Gonion	0,58	2,38	1,09	3,32

COMPARISON WITH KİRMAN'S STT TABLE

As a result of the t-test, with test group and Kirman's STT values participating, all measured points in both males and females were seen that they remained within the t_{table} limits (degree of freedom of $n_1 + n_2 - 2$ and $\alpha = 0,05$). In this regard, the mean values of the test group and Kirman's STT tables are completely coherent.

COMPARISON WITH LEBEDİNSKAYA (RUSSIAN)'S STT TABLE

In order to compare common measurements, menton, zygomatic arcus-posterior, corpus mandible margin, middle of ramus mandible and between alae nasi points which were not included in Lebedinskaya's renowned study, were discarded from Table-6.

Table-7: Statistical Comparison of Test Group and Lebedinskaya (Kazakh)'s Values.

Point on the Cranium	MALE		FEMALE	
	Difference between Test Group and Lebedinskaya (Kazakh)'s Mean Values	t-test value	Difference between Test Group and Lebedinskaya (Kazakh)'s Mean Values	t-test value
Metopion	-0,32	-1,69	-0,73	-5,05
Glabella	-0,30	-1,42	-0,81	-4,46
Nasion	0,04	0,21	0,09	0,47
Rhinion	-0,19	-1,73	-0,36	-3,21
Superior Labial Sulcus	-0,21	-0,72	-0,80	-3,08
Superior Labial Margin	-1,11	-4,21	-1,72	-6,16
Inferior Labial Margin	-1,85	-6,48	-1,78	-6,51
Inferior Labial Sulcus	-0,70	-3,15	-1,57	-5,66
Pogonion	-0,02	-0,07	-1,42	-5,07
Superciliary	-0,31	-1,41	-0,96	-4,91
Maxilla	-0,48	-1,15	-1,10	-2,61
Nose Side Point	0,25	2,77	0,16	1,19
Zygion	5,07	10,75	5,95	15,01
Supracanine	0,67	2,01	0,64	1,86
Middle of Corpus Mandible	1,06	2,84	-0,07	-0,14
Corpus Mandible Margin	0,55	3,07	-0,12	-0,40
Middle of Ramus Mandible	1,64	3,89	1,95	4,26
Gonion	1,18	5,23	1,19	3,52

As a result of the t-test, with test group and Lebedinskaya (Russian)'s STT values participating, only superior labial sulcus and maxilla in males, maxilla and middle of corpus mandible in females were seen that they remained within the t_{table} limits (degree of freedom of $n_1 + n_2 - 2$ and $\alpha = 0,05$). In this regard, the mean values of the test group and Lebedinskaya (Russian)'s STT tables are not coherent.

COMPARISON WITH LEBEDİNSKAYA (KAZAKH)'S STT TABLE

In order to compare common measurements, menton, zygomatic arcus-posterior and between alae nasi points which were not included in Lebedinskaya's study, were discarded from Table 7.

As a result of the t-test, with test group and Lebedinskaya (Kazakh)'s STT values participating, metopion, glabella, nasion, rhinion, superior labial sulcus, pogonion, superciliary and maxilla in males, nasion, nose side point, supracanine, middle of corpus mandible and corpus mandible margin in females were seen that they remained within the t_{table} limits (degree of freedom of $n_1 + n_2 - 2$ and $\alpha = 0,05$). In this regard, the mean values of the test group and Lebedinskaya (Kazakh)'s STT tables are not coherent.

STTs UPON BODY TYPE

We deem that a successful facial reconstruction study depends on determining the sex, age and race of the individual as well as his/her body type. It is very probable that individuals in the same test group with thin, normal and fat body types would lead to divergences in the mean values. At this end, a detailed STT table, which shows the STTs of thin, normal and fat individuals separately, was prepared with the help of body mass index.

DISCUSSION

According to the population census of 2000, total number of the inhabitants in Turkey is 79.814.871 of which 40.043.650 are males and 39.771.221 are females. In this regard, Turkey's male-female sex ratio is calculated as 100,6 (TÜİK, 2006). The sex ratio of our test group, which is composed of 67 male and 64 female individuals, is 104,68. Considering these two ratios, it is supposed that our test group simply models Turkey by means of sex.

As a result of the t-tests conducted, we determined coherence between the test group and Kirman's STT table whereas Lebedinskaya's studies on Russian and Kazakh populations have shown statistical discrepancy against the test group. It is assessed that this disparity is rooted from climatic and geographic features.

Although the results of the t-test between the test group and Lebedinskaya's Kazakh STT table display numerous differences, they seem to be more consistent than the results of the test group versus Russian values. We think that the reason for this is the historical genetic kinship of the Turkish and Kazakh population.

