Romanian Journal of Morphology and Embryology 2005, 46(1):63–66

The construction of human body – from model to reality

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Abstract

The human bodybuilding represented a complex research topic for the scientist in the most diverse domains. Although their interests and reasons were different, the goal was always the same: establishing a relation to verify the ratio between the dimensions of the constituent segments It appears that the mystery was solved out in the XIX-th century by Adolf Zeising, a German, who, using the statistic calculus, defined the division of a segment by the gold section. This purely mathematic legity confirms the human body's integration in proportion to the finest segments, thus providing the technical instrument of building a fully harmonious human body. The present study aims to compare the ideal, the calculated perfection to the reality, namely the theoretically obtained values to the average values of an 18–year-old male. It appears that the differences refer especially to the limbs; both the superior ones and the inferior ones being longer comparing to the ideal pattern while the bust is shorter and broader.

Keywords: human body, anthropometry, proportions.

Introduction

The human body is one of nature's artistic creations built according to unwritten and unknown rules, which have lasted throughout times and safeguarded growth and development. The attempts at finding these rules has led to establishing certain patterns called canons, in which the dimensions of the body were expressed according to a certain size called module (*e.g.*, the height of the skull). Meanwhile, these patterns proved to be far from showing the real construction, so that none of them could be considered a way of expressing the law that governs the proportional building of the human body [1, 2].

It seems that the person who managed to unravel the mystery was Adolf Zeising (1810–1876), a German scientist with various interests, none of which had any connection to the study of anatomy and human morphology. Zeising defines the golden section, a universal law, an inorganic law, a mathematical formula which sets the rule in the construction of all living organisms, as this law is present not only in the construction of the human body but also in that of plants and animals [2].

The golden section

Considering a segment of a straight line defined by two points A and B:

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A                  C         B
x------------------x---------x
          M              m
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On this straight line there is a single point C, which divides the AB segment into two unequal parts expressed by the relation: AB/AC = AC/CB, from where it results that $AC^2 = AB \times CB$.

By marking the segments AC = M and CB = m, we obtain:

$$(M + m) / M = M / m, \text{ that is } M^2 = m \times (M + m)$$

This second degree equation yields the value of the M/m ratio = 1.6179...

Considering that segment AB stands for the height of the body, point C was seen to correspond to the umbilicus, which thus divides the height into two segments, vertex–umbilicus and umbilicus–ground, present in the ratio of the golden section.

Going farther, by following the same rule these sections can be subdivided into ever-smaller sections. In this way, by successive calculus, we obtain the value of the smallest body segments.

This is the rule underlying the harmonious construction of an ideal model in establishing the proportions of the human body (Figure 1).

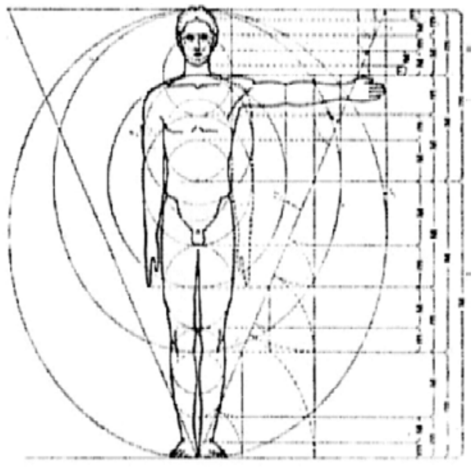

Figure 1 – ***The proportions of the human body and the "golden section"***

Material and methods

Starting from these premises, the study aims at revealing whether the rapports established between the average dimensions of an adult male, determined for the Romanian population, abide by this law of the ideal body shape and if not, which are the segments that deviate from the rule [3–5].

Table 1 shows the values of the measured dimensions together with their names according to the anthropometric defining points, in order to synthetically describe the technique by which the measurements were carried out. The ideal values for the reference size were determined by calculus according to the golden section ratio.

