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Determination of somatotype and physical activity level in frailty older adults

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Abstract - Aim: To determine the somatotype profile and level of physical activity in older adults. **Methods:** Seventy-two older adults were divided into two groups: frail (F = 33) and non-frail (NF = 39). Frailty status was determined using the Tilburg Frailty Indicator (TFI), somatotype using the Heath and Carter method, and physical activity by the International Physical Activity Questionnaire (IPAQ). **Results:** Somatotype analysis showed a predominance of endomorphy (F = 6.54 ± 1.65 vs NF = 6.12 ± 2.07 $p \leq 0.350$) followed by mesomorphy (F = 3.44 ± 1.62 vs NF = 3.15 ± 2.19, $p \leq 0.531$) and ectomorphy (F = 0.82 ± 0.99 vs NF = 0.95 ± 0.86 $p \leq 0.163$), but no significant differences were observed between groups. Regarding PA, twenty-eight participants (84.7%) of the F group were classified as sedentary and insufficiently active and twenty-one (53.8%) of NF were classified as active and very active. This difference in PA explains the higher total energy expenditure found in NF (median 1,087.43; IAQ = 3,954.30) when compared to F (median = 0.0; IAQ = 462.64 $p \leq 0.001$). The frailty group presented a higher endomorphic component as well as lower levels of physical activity and energy expenditure. **Conclusion:** Endomorphy was the predominant somatotype in F and NF older adults, followed by mesomorphy and actomorphy this profile can affect activities of daily living, functional capacity, and independent living and be associated with chronic diseases.

Keywords: frailty, somatotype, older adults, physical activity.

Introduction

The changes associated with age-related frailty are complex, slow and gradual, promoting biopsychosocial modifications that over time will result in phenotype of weakness, fatigue, diminished tolerance to stress, loss of adaptability, functional limitations, higher risks of diseases, increased risk of hospitalization, morbidity and mortality[1,2]. Researches, policymakers and health authorities are unanimous in saying that frailty has an impact on the person, families, health-care system and social relationships[1]. Lourenço et al.[2] showed that frailty in older adults brasilian population varies between 6.7 to 74.1% when the frailty scale of the Health Cardiovascular Study was applied. Furthermore, it was directly related to age, educational level, chronic diseases and being more prevalent in women than men.

Aging is also associated with significant changes in body composition, such as reduction of lean mass, bone density, height and increase in the body fat[3]. The muscle mass that represents almost half of the total body mass plays a fundamental role in locomotion, metabolic function, force production and maintenance of glucose metabolism. The muscle mass decreases approximately 3-8% per decade after the age fo 30 and this rate of decline is even higher after the age of 60. This fast loss of muscle mass is accompanied by a reduction in muscular force and power, resulting in sarcopenia[4].

Body fat increases with aging, which is associated with a reduction in insulin sensitivity[5]. Westphal[5] showed that the body fat location is more important than total body fat. The author stated that after middle age, there is a redistribution of body fat storage in the body, changing from subcutaneous to visceral. This visceral body fat is associated with insulin resistance, metabolic syndrome, hypertension, dyslipidemia, diabetes type 2, cardiovascular diseases and certain types of cancer. Furthermore, there is evidence that a higher percentage of body fat can predict independently functional incapacity[3].

Physical activity is recommended for reversing or delaying the progression of frailty[6]. Peterson et al.[7] showed that physical activity plays an important protective role in frailty syndrome by reducing associated risk factors such as sarcopenia, functional decline, cognitive performance, and depression. Furthermore, older adults that are physically active show lower percentage of body fat, higher levels of muscle mass, maintenance of their functional capacity and reduced risks of falls.

Currently there is an increased interest in the study of constitutional features of the human body and their correlation with the manifestations of various diseases. The use of anthropometric methods to determine health and disease conditions has always been a concern among researchers because they are low cost, non-invasive, and easy to apply in clinical medicine[8-10]. Moreover, the determination of somatotype and physical activity level conbined with clinical practice will increase the safety and efficacy of pharmacotherapy as well as overall treatment outcomes and the patient's quality of life[10].

