Original Article

ENDOMORPHY DOMINANCE AMONG NON-ATHLETE POPULATION IN ALL THE RANGES OF BODY MASS INDEX

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ABSTRACT

Introduction: Body composition and fitness testing for non-athlete population is being implemented only to those who take memberships in health clubs but still amidst various limitations like expertise and instrumentations, so the quality of fitness evaluation process remains substandard in many health clubs. At one point, for personal learning purpose and at the same time, to improve the quality of fitness evaluation and training services, data of somatotype variables were collected using Heath-Carter somatotype method to enhance the understanding of the somatotype, physical efficiency parameters and outcomes of exercise participation and life style modifications of personal clientele.

Objectives: The objective of this research study was to subject the collected data of somatotype variables of about 77 non-athlete subjects (males = 44, females = 33) into statistical analyses, interpret the somatotype diversity among the thirteen established somatotypes, compare the findings with the somatotype data of Olympic athletes obtained from Encyclopedia of International Sports Studies, relate the anthropometric variables with BMI classification and stimulate further researches.

Results: Out of 77 non-athlete subjects, it was found that approximately 87% were mesomorphic endomorph, 5% were ectomorphic endomorph, 7% were balanced endomorph, 1% was mesomorph endomorph and zero representation for other 9 somatotypes. This is chiefly because their endomorphy component was greater than the mesomorphy and ectomorphy components, regardless of BMI, as detected by Heath-Carter anthropometric somatotype method.

Conclusion: Heath-Carter anthropometric somatotype testing should be considered indispensable in Physiotherapy curriculum and practice. Sustained applications of somatotype test in all clinical and fitness evaluations have the potential of enhancing public awareness about measuring health through periodical somatotype testing not just only by BMI and laboratory testing of physiologic parameters because very high endomorphy component and its health risks may be hidden inside various accepted non-obese body frames as well.

KEY WORDS: Heath-Carter anthropometric somatotype, Body mass index, Endomorphy dominance.

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INTRODUCTION

Various inexpensive and less complicated assessments like Body Mass Index (BMI), Waist to Hip ratio (WHR) have been used to monitor the health status of humans, though these methods alone cannot help understanding the entirety of health of individuals. The diagnostic accuracy of BMI is limited and future studies are necessary to determine if body composition measurements predict obesity related risk better than WHR and waist circumference [1]. The BMI was invented by Adolphe Quetelet in the 1800's which considers only height and weight of an individual to compute and diagnose the health status but the body composition aspects are not discussed in this assessment. The magnitude of obesity epidemic may be greatly underestimated by the use of BMI as the marker of obesity [2]. In the process of scientific developments aimed at understanding human physique better, the term 'Somatotype' was introduced and described by William Sheldon in 1940, which got further advanced by Barbara Heath and Linday Carter to a level of universal acceptance as Heath-Carter anthropometric somatotype method since 1980. Somatotype is defined as the quantification of present shape and body composition of the human body which is expressed in three-number rating to represent the relative fatness (endomorphy), the relative musculoskeletal robustness (mesomorphy) and the relative slenderness (ectomorphy) of a physique [3].

Body composition and fitness testing for non-athlete population is being implemented only to those who take memberships in fitness clubs but still amidst various limitations like expertise of fitness experts and instrumentations. At one point, to improve the quality of fitness training services, it was decided to include Heath-Carter somatotype method to better understand the somatotype, physical efficiency parameters and outcomes of exercise participation and life style modifications of personal clientele. BMI is an inadequate proxy for somatotype [4]. This study observed somatotype characteristics in non-athlete population to understand their relationship with all BMI ranges.

METHODOLOGY

The objective was to subject the collected somatotype variables of 77 non-athlete individuals (males = 44, females = 33) into statistical analyses, interpret the somatotype diversity, compare the findings with the somatotype data of Olympic athletes (Table-1) obtained from Encyclopedia of International Sports Studies [5], relate the anthropometric variables with BMI classification [6] (Table-2) and stimulate further researches. The data pertinent to somatotype variables were collected using the instruments shown in Photograph-1 during the fitness evaluation process and uploaded into the MS Excel sheet after embedding the formulae in it mentioned below;

Endomorphy = $- 0.7182 + 0.1451 (\Sigma) - 0.00068 (\Sigma^2) + 0.0000014 (\Sigma^3)$

