Trakia Journal of Sciences, Vol. 10, Suppl. 2, 28-32, 2012

Available online at:
http://www.uni-sz.bg

ISSN 1313-7050 (print)
ISSN 1313-3551 (online)

INNOVATIVE METHODS FOR MATHEMATICAL ASSESSMENT OF ANTROPOSCOPIC LANDMARKS AND THEIR USE AS SEX DISCRIMINANTS

P. Timonov[1]*, I. Doychinov[1], A. Fusova[2], S. Fusov[3]

[1]Department of Pathological Anatomy and Forensic Medicine, Medical University, Plovdiv, Bulgaria
[2]Department of Anatomy, Histology and Embryology, Medical University, Plovdiv, Bulgaria,
[3]an architect, Plovdiv, Bulgaria

ABSTRACT
This study is focused on an innovative approach to the numerical assessment of gluteal tuberosity through 3D visualization and its use as sex discriminant. 3D laser surface scanning - surfaces of gluteal tuberosity of the femora were recorded in 3D using a lightweight hand-held laser scanner (FastSCAN). The points were placed as follows–on the uppermost point, on the roughness–femoral surface border (a), on the lowest point of the roughness–femoral surface border (d), on the most medial point, on the roughness–femoral surface border (b), on the most lateral point, on the roughness–femoral surface border (f) a few uppermost placed and distinctly protruding points are selected on the roughness itself [1, 2, 3,4, 5 and 6]. Each point contains x, y, and z values. After that we create two-dimensional shape which is a function of the three-dimensional one. This study demonstrates an innovative method of objective evaluation of the muscle's attachment points, which can be used successfully for sex determination, especially in case of highly fragmented bones that impede anthropometric analyses.

Key words: sex determination, laser scanning, femur, gluteal tuberosity.

INTRODUCTION

Regarding sex determination based on skeletal remains, forensic anthropology presents various results yielded mainly through analysis of anthropometric landmarks. In some forensic cases dealing with bones or fragments thereof, however, sex determination is hindered. Literature lacks adequate information about the use of descriptive (osteoscopic) methods in sex determination based on entire bones or fragments thereof. The cause is that their assessment is made on the basis of subjectively created schemes (according to the principle 'presence–absence', and if present or absent, is it strongly or poorly developed?), which poses the risk of error and impossibility for setting up a database of certain population unlike osteometric indices.

***Correspondence to**: *Pavel Todorov Timonov,Medical University - Plovdiv, Department of pathological anatomy and forensic medicine., Str.V.Aprilov № 15a, Plovdiv 4000, BulgariaTel: 0888409590, e-mail: paveltimonov@yahoo.fr*

This study aims to demonstrate some contemporary and innovative methods for quantitative assessment of tuberositas glutea femoris through 3D visualization. The said methods allow for its accurate mathematical estimation and use as a sex discriminant or as an additional quantitative variable in different discriminant functions for the purpose of sex determination of the femur. Furthermore, they could be useful in the assessment of other osteoscopic landmarks.

MATERIALS AND METHODS

Tuberositas glutea femoris is the subject of scanning due to the following features:
1. the strongest extensor muscle, gluteus maximus, in the human body is inserted in it.
2. due to the fact that the effect of muscle action is more powerful on the point of insertion than on the point of origin [1, 2].
3. gluteus maximus stabilizes the hip joint, which in its turn shows great sexual dimorphism.
4. the activity and function of gluteus maximus are continuous and daily, for instance, 60% of

the movements for taking a single stride when walking are performed by gluteus maximus along with gluteus medius [3].

5. muscle activity is higher in men than in women [3-5].

On the grounds of these features the following conclusion may be drawn in advance; this anthroposcopic landmark will differ considerably in men and women in its size and impression and will be successfully used as a sex discriminant.

Methods are generally based on the so called geometric morphometrics [5, 6]. Different objects are spatially characterized by shape and size, for example a football ball and a tennis ball have the same shape but are different in size, while balloons have identical shapes but different sizes depending on the way they have been modeled [5], therefore, when comparing objects, the entirety of both their size and shape should be taken into consideration.

Method 1. The surface of tuberositas glutea femoris is captured in a 3D image, using a Hand-held Laser Scanner-FastSCAN [7]. Afterwards, the following points (markers) are placed on the surface of the 3D image obtained. They are placed as follows–on the uppermost point, on the roughness–femoral surface margin (point a), on the lowest point of the roughness–femoral surface margin or on the margin where it meets labium laterale (point d), on the most medial point, on the roughness–femoral surface margin (point b), on the most lateral point, on the roughness–femoral surface margin (point f) and the uppermost point is empirically selected on the roughness itself (point 2). Each of these points is defined by certain x, y, and z values. The result is a 3D shape comprising two tetrahedrons with common base (abf2 and dbf2). Therefore, the volume of the roughness is approximately equal to the total of the volumes of these two tetrahedrons.