Heath and Carter[8] proposed an update on Sheldon's anthropometric method for somatotype estimation that takes into account physical type determination based on embryonic origin (endoderm, mesoderm, and ectoderm). Endomorphy is related to the predominance of adiposity in the establishment of the body type, mesomorphy reflects the predominance of musculoskeletal development, and ectomorphy translates the involvement of the relative linearity aspect of the body type. Although some researchers have determined somatotype profiles during growth[11] for cardiovascular risk factors[12], diabetes[13,14] and hipertension[15], somatotype profile in older frail adults still need to be determined. Therefore, to our knowledge this is firsty research that aimed to determine the somatotype profile and level of physical activity in older adults.

Methodology

Participants

Seventy-two (n = 72, 42 females and 30 males) older adults participated in this cross-sectional quantitative study. The older adults were recruited from the University hospital at the University of Sao Paulo Medical Centre. Older adults were divided into two groups (1) Frail (F; n = 33) and (2) non-frail (NF; n = 39). Participants signed an informed consent form approved by the Committee of Ethics in Human Research of the University Hospital at the University of Sao Paulo Medical Centre (protocol #2.497.068), respecting the CNS resolution 466/2012. Older adults with dementia, psychiatric disorders, cognitive impairment, stroke, blindness and deafness were excluded from the current study. Apparently healthy older adults with independent locomotion and no perceived cognitive impairment were included in our sample.

Frailty assessment

The frailty status was determined by an adapted version of the Tilburg Frailty Indicator (TFI)[16], taking into consideration cultural background[19]. This TFI consisted of fifteen (15) questions distributed in the physical, psychological and social domains, in which it is attributed to a score of zero (0) or one (1). Scores in the physical domain can vary from a minimum of zero (0) to a maximum of eight (8), the psychological domain varies from zero (0) to four (4), and the social domain varies from zero (0) to three (3). The final score can vary from a minimum of zero (0) and a maximum of fifteen (15). Higher scores in this instrument indicate higher frailty status, or if an individual reached 5 points or more, they were classified as frail.

Anthropometry and somatotype assessment

Height (cm) was measured by a stadiometer (Standard Sanny ES2030, São Bernardo do Campo, São Paulo, Brazil) with a precision of 0.1 cm. Body mass (kg) was measured by using a scale with a precision of 0.1 kg (Toledo BL2097PP, São Bernardo do Campo, São Paulo, Brazil). The body mass index (BMI) was determined by dividing the body weight expressed in kilograms by their height in meters squared (BMI = BM/H kg/m^2), where BW = body mass (kg) and H = height (m). Body composition was measured by a skinfold calliper (Lange, Beta Technology, Santa Cruz, California, USA) with a precision of 0.2 mm following standard anatomical sites. Biceps, triceps, subscapular, pectoral, midaxillary, suprailiac, supraspinal, abdominal (vertical), thigh and calf skinfolds were collected on the right side of the body. Body circumference was measured by an anthropometric measurement tape (Sanny, São Bernardo do campo, São Paulo, Brazil) with a precision of 1 mm. Waist, abdomen, hip, forearm, arm (relaxed and contracted), proximal and medial thigh and calf were measured on the right side of the body.

The Heath e Carter method[14] was used for the somatotype assessment. The endomorphic component was determined by the measurements of the subscapular, supraspinal and triceps skinfolds (mm) and height (cm). The mesomorphic component was determined by using height (cm), femur breadth (cm), humerus breadth (cm), upper arm girth (cm) and maximal calf girth (cm). The upper arm girth and maximal calf girth values were corrected by subtracting triceps and calf skinfolds values, respectively. The ectomorphic component was determined by calculating the ponderal index (height (cm)/body mass

[kg])$^{1/3}$). All These measurements followed the International Society for the Advancement of Kinanthropometry.

Physical activity assessment

Physical activity levels were determined by using the International Physical Activity Questionnaire (short IPAQ). This questionnaire allows the estimation of time spent per week in different aspects of physical activity, such as walking as well as activities of moderate and vigorous intensities. This tool only takes into account physical activities performed above 10 min[17].

Statistical analyses

The sample size required was estimated using G* Power 3.1 software (version 3.1.9.4), with the effect size of the previous study that to compare agility and dynamic balance in elderly women relating to morpho-functional changes[18]. A priori power analysis assuming an estimating error of α + 0.05, and power = 80% to an actual power was 0.80 suggested a sample size of 72 participants.

