



RESEARCH ON THE BODY-MASS INDEX OF THE BODY AND THE BODY CIRCUMFERENCE IN THE CURRENT SECTION OF THE EQUAL ROTATION MOMENTS OF THE UPPER AND LOWER PART OF THE BODY

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ABSTRACT

The bed-scales determine the section in which the torques of the upper and lower body is balanced. In this section, body circumference is measured and a relationship is sought between body circumference and body mass parameters (M, kg), body height (H, m), and body mass index (BMI, kg/m²). **Aim of the study:** Investigate the relationship between the circumference of the body in the cross section of the equal torques of the upper and the lower body and the body mass index of the body. **Results:** 64 people between the ages of 18 and 28 were examined. The high correlation coefficient between the body circumference and body mass and BMI, as well as low correlation coefficient between body circumference and body height were obtained. **Conclusions:** There is no statistically significant relationship between body circumference and height. At different body heights, equal body circumferences can be observed.

Key words: body center, body circumference, BMI, body rotation

INTRODUCTION

It is known that body mass index can be an indicator of health, and functional status, quality of life and risk of mortality in different age groups. In addition to the body mass index, the waist, hips, and chest circumference of the human body are also used as indicators of

health status. They are an objective indicator of diseases mainly related to overweight and the risk of cardiovascular disease [1]. In the previous study Atanasov [2] developed a method for measuring the center of the mass [3] of the human body using a BED-SCALES device (**Figure 1**).

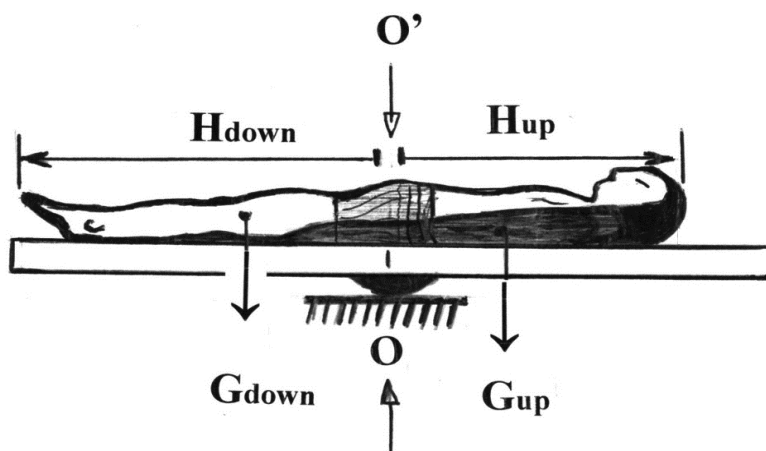


Figure 1. Bed-scales. The circumference of the body L in the cross section of the equal torques O-O' of the upper and lower part of the body.

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The bed-scales determine the section, in which the torques of the upper and lower part of the body is balanced (see 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 /m²). Indeed, Figure 1 shows that:

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

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

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

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

In the section O-O', in which the torques G_{up}H_{up} and G_{down}H_{down} are equal, the circumference of the body L is measured, with the help of which the center of gravity of the body is determined.

AIM OF THE STUDY

To study the relationship between the circumference of the body in the cross section

of the equal torques of the upper and lower body and the body mass index of the body.

MATERIALS AND METHODS

64 people aged between 18 and 30 of both sexes (24 men and 40 women) were studied.

1. Measure the mass of the body M, the height of the body H, the circumference of the body L in the cross section of the equal torques.
2. Calculate the body mass index.
3. The statistical relationship between body circumference, mass, height and body mass index is studied.
4. The statistical relationship between body weight and height is studied.
5. The statistical program STATISTICS is used in the calculations.
6. The statistical significance p of the found correlations was determined using Student's t-test.

RESULTS

The measured parameters - bodyweight M, body height H, body circumference L and calculated BMI values of the body are given in **Table 1**. The statistical sample of data for men and women in **Table 1** is not homogeneous (24 men against 40 women). For this reason, differentiating the result only for men and only for women will not be statistically significant. That's why we look at the two sexes together.