This method of calculation of volumes of descriptive characteristics by creation of geometrical figures similar in size and shape to the studied objects and their use as sex discriminants is applied, for example, in morphological assessment of lips and external nose in facial reconstruction [8, 9].

Figure 1. Algorithm of creation the first described method

Method 2. After the creation of a 3D model, markers are placed on the surface of the roughness: on the uppermost point, on the roughness–femoral surface margin (point a), on the lowest point of the roughness–femoral surface margin or on the margin where it meets labium laterale (point d), on the most medial point, on the roughness–femoral surface margin (point b), on the most lateral point, on the roughness–femoral surface margin (point f) and on the roughness itself some uppermost projecting points, as well as lowest points, are selected (points 1, 2, 3, 4, 5 and 6, the bigger the number of these points, the more precise the method is, as the impression of the roughness is more accurately described). Each point marked is defined by x, y, and z values.

Afterwards the following stages are performed:

1. Finding the sectioning point of the straight line bf (**point g**).
2. Creating three planes–the first one **A** is determined by points a, g and d, the second one **B**–by points a, f and d and the third one **C**–by a, b and d, so that the straight line bf lies simultaneously on the three planes created.

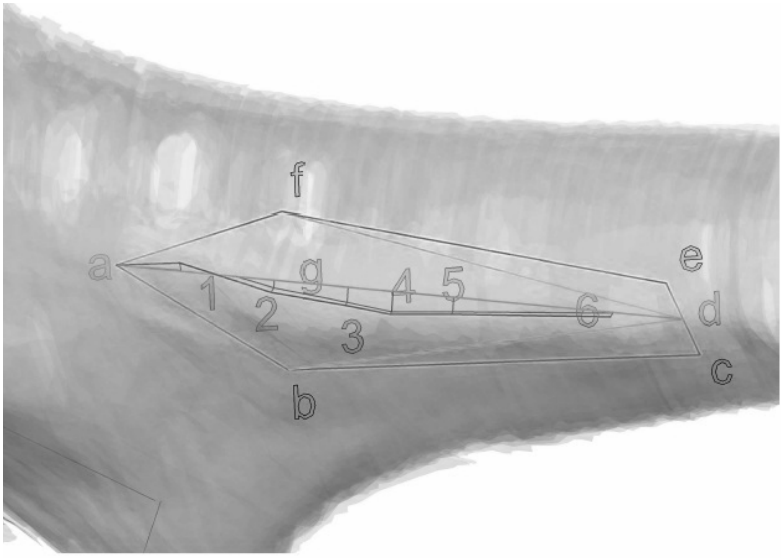

Figure 2. Algorithm of creation the second described method

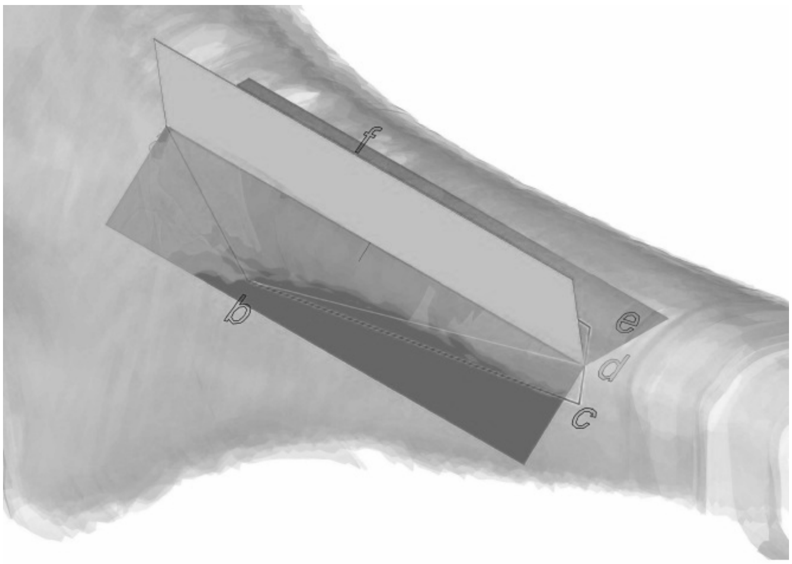

Figure 3. Algorithm of creation the second described method

3. Points 1, 2, 3, 4, 5 and 6 are transposed to the formed plane A, as the elevations at which they are positioned are respectively above planes B and C and are, respectively, equal to their elevations over the straight line ad in plane A.

This results in the formation of a 2D polygonal shape, defined within the following points a, g, d and transposed 1, 2, 3, 4, 5 and 6.

4. The newly created two-dimensional shape is a function of the three-dimensional one.

The area of the formed shape is measured **(area)** as well as its greatest elevation **(elevation)**, which are the variables themselves.