In order to establish the ideal dimensions according to the golden section, for the lengths and widths of a 177 cm tall subject, the authors used certain notations in order when making reference to certain points used in the calculations, points that are not found in the current measurement technique, some of them being quite difficult to determine from the sketched model only [6–10].

Table 1 – ***Average dimensions of the adult male***

No.	Abbreviation	Codification	-DS	VM	+DS
1.	T	Dist [v–pte]	164.55	177.00	198.45
2.	LMSdr	Dist [a–da] dr	66.53	77.44	88.36
3.	LBdr	Dist [a–ra] dr	24.44	31.89	39.33
4.	LABdr	Dist [ra–sty] dr	22.87	26.11	29.34
5.	LMdr	Dist [sty–da] dr	15.68	19.44	23.20
6.	LMIdr	Dist [troh–pte] dr	99.85	107.00	114.14
7.	LCSdr	Dist [troh–tib] dr	48.53	52.00	55.46
8.	LGB dr	Dist [tib–sphy] dr	39.40	46.56	53.70
9.	IP dr	Dist [sphy–pte] dr	5.97	8.44	10.92
10.	IC	Dist [v–gn]	20.76	23.00	25.24
11.	LG	Dist [gn–cerv]	6.58	8.00	9.41
12.	IB	Dist [v–tub]	84.30	89.00	63.69
13.	DBiAcr	Dist [a–a]	33.07	40.00	46.93
14.	DBitr	Dist [troh–troh]	24.03	30.44	36.86
15.	Anv	Dist [a–a]	170.29	194.44	218.59

To avoid any possible misunderstandings, the following notations have been introduced:

▪ Bg pt. – situated at the intersection of the median line of the anterior face of the thorax and the interacromonial line.

▪ Cs pt. – situated at the level of the body of the sternum, dividing the distance between the base of the neck and umbilicus into two segments present in the ratio of the golden section.

▪ Xyph pt. – situated, according to the drawing, at the level of the xyphoid appendix, dividing the Cs–Umb distance in the golden section ratio.

▪ Umb pt. – it is an anthropometric point; it corresponds to the umbilicus and divides the height of the body according to the golden section ratio.

▪ Tuber pt. – corresponds to the median and horizontal line that cross the two ischiadic tuberosities, taken as reference points in the measurement technique of the length of the bust. For a greater accuracy of the horizontal measurement technique, it is placed at the level of the two-gluteal folds that would correspond to the horizontal line crossing the Tuber pt.

▪ Mc pt. – situated at thigh level, at the intersection of the median line of the body and the horizontal line that marks the middle of the distance between Tuber pt. and Kn pt.

▪ Kn pt. – situated on the median line at the intersection with the horizontal line crossing the upper limitof the knees.

▪ Tib pt. – corresponding to the tibial points, situated at the intersection of the median line with the straight line that joins the two tibial points, located at the medial extremities of the two tibial plateaux.

▪ Sp pt. – corresponds to the intersection of the median line with the horizontal line that joins the Sphy points situated at the level of the tibial malleoli.

1. *Acromion* (*acrom*) – represents the tegumentary projection of the most outward point of the scapula.

2. *Radiale* (*ra*) – is the highest point of the upper margin of the head of the radius.

3. *Dactylion* (*da*) – the point situated at the distal extremity of the middle finger.

4. *Stylion* (*sty*) – represented by the lowest point of the styloid process of the radius.

5. *Trochanterion* (*troh*) – represents the point corresponding to the large trochanter of the humerus, situated on the lateral face of the thigh.

Results and discussions

The calculations were made for a scale H = 177 cm. According to the drawing, the length of the following segments was determined:

H (distance Vertex–ground) = 177 cm, is divided, according to the golden section, into two parts:

▪ Dist. Vertex–Umbilicus = m = 67.61 cm.

▪ Dist. Umbilicus–Ground = M = 109.39 cm.

Dist. Vertex–Umbilicus = 67.61 cm is divided into:

▪ Dist. Vertex–Bg = m = 25.82 cm.

