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Original Contribution

THE RATIO BETWEEN THE LENGTH OF UPPER AND DOWN PARTS OF THE BODY IN THE CROSS-SECTION OF THE EQUAL TORQUES APPEARS AS AN ANATOMICAL CONSTANT

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ABSTRACT

The bed scales determine the section, in which the torques of the upper and the down body parts are balanced. In this section the length and mass of the upper and down parts of the body were measured. **Aim of the study**: To investigate the ratio between the length of the upper and down part of the body in the cross-section of the equal torques of the upper and the down bodily parts. **Results**: 62 people between the ages of 18 and 28 were examined. The ratio H_{up} /H_{down} in the cross-section of the equal torques of the upper and down bodily parts don't depend from body height H and is equals to: H_{up} /H_{down} =0.791 H (i.e. H_{up} /H_{down} ~0.8 H). **Conclusions**: The ratio between the length of upper and down parts of the body in the cross-section of the equal torques of upper and lower bodily parts appears nearly an anatomical constant.

Key words: body, mass center, height, BMI, torques.

INTRODUCTION

In the previous study Atanasov [1, 2] developed a method for measuring the mass-center of the human body using a BED-SCALES device **(Figure 1).**

The bed-scales determine the section, in which the torques of the upper and down part of the body are balanced in the section O-O'. In this section, the body circumference is measured and a connection is sought between the measured body circumference and the parameters - body weight (M, kg), body height (H, m), and body mass index (BMI, kg /m^2). Indeed**, Figure 1** shows that:

$G_{up} H_{up} = G_{down} H_{down}$ (1)

$H = H_{up} + H_{down}$ (2)

$G = G_{up} + G_{down}$ (3)

Where G, G_{up} and G_{down} are the mass of the whole body of the upper body, and of the down body respectively. H, H_{up} and H_{down} are the height of the whole body and the upper and the down part of the body, respectively. The products $G_{up}H_{up}$ and $G_{down}H_{down}$ are the torques of the upper and down body parts.

In the section O-O ', in which the torques GupHup and Gdown Hdown are equal, the circumference of the body L is measured, with the help of which the center of gravity of the body is determined.

From G_{up} and G_{down} it can calculate the mass of the upper and down part of the body:

$M_{up} = G_{up}/g$ (4) and

$M_{down} = G_{down}/g$ (5), where

g is the Earth acceleration (g=9.81 m/s^2).

Thus, the ratio (1) gives the form of:

$M_{up}\, g\, H_{up} = M_{down}\, g\, H_{down}$ (6) or

$M_{up}\, H_{up} = M_{down}\, H_{down}$ (7) and

$H_{up} / H_{down} = M_{down} / M_{up}$ (8)

AIM OF THE STUDY

To investigate the ratio between the length of upper and down parts of the body in the cross section of the equal torques of the upper and the down bodily parts:

1. Measure the mass of the body M, the height H of body, H_{up}, and H_{down} length, M_{down} and

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M_{up} mass in the cross section of the equal torques.
2. Calculate the body mass index (BMI).
3. Calculate H_{up}/H_{down} and M_{down}/M_{up} ratio.
4. Investigate the statistical relationship between the measured parameters.