Mesomorphy = $(0.858\ HB + 0.601\ FB + 0.188\ CAG + 0.161\ CCG) - (0.131\ H) + 4.5$

Ectomorphy =

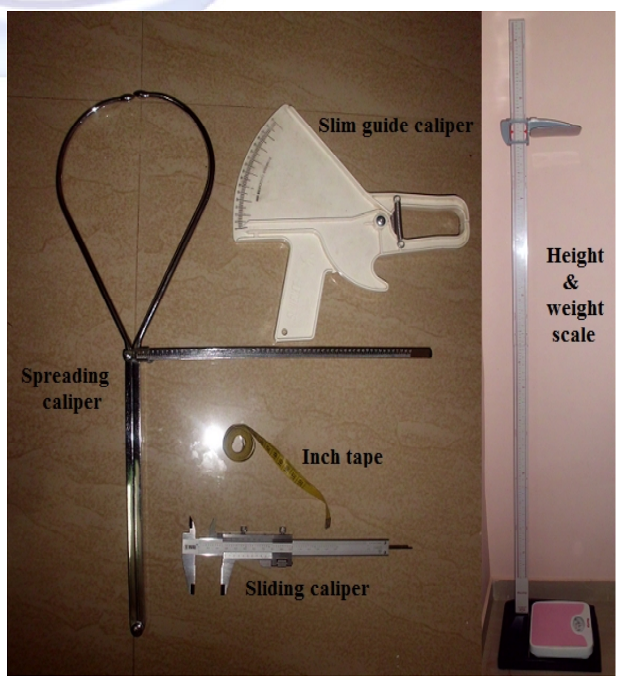
If HWR $\geq$ 40.75, then Ectomorphy = $0.732\ HWR - 28.58$

If HWR < 40.75 and > 38.25, then Ectomorphy = $0.463\ HWR - 17.63$

If HWR $\leq$ 38.25, then Ectomorphy = 0.1

where: Σ = (sum of triceps, subscapular and supraspinale skinfolds) multiplied by (170.18/ height in cm); HB = humerus breadth; FB = femur breadth; CAG = corrected arm girth; CCG = corrected calf girth; H = height; HWR = height / cube root of weight. CAG and CCG are the girths corrected for the triceps or calf skinfolds respectively as follows: CAG = flexed arm girth - triceps skinfold/10; CCG = maximal calf girth - calf skinfold/10.

Photograph 1: Precision instruments used in Heath-Carter anthropometric somatotype test.



(Sliding caliper - Humeral condylar breadth, Spreading caliper - Femoral condylar breadth, Slim guide caliper - Skin fold thickness, Inch tape - arm and calf circumferences)

This non-athlete group was in the age group of 20 - 45 years and had a mixture of sedentary life stylists and exercisers who exercise recreationally without scientific guidance. This group contained 90% of Indians and remaining 10% of subjects from other countries like Israel, United Kingdom and Spain.

Table 1: Somatotype values of male and female Olympic athletes, taken from Encylopedia of International Sports Studies (P-Z).

Somatotype of male Olympic athletes			
	Endomorphy	Mesomorphy	Ectomorphy
Olympic Sprinters	1.6	5	3
Olympic Jumpers	1.8	5.1	2.6
Olympic Swimmers	2.1	5.1	2.8
Olympic Gymnasts	1.4	5.8	2.5
Olympic Canoeists	1.5	5.2	3.1
Somatotype of female Olympic athletes			
	Endomorphy	Mesomorphy	Ectomorphy
Olympic Sprinters	2.2	3.6	3.2
Olympic Jumpers	2.4	2.7	4.3
Olympic Swimmers	3.2	3.8	3
Olympic Gymnasts	2.1	4	3.4
Olympic Canoeists	2.8	4.1	2.9

Table 2: Body Mass Index classification.

Category	BMI range - kg/m^2
Underweight	Less than 18.5
Normal weight	18.5 - 24.9
Overweight	25 - 29.9
Obese	30 & above

BMI Classification. Global Database on Body Mass Index. World Health Organization. 2006.