▪ Dist. Bg–Umb = M = 41.788 cm.

In connection to the point situated on the median line at the base of the neck, according to the drawing it is situated on the straight line that joins the two-acromial points. In the currently used technique, assessment of the length of the neck is made up to the suprasternal point, situated on the median line of the anterior thorax, at the level of jugular incisure of the sternum.

This inconsistency in defining the length of the neck will further perpetuate in the differences between the measured dimensions and the dimensions calculated for its length.

Observing the circumscribed circles with the umbilicus (Umb) as their centers, we can notice that:

▪ Dist. (Bg–Umb) = Dist. (Umb–Mc) = Dist. (Sst–Ra) = 41.788cm

▪ Dist. (Vertex – Umb) = Dist. (Sst – Sty) = 67.61cm

▪ Dist. (Elb joint– Umb) = Lgth Frarm = Dist. (Ra–Sty) = 67.61 – 41.788 = 25.821 cm

▪ Dist. (Base neck–Umb) = 41.788 cm is divided into:

Dist. (Bg–Cs) = m = 15.95 cm
Dist. (Cs–Umb) = M = 25.828 cm
▪ Dist. (Sternal body–Umb) = 25.828 cm is divided into:
Dist. (Cs–Xyph) = m = 9.86 cm
Dist. (Xyph–Umb) = M = 15.96 cm
▪ Dist. (Xyph–Umb) = Dtis. (Sst–Acrom) = 1/2 Biacr. diam.
▪ Biacr diam = 2 × 15.96 = 32 cm
▪ Dist (Sst–Ra) – Dist. (Sst–Acrom) = Arm lgth = 41.788 – 15.96 = 25.828 cm
▪ Dist. (Umb–Gr) = 109.39 cm is divided into:
Dist. (Umb–Tb) = M = 67.61 cm
Dist. (Tb–Gr) = m = 41.788 cm
▪ Dist (Umb–Tibials) = 76.61 cm is divided into
Dist. (Umb–Mc) = M = 41.788 cm
Dist (Mc–Tb) = m = 25.828 cm
▪ Dist. (Mc–Tb) = 25.828 cm is divided into:
Dist. (Mc–Kn) = M = 15.95 cm
Dist. (Kn–Tb) = m = 9.86 cm
▪ Dist. (Umb–Mid thigh) = 41.788 cm is divided into:
Dist. (Umb–Tuber) = M = 25.828 cm
Dist. (Tuber–Mc) = m = 15.95 cm
▪ Dist. (Tibials–Gr) = 41.788 cm is divided into:
Dist. (Tb–Tg) = M = 25.828 cm
Dist. (Tg–Gr) = m = 15.95 cm
▪ Dist. (1/3 shank–Gr) = 15.95 cm is divided into:
Dist. (1/3 shank–Sphy) = M = 9.86
Dist. (Sphy–Gr) = m = 6.09 cm
▪ Shank height = Dist. (Tib–Gr) – Dist. (Sph–Gr) = 41.788 – 6.09 = 35.69 cm
▪ Bust = Dist. (Vertex–Umb) + Dist. (Umb–Tuber) = 25.828 + 67.61 = 93.43 cm
▪ Dist. (Tuber–Gr) = H – Bust = 177 – 93.43 = 83.57 cm
▪ Dist. (Tuber–Tb) = Dist. (Tuber–Gr) – Dist. (Tb–Gr) = 83.57 – 41.788 = 41.788 cm
▪ Dist. (Troch–Tb) = Dist. (Umb–Cs) – Dist. (Umb–Xyph) = 25.828 – 15.96 = 9.86 cm
▪ Lgth Thigh = Dist. (Tuber–Tb) + Dist. (Troch–Tuber) = 41.788 + 15.95 = 57.73 cm
Figure 1 shows that:
▪ Dist. (Sst–da) = Dist. (sst–ra) × H/Dist. (Tuber–Gr) = 88.50 cm
▪ Span = 2 × Dist (Sst–da) = 177 cm
▪ Lgth Upp Lmb = (span–Diam. Biacr) = 72.5 – (25.82 + 25.82) = 20.86 cm
▪ Lgth Lmb = Lgth Upp Lmb – (Lgth Arm + Lgth Frarm) = 72.5 – (25.82) = 20.86 cm
▪ H (head + neck) = 25.82 cm

Referring to this value, the authors stated that it could not be compared to the measured values due to the difference between the reference points in determining the length of the neck (Table 2).