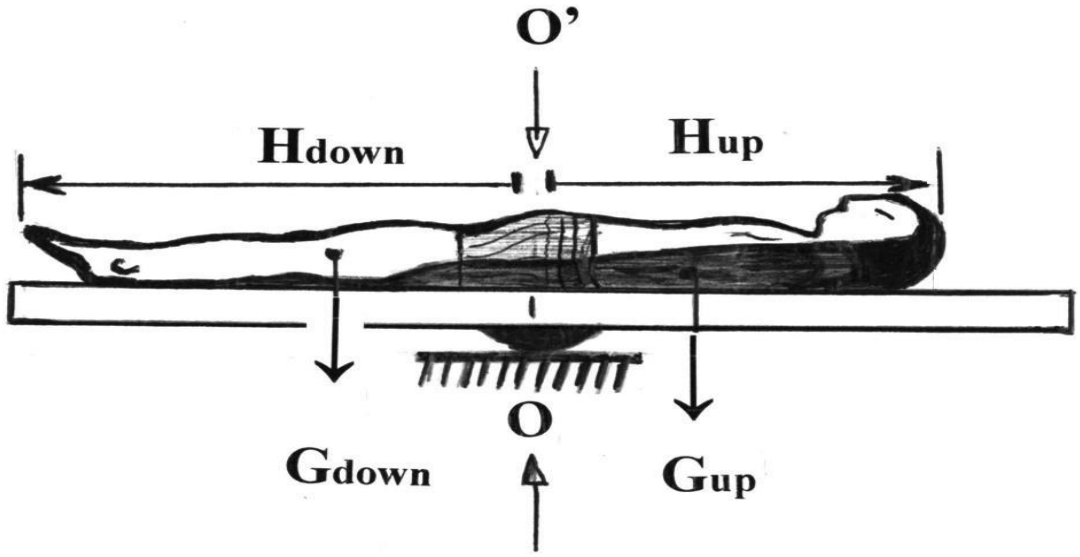

Figure 1. Bed-scales device. H_{up} and H_{down} length were measured in the cross-section OO' of the equal torques of upper and down bodily parts.

MATERIALS AND METHODS

62 people aged between 18 and 28 of both sexes were studied (24 men against 40 women).
The statistical program STATISTICS is used in the calculations.
The statistical significance of the found correlations was determined using Student's t-test.

RESULTS

The measured parameters - body weight M, body height H, H_{up} , H_{down}, calculated BMI and H_{up}/H_{down} values are given in **Table 1**. From the ratio (8) it can see that H_{up} /H_{down} ratio is equals to M_{down}/M_{up} ratio, because of that the M_{down}/M_{up} values are not given in **Table 1.**

Table 1. *Body mass M, body height H, BMI, H_{up} , H_{down}, and calculated H_{up}/H_{down} ratio*.*
Gender of participants are signed as (m) man and (w) woman.

N	M (kg)	H (m)	BMI (kg/m^2)	H_{up} (m)	H_{down} (m)	H_{up}/H_{down}
1	75 (m)	1.87	21.44	0.82	1.050	0.78095
2	44 (w)	1.60	17.1875	0.71	0.89	0.79775
3	102 (m)	1.84	30.1275	0.82	1.020	0.8039
4	97 (m)	1.83	28.9647	0.82	1.010	0.81188
5	57.9 (w)	1.57	23.4897	0.70	0.87	0.80459
6	54.4 (w)	1.55	22.64	0.71	0.84	0.84523
7	70 (m)	1.74	23.12	0.75	0.99	0.7575
8	59.3 (w)	1.75	19.36	0.79	0.96	0.82251
9	64.8 (w)	1.74	21.40	0.79	0.95	0.83157
10	69.7 (m)	1.64	25.91	0.70	0.94	0.7446
11	56 (w)	1.65	20.57	0.77	0.88	0.8750
12	64 (m)	1.83	19.11	0.78	1.050	0.7428
13	52.1 (w)	1.66	18.906	0.77	0.925	0.8324
14	63.9 (w)	1.66	23.189	0.69	0.97	0.71134
15	103 (m)	1.7	35.64	0.73	0.97	0.7525