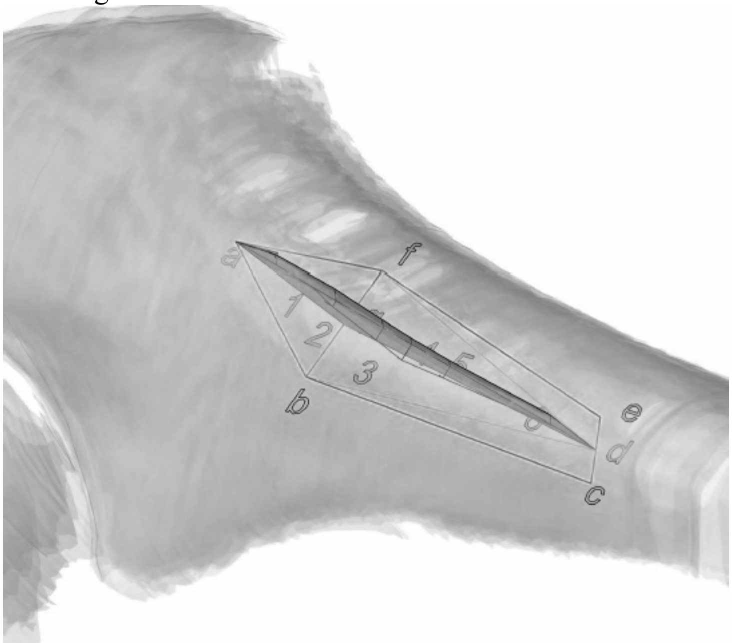

Figure 4. Algorithm of creation the second described method

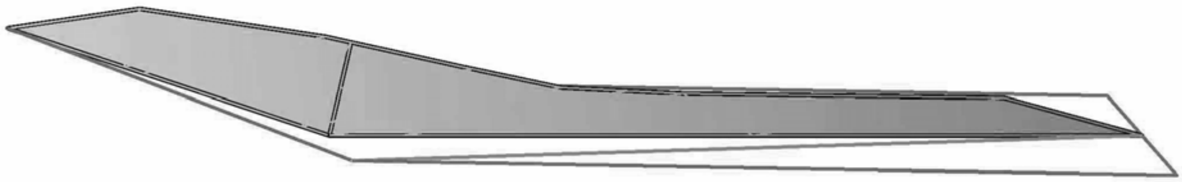

Figure 5. Algorithm of creation the second described method

Why have we selected the above points?
1. Points a, d, b and f characterize the size of the point of insertion and the function of gluteus
maximus, respectively, extension, external rotation, abduction and adduction.
2. Points 1,2,3,4,5 and 6 characterize the impression of the point of insertion.
3. Point g (the middle of the line bf) also characterizes the functional activity of the muscle, especially the external rotation of the hip, the wider the roughness, the lower the position of point g under straight line ad, and the area of the 2D polygonal shape will be larger and vice versa.

In women the point of insertion of the muscle in the bone is smaller in size and has less distinctive impression [1, 2]. Based on the above data, it could be concluded that the variables of the shape obtained will be indicative of sex differences.

CONCLUSIONS

Muscle activity is higher in men than in women. This, in its turn, results in difference in both the anthropometric and anthroposcopic landmarks, in favour of the male sex. This study demonstrates innovative methods for objective evaluation of the muscles' points of insertion which can be used successfully for sex determination, especially in case of highly fragmented bones that impede anthropometric analyses.

REFERENCES

1. Breathnach, A., Frazer's Anatomy of Human Skeleton, 5th ed. J.A. Churchill Ltd., London, 1958.

2. France D., Osteometry at muscle origin and insertion in sex determination, *Am. J. Phys. Anthropol.,* 76:515–526,1988.
3. Hamill,J., Knutzen,K., Biomechanical Basis of Human Movement, 3rd Edition, Lippincott Williams & Wilkins,2009.
4. Purkait R., Triangle identified at the proximal end of femur: a new sex determinant, *Forensic Science International*, 147:135–139,2005.
5. Hennessy R., McLearie S., Kinsella A. and Waddington J., Facial Shape and Asymmetry by Three-Dimensional Laser Surface Scanning Covary With Cognition in a Sexually Dimorphic Manner, *J Neuropsychiatry Clin Neurosc*i 18:73-80, 2006.
6. Hennessy R., Baldwin P., Browne D., Kinsella A., and Waddington L., Frontonasal dysmorphology in bipolar disorder by 3D laser surface imaging and geometric morphometrics: comparisons with schizophrenia, *Schizophr Res*., 122: 63–71,2010.
7. www.fastscan3d.com
8. Sforza C., Grandi G., Binelli M., Dolci C., De Menezes M. and Ferrario V., Age- and sex-related changes in three-dimensional lip morphology, F*orensic Science International,* 200:182.e1–182.e7, 2010.
9. Sforza C., Grandi G., De Menezes M., Tartaglia G. and Ferrario V., Age- and sex-related changes in the normal human external nose, *Forensic Science International* 204:205.e1–205.e9, 2010.