Table 1. BMI and circumference of the body in the cross section of equal torques.

N	Mass (kg) man-(m) woman-(w)	Height (m)	BMI (kg/m ²)	Circumference of the body L in the cross section of equal torques (m)
1	75 (m)	1.87	21.44	87
2	44 (w)	1.60	17.1875	77
3	102 (m)	1.84	30.1275	109
4	97 (m)	1.83	28.9647	101
5	57.9 (w)	1.57	23.4897	96
6	54.4 (w)	1.55	22.64	95
7	70 (m)	1.74	23.12	85
8	59.3 (w)	1.75	19.36	98
9	64.8 (w)	1.74	21.40	96.5
10	69.7 (m)	1.64	25.91	107
11	56 (w)	1.65	20.57	96
12	64 (m)	1.83	19.11	78
13	52.1 (w)	1.66	18.906	91
14	63.9 (w)	1.66	23.189	90
15	103 (m)	1.7	35.64	126
16	66.6 (w)	1.7	23	96
17	73.5 (m)	1.8	22.685	96
18	51 (w)	1.69	17.857	81
19	43.8 (w)	1.56	17.998	86

20	67.3 (w)	1.73	22.485	95
21	63 (m)	1.78	19.88	89
22	63.5 (w)	1.65	23.32	96
23	86.5 (m)	1.88	24.47	105
24	81 (m)	1.83	24.187	96
25	82 (m)	1.77	26.17	101
26	95 (m)	1.9	26.315	106
27	81 (m)	1.78	25.564	105
28	93 (m)	1.75	30.367	93
29	86 (m)	1.85	25.128	97
30	73 (m)	1.83	21.798	90
31	55 (w)	1.73	18.377	88
32	76 (m)	1.88	21.50	99
33	90 (m)	1.88	25.46	100
34	50.7 (w)	1.59	20.05	87
35	74 (w)	1.6	28.906	109
36	58 (w)	1.55	24.14	84
37	88 (m)	1.74	29.065	98
38	60 (w)	1.64	22.30	95
39	110 (m)	1.81	33.57	115
40	56 (w)	1.54	23.61	95
41	95 (m)	1.79	29.65	102
42	55 (w)	1.56	22.6	90
43	54 (w)	1.70	18.685	95
44	54 (w)	1.7	18.685	87
45	54 (w)	1.59	21.36	91
46	55 (w)	1.60	21.484	98
47	60 (w)	1.65	22.038	93
48	59.5 (w)	1.63	22.394	97
49	104 (m)	1.8	32.1	121
50	63 (w)	1.68	22.32	96
51	75.5 (m)	1.84	22.30	104
52	55 (w)	1.72	18.591	89
53	67 (w)	1.70	23.18	101
54	57 (w)	1.65	20.936	89
55	83 (w)	1.60	32.422	118
56	52 (w)	1.54	21.93	94
57	47 (w)	1.64	17.475	85
58	54 (w)	1.63	20.32	88
59	90 (w)	1.62	34.293	118
60	60 (w)	1.5	26.66	102
61	59 (w)	1.65	21.671	95
62	62 (w)	1.63	23.335	98
63	51 (w)	1.54	21.5	84
64	47 (w)	1.58	18.827	87

The calculated BMI from **Table 1** of the age group between 18 and 30 years falls in the range from 17 kg/m² to 34 kg/m². These values range from lean people with an underweight body mass index (BMI <19) to overweight people (BMI > 34). This wide range of body mass indices contributes to the objectivity of the dependences obtained below from **Figure 2** to **Figure 5**.

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

- a. Circumference (L) and body mass of the subjects (M) – **Figure 2**.
- b. Circumference (L) and body height of the subjects (H) – **Figure 3**.

c. Circumference (L) and body mass index of the subjects (BMI) – **Figure 4**.

d. Body mass (M) and body height of the subjects (H) – **Figure 5**.