Descriptive statistical analysis with measurements of central tendency and preliminary analysis was performed to ensure no violation of the assumption of symmetry, skewness (Kurtosis), homogeneity (Levene test) and normal distribution of the data (Shapiro-Wilk test). If data passed ($p > 0.05$), an independent sample T-test was used to identify any statistically significant differences between the frail and non-frail groups related to the dependent variables; otherwise, a Mann-Whitney Rank Sum test was used to identify these statistical differences. The effect size was determined by using Cohen's d analysis and correlational effect based on Cohen's d values ($d = d/\sqrt{d^2 + 4}$). A stepwise Wilks' Lambda was used to assess the differences between the frail and non-frail groups on multiple variables simultaneously. The significance level was set at $p < 0.05$. All analyses were conducted using Statistical Package for Social Sciences (SPSS) version 23.0 (IBM, Armonk, New York, USA). Data are presented as mean ± standard deviation (SD).

Results

Participants characteristics

The participants' characteristics are described in Table 1. Our sample was comprised of 72 older adults, where 42% (30) were males and 58% (42) females. More specifically, the frailty group consisted of thirty-three individuals (*n* = 33; 23 females and 10 males), and the non-frailty group of thirty-nine (*n* = 39; 19 females and 20 males) older adults. Body mass (BM), height (H), and percentage of body fat (%BF) passed the Shapiro-Wilk normality test ($p > 0.05$). However, age, body mass index (BMI) and Tilburg Frailty Indicator (TIF) failed the normality test ($p < 0.05$). Therefore, a T-test for independent samples was performed in the normally distributed and a Mann-Whitney Runk Sum Test for the non-normally distributed variables to determine significantly statistical differences between groups (F and NF). The Mann-Whitney Runk Sum Test showed that there were differences in TIF between groups (F = 7.2 ± 1.9; NF = 2.0 ± 1.5); $U = 3.500$; $p < 0.001$; 95%CI [2.45-3.83]) with large effect (Cohen's $d = 3.07$) and correlational effect $r = 0.8$) and the probability of 98.5% that F would be higher than NF. Age, BM, H, BMI, and %BF were not statistically different between groups ($p > 0.05$) with insignificant effects (see Cohen's d values in the table).

Somatotype

All variables passed the Shapiro-Wilk normality test ($p > 0.05$), except the ectomorphic component. Although the endomorphic component did not show statistical differences between F (6.54 ± 1.65) and NF (6.09 ± 2.05) ($t(70) = -1.01$; $p < 0.32$; 95%CI [5.95-7.13]), there was a small effect (Cohens' d = 0.24; r = 0.1) and probability of 56.7% that F would be greater compared to NF. The mesomorphic and ectomorphic body types did not show statistically significant differences between F (meso: 3.44 ± 1.62; ecto: 0.82 ± 0.98) and NF (meso: 3.13 ± 2.16; ecto: 0.98 ± 0.88) (meso: $t(70) = -0.68$; $p < 0.50$; 95%CI [2.87-4.01]; ecto: $U = 539.00$; $p < 0.23$; 95%CI [0.47-1.18]. There were non-significant effects for meso (Cohens' d = 0.16; r = 0.1) and ecto (Cohen's

Table 1 - Participants characteristics.

Variables	F (*n* = 33)	NF (*n* = 39)	95% CI	p-value	Cohen d
Age (yrs)	74.4 ± 10.6	73.2 ± 10.2	−3.7-6.1	0.59	0.12
Body mass (kg)	66.8 ± 12.6	67.2 ± 10.1	−5.84-5.04	0.86	−0.04
Height (m)	1.60 ± 0.1	1.57 ± 0.1	−0.02-0.08	0.17	−0.30
BMI (kg/m^2)	27.1 ± 4.4	26.3 ± 4.0	−1.19-2.79	0.31	0.19
%BF	32.3 ± 7.1	30.5 ± 8.4	−1.84-5.44	0.33	0.23
TIF	7.2 ± 1.9	2.0 ± 1.5	4.38-6.02	< 0.001*	3.07

Data are presented as mean ± SD. F (frail); NF (non-frail); CI (confidence interval); BMI (body mass index); %BF (percentage of body fat); TIF (Tilburg Frailty Indicator). *Statistically significant difference between F and NF.

d = −0.17; r = −0.1) with probability of 54.5% and 45.1% that F would have higher values than NF, respectively (Table 2).