16	66.6 (w)	1.7	23	0.76	0.94	0.8085
17	73.5 (m)	1.8	22.685	0.79	1.02	0.7745
18	51 (w)	1.69	17.857	0.76	0.93	0.8172
19	43.8 (w)	1.56	17.998	0.68	0.88	0.7727
20	67.3 (w)	1.73	22.485	0.77	0.96	0.80208
21	63 (m)	1.78	19.88	0.80	0.98	0.8163
22	63.5 (w)	1.65	23.32	0.75	0.90	0.8333
23	86.5 (m)	1.88	24.47	0.835	1.05	0.7952
24	81 (m)	1.83	24.187	0.87	0.97	0.8969
25	82 (m)	1.77	26.17	0.79	0.97	0.8144
26	95 (m)	1.9	26.315	0.83	1.08	0.7685
27	81 (m)	1.78	25.564	0.78	1.00	0.78
28	93 (m)	1.75	30.367	0.71	1.04	0.6893
29	86 (m)	1.85	25.128	0.81	1.05	0.7714
30	73(m)	1.83	21.798	0.80	1.03	0.7767
31	55 (w)	1.73	18.377	0.79	0.94	0.8404
32	76 (m)	1.88	21.50	0.84	1.04	0.8077
33	90 (m)	1.88	25.46	0.82	1.05	0.78095
34	50.7 (w)	1.59	20.05	0.70	0.89	0.7865
35	74 (w)	1.6	28.906	0.71	0.88	0.8068
36	58 (w)	1.55	24.14	0.70	0.86	0.81395
37	88 (m)	1.74	29.065	0.76	0.98	0.7755
38	60 (w)	1.64	22.30	0.69	0.96	0.71875
39	110 (m)	1.81	33.57	0.81	1.0	0.81
40	56 (w)	1.54	23.61	0.68	0.87	0.7816
41	95 (m)	1.79	29.65	0.75	1.04	0.7211
42	54 (w)	1.70	18.685	0.74	0.96	0.7708
43	54 (w)	1.7	18.685	0.74	0.96	0.7708
44	54 (w)	1.59	21.36	0.70	0.90	0.7777
45	55 (w)	1.60	21.484	0.70	0.90	0.7777
46	59.5 (w)	1.63	22.394	0.73	0.90	0.81111
47	104 (m)	1.8	32.1	0.74	1.05	0.7047
48	63 (w)	1.68	22.32	0.77	0.92	0.83695
49	75.5 (m)	1.84	22.287	0.77	1.06	0.7264
50	55 (w)	1.72	18.591	0.76	0.96	0.7917
51	67 (w)	1.70	23.18	0.76	0.94	0.8085
52	57 (w)	1.65	20.936	0.73	0.93	0.7849
53	83 (w)	1.60	32.422	0.68	0.91	0.74725
54	52 (w)	1.54	21.93	0.71	0.83	0.8554
55	47 (w)	1.64	17.475	0.77	0.87	0.885
56	54 (w)	1.63	20.32	0.72	0.92	0.7826
57	90 (w)	1.62	34.293	0.73	0.89	0.8202
58	60 (w)	1.5	26.66	0.66	0.85	0.7764
59	59 (w)	1.65	21.671	0.72	0.94	0.7595
60	62 (w)	1.63	23.335	0.72	0.91	0.7912
61	51(w)	1.54	21.5	0.68	0.87	0.7816
62	47 (w)	1.58	18.827	0.70	0.87	0.8046

*H_{up} /H_{down} = M_{down} /M_{up}

A parametric linear regression analysis of the statistical relationship between the body parameters (a, b, c) was performed:

a. (H_{up}/H_{down}) ratio and body height (H) of the subjects – **Figure 2.**

b. (H_{up}/H_{down}) ratio and body mass (M) of the subjects – **Figure 3.**

c. (H_{up}/H_{down}) ratio and body mass index (BMI) of the subjects –**Figure 4.**

Table 2 presents the studied dependencies and their correlation coefficients.

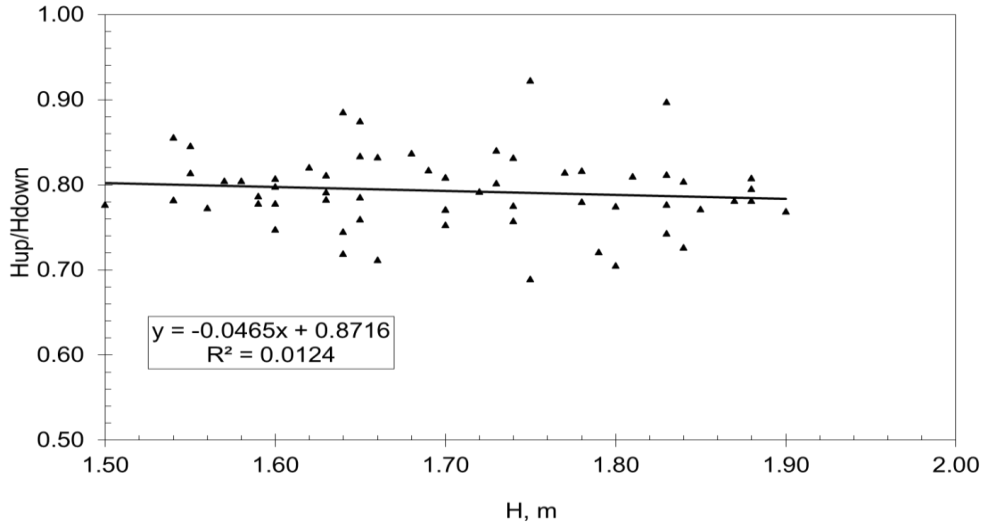

Figure 2. Relationship between H_{up} /H_{down} and body height H.