Student t-test was performed for each of these 4 (a, b, c, d) regression relationships.

It was found that with the exception of the relationship between circumference (L) and body height (H), the remaining relationships

were statistically significant with a level of statistical significance $p < 0.00001$.

In **Figure 2**, the relationship between body circumference and body mass is presented. **Figure 3** shows the relationship between body circumference and body height. **Figure 4** shows the relationship between body circumference and body mass index. **Figure 5** shows the relationship between body weight and body height. All figures are presented on a linear scale.

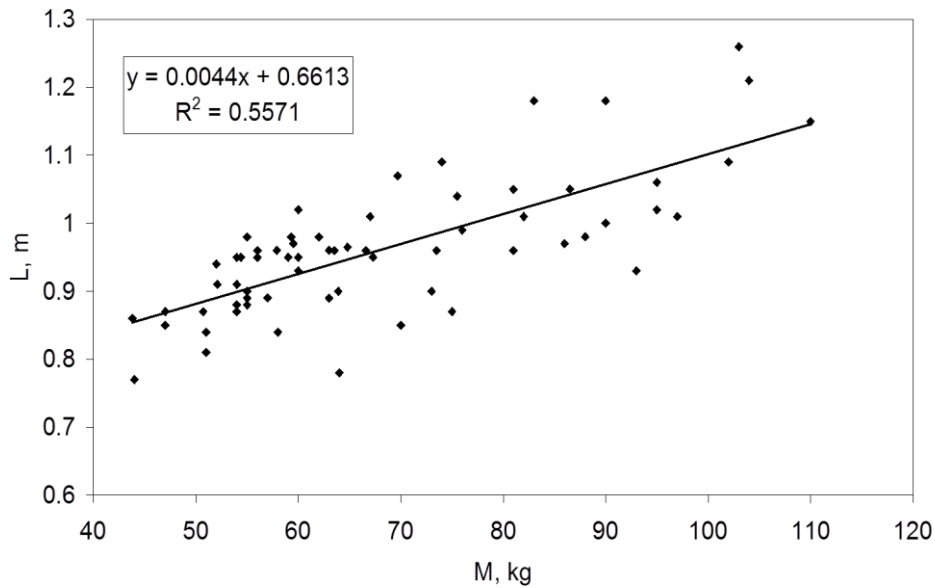


Figure 2. Dependence between the circumference length L (m) and the mass M (kg) of the subjects. Level of statistical significance $p < 0.00001$.