RESULTS

Frequency distribution of 77 individuals in all BMI ranges can be found in table-3 and there was no male found with BMI less than 18.5 but only one female in this category who displayed Ectomorphic endomorph somatotype with 6.2-1.9-4.2. Table 4 - 9 shows the relationship between all observed anthropometric variables and BMI ranges (excluding < 18.5 category). The endomorphy dominance of these non-athletes in all BMI ranges can be seen in the graphs -1 and 2 that compare the findings with somatotype of Olympic sprinters. For general understanding, though there is no direct connection between this somatotype data of Olympic sprinters taken from the Encylopedia of International Sports Studies (P-Z), the graph description also contains the BMI of 100 meters sprint male and female finalists of 2012 London Olympics calculated combining data from two internet resources [7]. Table-10 shows the somatotype distribution of this non-athlete population.

Table 3: Frequency distribution of 44 males and 33 females in all BMI ranges.

BMI classification	Frequency (n = 44) - Males	Frequency (n = 33) - Females
< 18.5	0	1
18.5 - 24.9	14	17
25 - 29.9	19	12
30 & above	11	3

Table 4: Relationship between observed anthropometric variables of females and BMI range of 18.5-24.9.

Variables	BMI = 18.5 - 24.9 (n=17)		
	Range	Mean	Standard deviation
BMI	18.8 - 24.4	21.85	1.78
Height (cm)	154 - 178	163.59	5.8
Weight (Kg)	49 - 71	58.5	5.43
Triceps (mm)	16 - 29	20.59	3.15
Subscapular (mm)	16 - 47	27.59	9.2
Suprailiac (mm)	19 - 51	31.88	9.7
Medial calf (mm)	10 - 25	17.94	4
Humeral condyle (cm)	5.3 - 6.4	5.87	0.35
Femoral condyle (cm)	8.4 - 9.8	8.56	0.51
Arm girth (cm)	23.5 - 29.5	26.53	1.41
Corrected arm girth (cm)	22.1 - 26.6	24.47	1.33
Calf girth (cm)	31 - 35	33.67	0.58
Corrected calf girth (cm)	29.8 - 33.4	31.88	1
Endomorphy	6 - 10.3	7.8	1.14
Mesomorphy	1.2 - 4.3	3	2.98
Ectomorphy	0.8 - 4	2.3	2.3

Table 5: Relationship between observed anthropometric variables of females and BMI range of 25-29.9.

Variables	BMI = 25 - 29.9 (n=12)		
	Range	Mean	Standard deviation
BMI	25.1 - 28.7	27.1	1.08
Height (cm)	154 - 176	164.25	6.68
Weight (Kg)	64 - 87	73.26	7.6
Triceps (mm)	18 - 34	26	4.94
Subscapular (mm)	22 - 59	40	9.52
Suprailiac (mm)	30 - 58	44.25	8.9
Medial calf (mm)	14 - 36	25.16	8
Humeral condyle (cm)	4.8 - 6.6	5.9	0.79
Femoral condyle (cm)	8.3 - 10.1	8.96	0.61
Arm girth (cm)	29 - 33	30.46	1.36
Corrected arm girth (cm)	26 - 30	27.85	1.39
Calf girth (cm)	33 - 41	36.62	2.56
Corrected calf girth (cm)	31.2 - 37.4	34.1	2.14
Endomorphy	8.6 - 10.8	9.5	0.85
Mesomorphy	2.8 - 5	4.2	0.57
Ectomorphy	0.1 - 1.1	0.6	0.32

Table 6: Relationship between observed anthropometric variables of females and BMI range of 30 & above.

Variables	BMI = 30 & above (n=3)		
	Range	Mean	Standard deviation
BMI	30.3 - 34.9	33.1	2.13
Height (cm)	153 - 157	155.3	3.59
Weight (Kg)	71 - 86	80	6.48
Triceps (mm)	33 - 37	34.3	2.4
Subscapular (mm)	42 - 60	53.66	8.3
Suprailiac (mm)	39 - 54	44.3	6
Medial calf (mm)	16 - 32	26	7.1
Humeral condyle (cm)	5.8 - 6.9	6.23	0.43
Femoral condyle (cm)	9.4 - 10.7	9.93	0.61
Arm girth (cm)	30 - 36	33.8	3.1
Corrected arm girth (cm)	26.7 - 32.7	30.4	2.8
Calf girth (cm)	38 - 43	40	2.14
Corrected calf girth (cm)	35.8 - 50	37.4	1.85
Endomorphy	10 - 11.5	10.7	1.54
Mesomorphy	6.1 - 8.8	7.2	1.24
Ectomorphy	-	0.1	0

Table 7: Relationship between observed anthropometric variables of males and BMI range of 18.5 - 24.9.