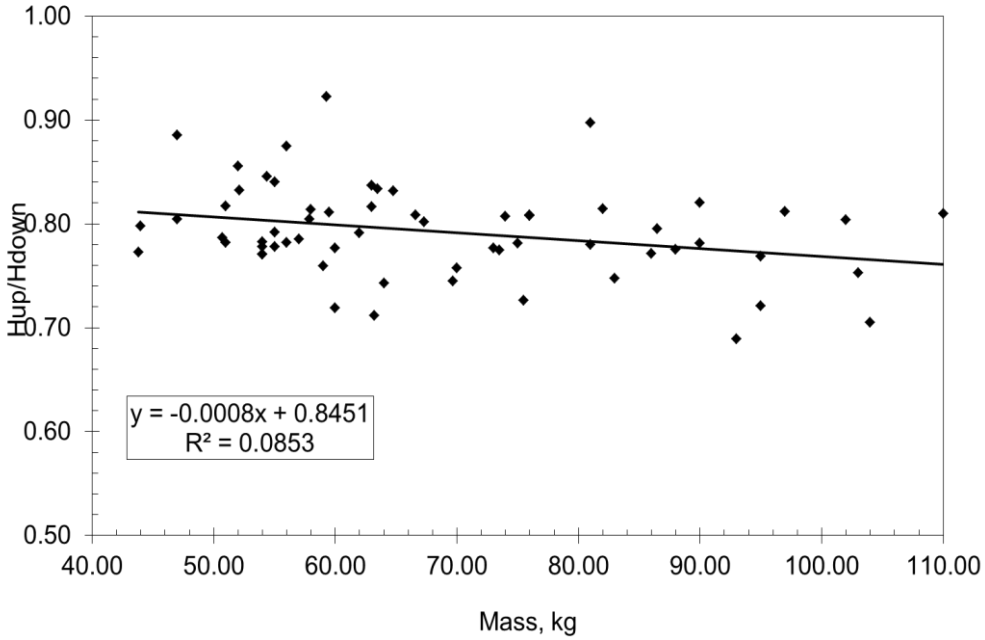

Figure 3. Relationship between H_{up} /H_{down} and body mass M.

Table 2. *The studied bodily dependencies and their correlation coefficients*

Measured values	Statistical relationship	Correlation coefficients	(Statistical - significance)
1). H_{up} /H_{down}- H	H_{up} /H_{down} = - 0.0465 H + 0.8716	R = - 0.11	(p>0.05)
2). H_{up} /H_{down}- M	H_{up} /H_{down} = - 0.0008 M + 0.8451	R = - 0.29	(p<0.05)
3). H_{up} /H_{down}- BMI	H_{up} /H_{down} = - 0.0031 BMI + 0.8666	R = - 0.31	(p<0.05)

From experimental data on **Table 2** and **Figure 2** it can see that the ratio H_{up} /H_{down} in the cross section of the equal torques of the upper and lower bodily parts don't depend from body height H. The correlation coefficient between H_{up} /H_{down} and H (see Eq.1) is very low (R=-0.11) and the connection between two quantities do not have statistical significance (p> 0.05).

The calculated H_{up}/H_{down} ratio of 62 persons fall in the range of 0.75 – 0.832 with mean (±SD) equals to 0.791 (± 0.041). Independently to the body height, the body mass and the body-mass index this, this ratio remains constantly: H_{up}/H_{down} = 0.791 H.

Because of H_{up} /H_{down} = M_{down} /M_{up} , the ratio between the down and the upper body mass in the cross section of the equal torques is equals to: M_{down} /M_{up} =0.791H .

From experimental data on **Table 2** and **Figure 3**, and **Figure 4** is observed that the relationship H_{up}/H_{down} depends slightly from the body mass M (Eq.2) and the body mass index BMI (Eq.3). In the two cases the correlation coefficients R= -0.29 and R = -0.31 are low, but the connection between H_{up}/H_{down} and M, and BMI have a statistically significance (p <0.05).