Table 2 – ***Measured and calculated values of the male subject, H = 177 cm***

No.	Name of the assessment	Measured values			Calculated values
		-DS	*VM*	*+DS*	
1.	T	164.55	177.00	198.45	177.00
2.	LMSdr.	66.53	77.44	88.36	72.50
3.	LBdr.	24.44	31.89	39.33	25.82
4.	LABdr.	22.87	26.11	29.34	25.82
5.	LMdr.	15.68	19.44	23.20	20.86
6.	LMIdr.	99.85	107.00	114.14	99.51
7.	LCSdr.	48.53	52.00	55.46	57.73
8.	LGBdr.	39.40	46.56	53.70	35.69
9.	IPdr.	5.97	8.44	10.92	6.09
10.	IC	20.76	23.00	25.24	IC+LG= 25.82
11.	LG	6.58	8.00	9.41	
12.	IB	84.30	89.00	93.69	93.43
14.	DBiAcr.	33.07	40.00	46.93	32.00
16.	DBitr.	24.03	30.44	36.86	32.00
17.	Anv.	170.29	194.44	218.59	177.00

The model achieved by applying the golden section rule, the actual calculation of the segments presented in the drawing, reveals the equality between segments, as follows: Leonardo da Vinci, who for the first time inscribed the human body in a circle and a square, creates the model thus conceived.

The square represents the human body in supine position with the arms abducted, so as to be in the same line. The size of the square is equal to the height of the respective body with the maximum arm span, thus considering that the two measurements have equal values.

The circle represents the inscription of the body in a circle. The individual is in supine position with both upper and lower limbs extended and at a 45-degree angle to the median line of the body.

The center of the circle is situated at the level of the umbilicus and the radius is equal to the distance umbilicus-finger / toe tips on condition that the limbs and fingers / toes are maintained in position with the articulations extended.

Unlike this model, the one created by applying the golden section rule situates the center of the circle at the level of the pubic symphysis and, consequently, this point divides the height of the body into two equal parts. The umbilicus plays a special role, as it divides height into two segments that correspond to the golden section ratio. Still, the rule of inscription into a square applies, in other words the length of the body equals its span.

Comparing the values determined by calculating the lengths of the segments to those obtained by measurements, there are a number of important differences, which, probably, represent the individual's adaptation to the modern man's lifestyle.

One can notice that the length of the upper limbs is in fact greater than in the model, the arm is longer than the forearm and they both exceed the values calculated according to the golden section rule.

The biacromial diameter is also greater, so that by adding these dimensions the resulting span is significantly greater for the measured values than for the theoretical ones. This adaptation can probably be put down to the use of the upper limbs in man's daily activities, which is characteristic of the modern man.

The length of the bust is lower than for the calculated values. The lower limbs have a totally different construction as compared to the ideal model. In the measured individual, versus the model, the height of the leg is greater; the shank is taller, so that the knee is situated higher from the ground.

From this level on, the ratios are reversed, so that the measured thigh is shorter than its calculated value. Considered as a whole, the lower limb is longer than the calculated value, displaying the same tendency as the upper limb.

Conclusions

In other words, we tend to grow farther from harmony and perfection. The actual individual has longer lower limbs, mainly due to a lengthening of the shanks to the prejudice of the thighs, maintains the optimum size for his bitrochanterian diameter, his bust is shorter and wider, and his upper limbs are longer due to a lengthening of both his arm and forearm.

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Received: 17 November, 2004

Accepted: 10 February, 2005