Variables	BMI = 18.5 - 24.9 (n=14)		
	Range	Mean	Standard deviation
BMI	20.6 - 24.8	22.89	1
Height (cm)	159 - 182	172.1	6.62
Weight (Kg)	52 - 78.5	67.97	6.63
Triceps (mm)	6 - 20	12.57	3.9
Subscapular (mm)	13 - 42	30.7	8.7
Suprailiac (mm)	19 - 65	34.7	12.1
Medial calf (mm)	6 - 16	11.14	2.98
Humeral condyle (cm)	5.5 - 7	6.34	0.5
Femoral condyle (cm)	8.4 - 9.8	8.98	0.32
Arm girth (cm)	26 - 31.5	29.1	2.9
Corrected arm girth (cm)	24.8 - 30.2	27.85	1.41
Calf girth (cm)	31 - 37	33.57	1.73
Corrected calf girth (cm)	30 - 35.8	32.45	1.73
Endomorphy	5.2 - 9.6	7.4	1.3
Mesomorphy	2.2 - 4	3.2	0.48
Ectomorphy	1.3 - 3.6	2.3	0.61

Table 8: Relationship between observed anthropometric variables of males and BMI range of 25 - 29.9.

Variables	BMI = 25 - 29.9 (n=19)		
	Range	Mean	Standard deviation
BMI	25 - 29.9	27.8	1.73
Height (cm)	163 - 183	173.89	5.44
Weight (Kg)	73.4 - 99.3	84.13	6.75
Triceps (mm)	5 - 21	13.89	4.16
Subscapular (mm)	17 - 59	40.2	9.34
Suprailiac (mm)	14 - 52	38.3	9
Medial calf (mm)	6 - 25	13.1	5.64
Humeral condyle (cm)	6.1 - 7.3	6.7	0.64
Femoral condyle (cm)	8.5 - 9.8	9.27	0.4
Arm girth (cm)	28 - 36	32.18	2.2
Corrected arm girth (cm)	26.4 - 34.8	30.8	2.23
Calf girth (cm)	32.5 - 41	36.8	2.67
Corrected calf girth (cm)	32 - 40.1	35.5	2.55
Endomorphy	4.1 - 10.4	8.3	1.34
Mesomorphy	2.7 - 6.6	4.6	0.93
Ectomorphy	0.1 - 1.62	0.8	0.44

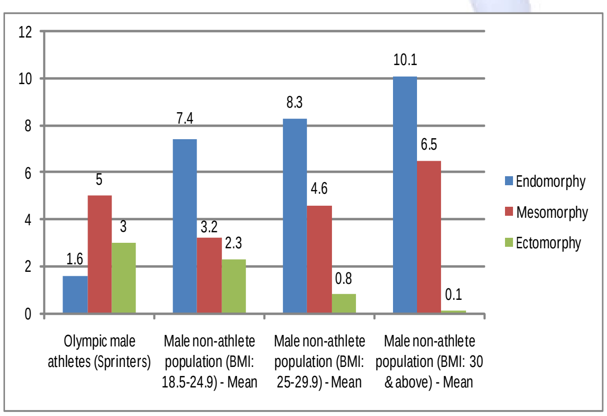
Table 9: Relationship between observed anthropometric variables of males and BMI range of 30 & above.

Variables	BMI = 30 & above (n=11)		
	Range	Mean	Standard deviation
BMI	30.5 - 41.3	35.35	3.6
Height (cm)	164 - 177	172.13	4.64
Weight (Kg)	85 - 123	104.9	12.9
Triceps (mm)	15 - 35	20.8	5.89
Subscapular (mm)	36 - 68	54.8	7.87
Suprailiac (mm)	39 - 65	53.63	7.55
Medial calf (mm)	11 - 34	21.3	7.8
Humeral condyle (cm)	5.7 - 7.5	6.77	1
Femoral condyle (cm)	8.8 - 11.2	9.88	0.73
Arm girth (cm)	32 - 41	36.59	2.73
Corrected arm girth (cm)	30.4 - 39.4	34.7	3.3
Calf girth (cm)	36.5 - 46	41	4.06
Corrected calf girth (cm)	35.3 - 43.2	38.95	2.64
Endomorphy	9 - 11.2	10.1	0.71
Mesomorphy	4.5 - 8.2	6.5	1.21
Ectomorphy	0.1 - 0.2	0.1	0.04