It is assessed that body types must be taken into account while scaling STTs. Determining the body type should provide very important advantages for the facial reconstruction applications just like age, sex and race do so. We believe that applying the values of a fat-individual-included STT table on a thin bodied person would not be that reliable, just in the same way as applying negroid values on a caucasian individual or using males' values on a female would be very wrong.

In case of absence of evidences that might help determining the body type of the skeleton is found, generalized STT tables could be used. It should be taken into consideration that the differences between the minimum and maximum values on the anthropometric landmarks would be far and the standard deviation should be higher in such cases.

In addition, we believe that the possible effects of climatic factors on genetic structure should also be researched. To this end, the question of "Does living under warm or cold climates make a difference in the STT values?" is yet to be studied.

Another area of focus might be reducing the margins of error on the critical facial areas such as eyebrows, ears, hair, and eyelids that have no direct relation with the cranium and hence it is very difficult to identify their shapes.

Most methods of soft tissue thickness measurements have dangers of potential radiation hazards. Moreover, the use of MRI and CT scanning are more accurate but are relatively expensive.

CONCLUSION

The success of facial reconstruction and the question of "Can facial reconstruction studies be accepted as criminal evidence?" are still divisive issues. The purpose of forensic facial reconstruction is to recreate, based on the skull, the face of the deceased at the time of his/her death, with sufficient likeness to the deceased to contribute to his/her recognition, hence leading to identifying the body. Facial reconstruction does not correspond to a photograph of the individual when alive, but can be considered successful if it is realistic enough to produce a good response from the public, leading to the identification of the subject. It is not an identification method, but rather a tool used for recognition (Fernandes et.al., 2012). Within this context, facial reconstruction should be considered as a last resort where more reliable methods like personal identification documents, personal belongings found with the dead body, dental records, photographical comparison, superimposition, erythrocyte enzymes and DNA researches (Kirman, 1999) stay inadequate. In such cases, the method of facial reconstruction to be used would be dependant on material in hand, time and the features of the case. No matter which method is used, it should be never forgotten that determining the age, sex, race and body type of the individual is of utmost importance.

More recently, a combination of video and laser equipment has allowed 2000 measurements to be taken and stored within 30 seconds. The data from an unknown skull are then electronically "clothed" within Standard soft tissue from the memory bank and modified on screen to produce various images (El-Mehallawi and Soliman, 2011). This achievement must be developed in the future.

To conclude, we believe that the STTs delivered with this study will provide a precious contribution to the databases which should be established in Turkey. Besides, it is assessed that researches performed by joint groups including anthropologists, medical doctors, dentists and statisticians will bring utmost advantages.

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Table-8: Test Group's STTs Upon Body Types.

Points on the Cranium	MALE			FEMALE		
	Thin n: 15	**Normal** n: 35	**Fat** N: 17	**Thin** n: 15	**Normal** n: 30	**Fat** n: 19
Metopion	2,47	4,24	5,55	3,35	4,09	4,93
Glabella	2,93	5,00	6,81	3,25	4,62	6,28
Nasion	3,50	4,86	5,99	3,11	4,54	6,16
Rhinion	2,38	2,62	3,59	1,82	2,51	3,18
Superior Labial Sulcus	9,49	11,36	13,52	7,82	9,29	11,18
Superior Labial Margin	9,73	11,15	12,95	8,01	9,24	10,68
Inferior Labial Margin	10,18	11,75	13,54	8,59	10,72	12,08
Inferior Labial Sulcus	8,63	10,40	12,38	7,82	8,91	11,87
Pogonion	8,07	10,85	13,41	8,40	10,09	11,05
Menton	4,35	6,54	8,95	4,24	6,15	8,12
Superciliary	2,76	4,80	6,94	3,13	4,57	5,97
Maxilla	8,07	13,47	15,30	9,78	13,26	16,48
Nose Side Point	2,51	3,24	3,93	2,14	3,13	4,01
Zygion	4,96	9,55	13,68	7,67	11,00	14,47
Zygomatic Arcus Posterior	3,88	5,38	7,82	3,45	7,22	11,36
Supracanine	8,32	11,20	14,39	7,50	10,26	13,37
Middle of Corpus Mandible	12,19	13,62	15,05	11,00	14,31	17,68
Corpus Mandible Margin	5,10	6,12	7,14	4,78	6,75	8,73
Middle of Ramus Mandible	16,32	18,12	21,76	15,79	18,76	21,41
Gonion	3,74	5,65	7,83	4,69	5,71	8,81
Between Alae Nasi Burun	31,32	33,70	36,55	27,27	33,40	37,15

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