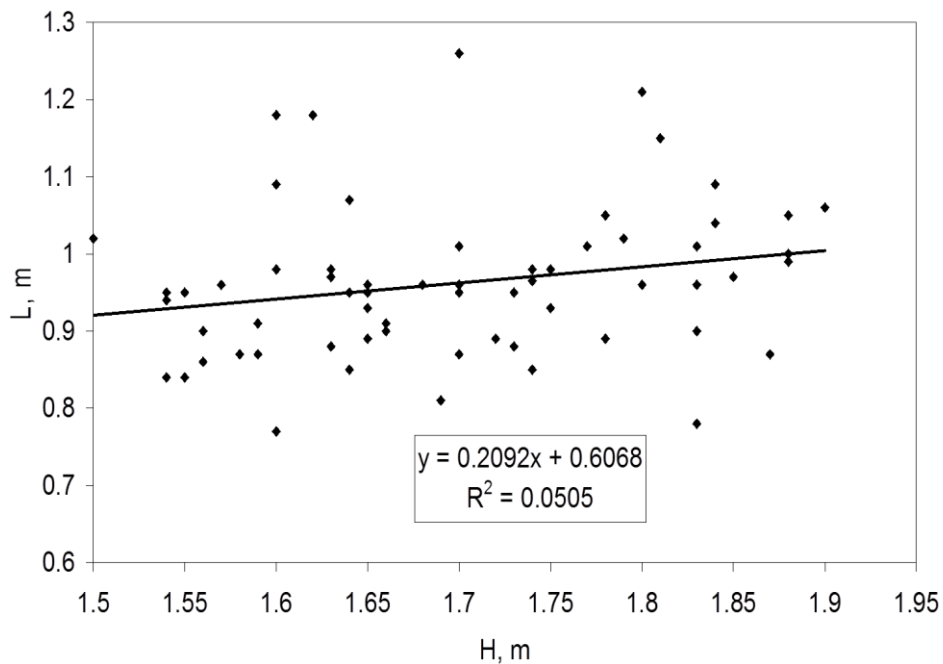


Figure 3. Dependence between body circumference L (m) and body height H (m). Insignificant correlation $p > 0.05$.

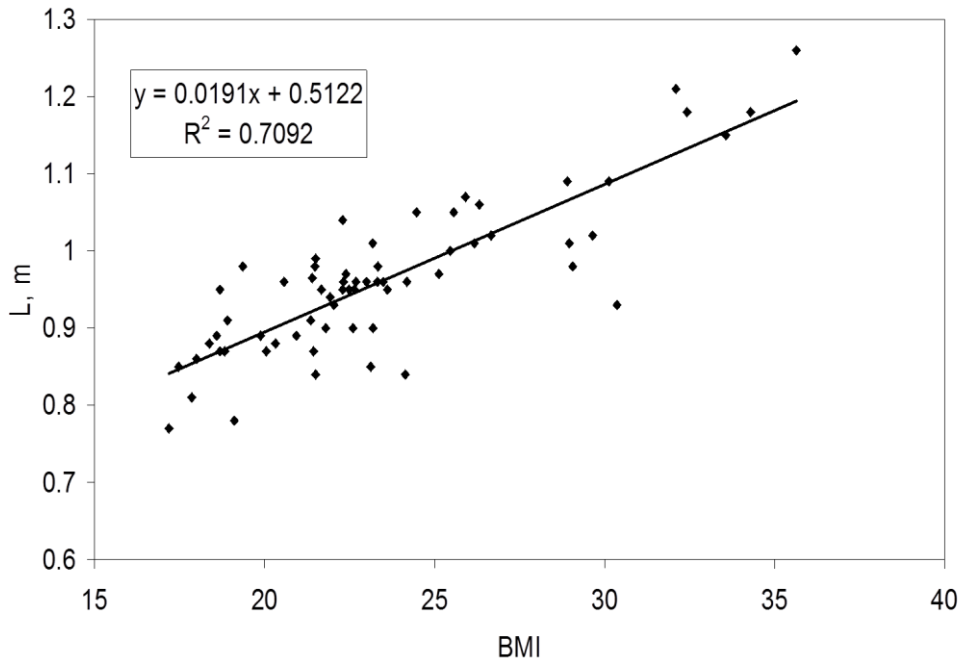


Figure 4. Relationship between body circumference L (m) and BMI (kg/m²). Level of statistical significance $p < 0.00001$.