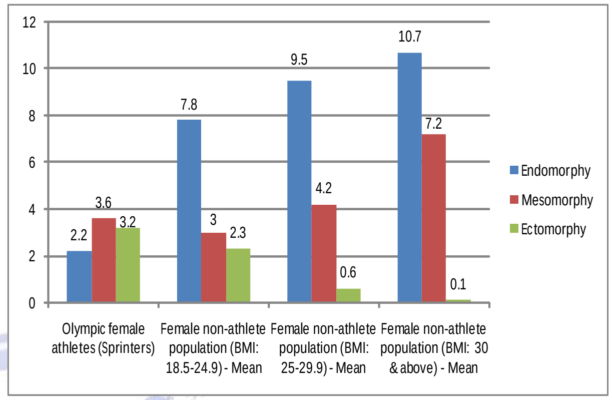
Table 10: Somatotype distribution of 77 individuals in all BMI ranges. These non-athlete subjects did not display characteristics of other nine somatotypes.

	BMI: < 18.5		BMI: 18.5 - 24.9		BMI: 25 - 29.9		BMI: 30 & above	
	Males	Females	Males	Females	Males	Females	Males	Females
Balanced endomorph	0	0	3	2	0	0	0	0
Mesomorph endomorph	0	0	0	0	1	0	0	0
Mesomorphic endomorph	0	0	11	12	18	12	11	3
Ectomorphic endomorph	0	1	0	3	0	0	0	0

Graph 1: Endomorphy dominance of 44 males in all BMI ranges as compared to mesomorphy dominance among Olympic male athletes. The average BMI of 8 male 100 meters finalists in London Olympics 2012 was calculated and understood as 23.43, BMI range: 22 - 24.5 tracing their personal performance and height-weight data in two internet resources [7].



Graph 2: Endomorphy dominance of 32 females in all BMI ranges as compared to mesomorphy-ectomorph dominance among Olympic female athletes. The average BMI of 8 female 100 meters finalists in London Olympics 2012 was calculated and understood as 21, BMI range: 19.42 - 24.8 tracing their personal performance and height-weight data in two internet resources [7].



DISCUSSION

Out of 77 non-athletes subjects, approximately 87% were mesomorphic endomorph, 5% were ectomorphic endomorph, 7% were balanced endomorph, 1% was mesomorph endomorph and zero representation for other 9 somatotypes. This is chiefly because the endomorphy component for all the 76 individuals were greater than other two components (except only one male who showed Mesomorph endomorph features with BMI = 25) regardless of BMI which is very evident in table 4 - 9. One of the major contributors for higher percentage of endomorphy dominance in this study, regardless of BMI, is the skin fold thickness at subscapular and suprailiac regions (Table: 4-9). According to table-1, Olympic male athletes display characteristics of Ectomorphic mesomorph but Mesomorph ectomorph, Balanced ectomorph, Central, Ectomorphic mesomorph and Balanced mesomorph are the characteristics of female Olympic sprinters, jumpers, swimmers, gymnasts and canoeists, respectively. Most Olympic athletes dominate over their endomorphy component with their mesomorphy and ectomorphy components; hence able to demonstrate their heightened physical efficiency in the competitions they participate. Considering the Olympic male athletes' ectomorphic mesomorph somatotype as the best on the basis of their world class physical efficiency parameters through mesomorphy dominance with endomorphy being the least, this research puts forward a hypothetical ranking system for the thirteen somatotypes (Table-11) in which Ectomorphic endomorph secures last rank as it is dominated by endomorphy with mesomorphy being the least. It is a well known fact that individuals with high mesomorphic and low endomorphic components can perform work more efficiently than those with high endomorphic and low mesomorphic components [8]. Exploring this hypothetical somatotype ranking system can be one of the next levels of somatotype researches associating various kinanthropometric parameters. In fact, during this research study, it was also observed that individuals belonging to same somatotype varied in their body size, somatotype variables and physical efficiency levels. Such variations are highly likely, for example, 1-1-7 and 1.53-1.61-3.86 belongs to balanced ectomorph, but the former seems a representation of malnourished individuals whilst, the latter was found to be the anthropometric characteristics of top-class Kenyan marathon runners [9]. The variations of body size and shape of individuals with same somatotype can be understood in 'Somatotyping - Development and applications' in the appendix sections [10].