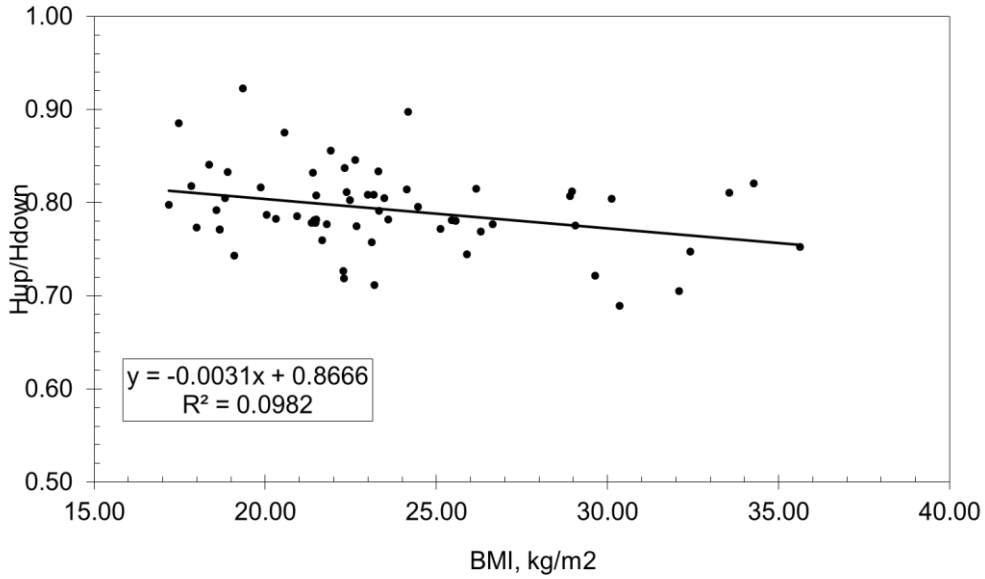

Figure 4. Relationship between H_{up} /H_{down} and BMI.

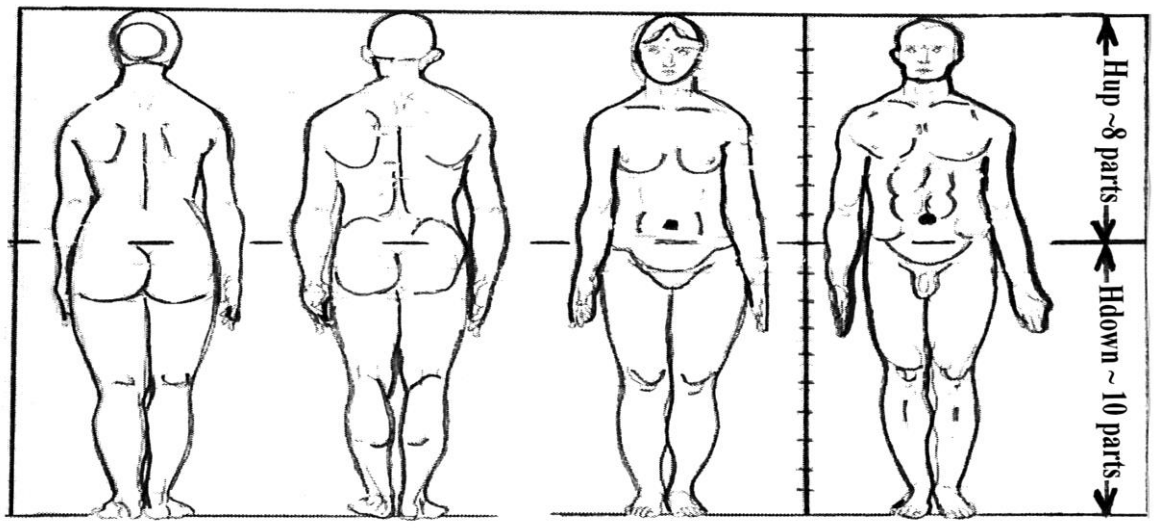

Figure 5. The approximate location of the cross section of the equal torques of the upper and lower part of the human body: Hup / Hdown ~ 8/10.

DISCUSSION

The ratio H_{up}/H_{down} remains constantly, independently to the gender, the body height, the body mass and the body-mass index: $H_{up}/H_{down} = 0.791$ H (/i.e. $H_{up}/H_{down} \sim 0.8$ H).

Because of $H_{up}/H_{down} = M_{down}/M_{up}$, the ratio between the down and the upper body parts of the mass in the cross section of the equal torques is
equals to: $M_{down}/M_{up} = 0.791H$ (i.e. $M_{down}/M_{up} \sim 0.8$ H).

On **Figure 5** is shown the approximate location of the cross section of the equal torques of the body.

The find relationships can be used to solve various scientific problems such as abdominal obesity, spinal deformities and others [3-6].

CONCLUSSION

The ratio between the length of H_{up} and H_{down} part of the body in the cross section of the equal torques of upper and lower bodily parts appears nearly an anatomical constant. This ratio can be presented as $H_{up}/H_{down} \sim 8/10$.

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