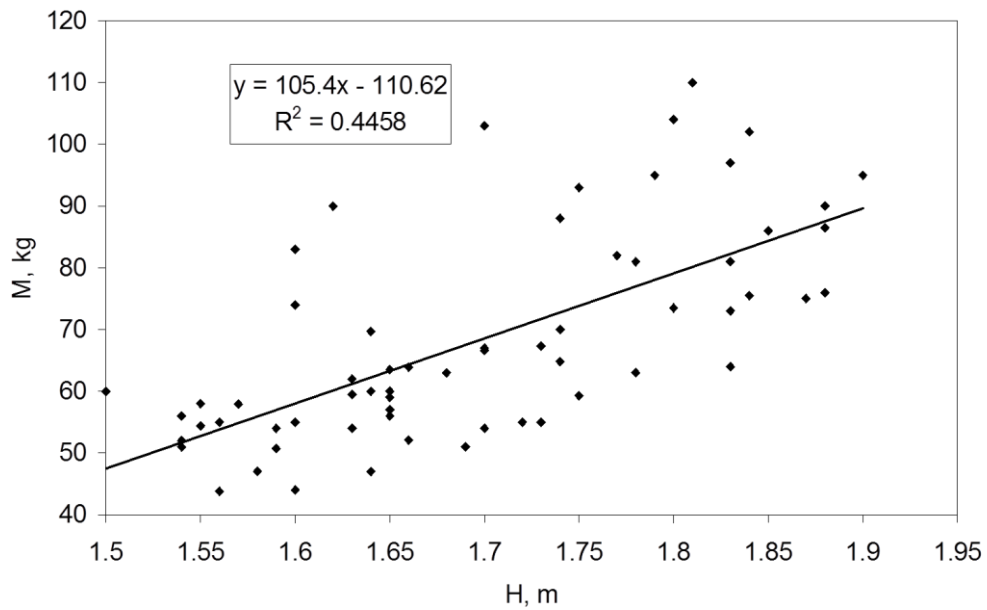


Figure 5. Dependence between body mass M (kg) and body height H (m). Level of statistical significance $p < 0.00001$.

Table 2 presents the studied dependencies and their correlation coefficients.

Table 2. The studied bodily dependencies and their correlation coefficients

Measured values	Statistical relationship	Correlation coefficients	Significant level
L-M	$L = 0.0044 M + 0.6613$	$R=0.7464$	$p < 0.00001$
L-H	$L= 0.2092 H + 0.6068$	$R=0.2247$	$p > 0.05$
L -BMI	$L = 0.0191 \text{ BMI} + 0.5122$	$R =0.8421$	$p < 0.00001$
M - H	$M = 105.4 H - 110.62$	$R = 0.6677$	$p < 0.00001$

DISCUSSION

Interestingly, from **Table 2** it can be observed that there is no statistically significant relationship between body circumference and its height - the correlation coefficient is relatively low ($R = 0.22$), the level of statistical significance is $p > 0.05$. Therefore, it can be considered that the two parameters of the body are practically unrelated. At different heights of the body, close circumferences of the body and vice versa can be observed.

It is known that the criterion for abdominal obesity is the circumference of the waist, which is measured horizontally around the middle of the body and represents the distance from the hip ridge of the pelvic floor to the lower end of the last rib [4]. The larger the waist circumference, the higher the risk of cardiovascular disease. In our study, we measured the circumference of the body in the cross section of the equal torques of the upper and lower body, which also falls from the hip ridge of the upper of the pelvis to the lower end of the last rib. In this way we have fixed a specific place in the human body in which we believe that the waist circumference is the most representative. In this case, due to the high correlation coefficient (0.8421) between the circumference of the body L / i.e. waist (s) and body mass index (BMI), it can be concluded that these body characteristics are related parameters with a level of statistical significance $p < 0.00001$.

This is a new result that has not been reported in the scientific literature. The obtained results can find applications in solving various scientific problems [5, 6].

CONCLUSIONS

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

- a. Circumference (L) and body weight (M)
- b. Circumference (L) and body height (H)
- c. Circumference (L) and body mass index (BMI)
- d. Bodyweight (M) and body height (H)

Student t-test was performed for each of these 4 regression relationships.

It was found that with the exception of the relationship between circumference (L) and body height (H), the remaining relationships were statistically significant with a level of statistical significance $p < 0.00001$.

At a relatively high correlation coefficient ($R = 0.7464$) between the circumference of the body L (in the cross section of equal torques) and the mass of the body M and a low correlation coefficient (0.2247) between the circumference of the body L and the height of the body H, a high correlation coefficient is obtained (0.8421) between the body circumference and the BMI.

A correlation coefficient (0.6677) was observed between body mass M and body height H, which is less than that between body circumference and body mass (0.7464).

The level of statistical significance (p) of the found linear correlations between the circumference of the body L with the mass of the body M, the height of the body H and the body mass index BMI is $p < 0.00001$.

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