Somatotype, by itself, was found to be significantly related to longevity and the endomorphs were shorter lived [11]. Although the mesomorphy dominance has been proven to exhibit better physical work capacity, the mesomorphy component alone may not be the sole determinant of fitness and health, hence important modifications in exercise methods, nutrition and lifestyle are needed to obtain a satisfactory strength of all somatotype components. Somatotype having a dominant mesomorphy and marked endomorphy constitutes a risk factor as a particular predisposition toward certain diseases and requires body weight control [12]. Paulina Yesica Ochoa Martíne et al researched two groups of older adults with and without metabolic syndrome, whose somatotype was 6.5-8.7-0.1 and 6.2-7.9-0.2, respectively, and found that the agility and dynamic balance were significantly better in older adults with absence of metabolic syndrome despite having a similar somatotype of the group with metabolic syndrome [13]. Katarzyna L. Sterkowicz-Przybycieñ et al found endomorphic mesomorph wrestlers (2.0–6.6-1.2) with lower endomorphy and interrelated with higher competition level presented by the wrestlers [14]. This wrestlers' somatotype is an example that the mesomorphy dominance with lower endomorphy can exhibit higher fitness competency, so mesomorphy dominance alone may be insufficient to give an ideal body structure associated with health and higher physical capabilities.

Table 11: Hypothetical somatotype ranking.

Rank	Somatotype	Rationale
1	Ectomorphic mesomorph	Mesomorphy component is greater than the ectomorphy whereas the endomorphy is the smallest.
2	Mesomorph ectomorph	Mesomorphy and ectomorphy are either equal or differ no more than 0.5 units and dominates over the endomorphy.
3	Balanced mesomorph	Mesomorphy dominates whereas the ectomorphy and endomorphy are either equal or differ no more than 0.5 units.
4	Endomorphic mesomorph	Mesomorphy is greater than the endomorphy whereas the ectomorphy is the smallest.
5	Mesomorphic ectomorph	Ectomorphy is greater than the mesomorphy and the endomorphy is the smallest.
6	Balanced ectomorph	Ectomorphy dominates whereas the mesomorphy and endomorphy are either equal or differ no more than 0.5 units.
7	Central	All the three somatotype components are either equal or differ no more than one unit from the other two, the ratings of all the components should be within and consist of ratings of 2, 3 or 4.
8	Mesomorph endomorph	Endomorphy and mesomorphy components are either equal or differ no more than 0.5 units and dominate over ectomorphy.
9	Balanced endomorph	Endomorphy dominates whereas mesomorphy and ectomorphy are either equal or differ no more than 0.5 units.
10	Mesomorphic endomorph	Endomorphy is greater than the mesomorphy whereas ectomorphy is the smallest.
11	Endomorphic ectomorph	Ectomorphy dominates over endomorphy and the mesomorphy is the smallest.
12	Endomorph ectomorph	Endomorphy and ectomorphy are either equal or differ no more than 0.5 units and dominate over mesomorphy.
13	Ectomorphic endomorph	Endomorphy is greater than the ectomorphy whereas mesomorphy is the smallest

CONCLUSION

This study has incorporated somatotype observations in all BMI ranges and made evident that the endomorphy dominance was exhibited by larger number of non-athletes regardless of BMI and predominantly, this non-athlete population tended to be Mesomorphic endomorph. Investi

-gation of the hypothetical somatotype ranking system along with establishment of physical efficiency variations (both intra-somatotype and inter-somatotype) can be pursued as cross-sectional and longitudinal researches. Heath-Carter anthropometric somatotype testing should become a part of Physiotherapy curriculum and considered indispensable in all clinical and fitness evaluations for enhancing public awareness about measuring health through periodical somatotype testing not just only by BMI and laboratory testing of physiologic parameters because very high endomorphy component and its connected health risks may be hidden inside various accepted non-obese body frames as well.

Conflicts of interest: None

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