Calories expenditure

Total calorie expenditure and calories expended during walking, moderate, and vigorous activities (kcal/week) in frail and non-frail older adults are presented in Table 3. All the variables failed the Shapiro-Wilk Normality Test ($p < 0.05$); thus, a Mann-Whitney Rank Sum was used to determine statistical differences between groups. Non-frail individuals showed higher total energy expenditure (median = 1087.43 kcal/week; *IQR* = 3954.30 kcal/week) in comparison with frail (median = 0.0; *IQR* = 462.64) ($p < 0.001$). The NF also demonstrated that they had higher levels of moderate activities (median = 20.00 kcal/week; *IQR* = 1271.02 kcal/week) than the F (median = 0.0 kcal/week; *IQR* = 0.0 kcal/week) (p = 0.002) For vigorous activities, the NF group had higher levels (median = 0.0 kcal/week; *IQR* = 941.50 kcal/week) compared with the F group (median = 0.0 kcal/week; *IQR* = 0.0 kcal/week) (p = 0.025). However, there were no statistically significant differnces in walking calorie expenditure (kcal/week) between groups (p = 0.371).

Physical activity levels

Table 4 depicted the levels of physical activity based on the IPAQ instrument. A sedentary lifestyle was presented in 18 of 33 participants in the F group (54.5%) and 11 of 39 participants in the NF group (28.2%). Insufficient active A accounted for 12.1% in the F group (4 of 33 participants) and 10.3% in the NF group (4 of 39 participants). Additionally, 6 of 33 participants (18.2%) were classified as insufficient active B in the F and 4 of 39 participants (10.3%) in the NF. In the F group, 2 of 33 participants (6.1%) were considered active, and 12 of 39 individuals (30.8%) were active in the NF. Only 9.1% (3 of 33) of the participants in the F and 20.5% (8 of 39) in the NF were classified as very active.

Table 2 - Somatotype values in frail and non-frail older adults.

Variables	F (*n* = 33)	NF (*n* = 39)	95% CI	p-value	Cohen's d
Endo	6.54 ± 1.65	6.09 ± 2.05	5.95-7.13	0.32	0.24
Meso	3.44 ± 1.62	3.13 ± 2.16	2.87-4.01	0.50	0.16
Ecto	0.82 ± 0.98	0.98 ± 0.88	0.47-1.18	0.23	−0.17

Data are presented as mean ± SD. F (frail); NF (non-frail); CI (confidence interval); endo (endomorphic body type); meso (mesomorphic body type); ecto (ectomorphic body type). *Statistically significant difference between F and NF.

Table 4 - Levels of physical activity based on the IPAQ.

Classification	F (n = 33)	NF (n = 39)
Sedentary	18 (54.5%)	11 (28.2%)
Insufficient active A	4 (12.1%)	4 (10.3%)
Insufficient active B	6 (18.2%)	4 (10.3%)
Active	2 (6.1%)	12 (30.8%)
Very active	3 (9.1%)	8 (20.5%)

Data are presented as percentage values. F (frail); NF (non-frail); IPAQ (International Physical Activity Questionnaire).

Discussion

The main aim of the study was to determine the predominant somatotype in F older adults. Thus, we found a predominance of endomorphism (fat component), which was accompanied with higher values in body fat percentage and BMI. However, when these variables were compared with NF Older adults there was no difference.

To our knowledge, our study is the first to determine somatotype in frail older adults, which makes a comparison with other studies more difficult. However, the results obtained are in agreement with previous studies performed with type 2 diabetics, hypertensive individuals, and breast cancer patients[12-15,19]. The authors also found higher values for endomorphy, followed by mesomorphy and ectomorphy. Researchers were unanimous in stating that the predominance of endomorphy is associated with chronic diseases.

Buffa et al.[9] studied healthy elderly women divided into class intervals (60-69, 70-79, and 80-89 years), found that the endomorphic component changes with the aging process. Thus there may be an association between endomorphy, visceral and subcutaneous fat.

In this line of thought Reinders et al.[20] and Liyu Xu[21] showed that higher body fat, larger waist circumference, and lower muscle mass are associated with a higher risk of frailty and mortality. However, the relationship between frailty and BMI is discordant. Some studies

Table 3 - Total calorie expenditure and calories expended during walking, moderate, and vigorous activities in frail and non-frail older adults.

Variables	F (*n* = 33) Median (IQR)	NF (*n* = 39) Median (IQR)	p-value
Walking (kcal/week)	0.0 (337.34)	0.0 (815.57)	0.371
Moderate activity (kcal/week)	0.0 (0.0)	20.0 (1271.02)	0.002*
Vigorous activity (kcal/week)	0.0 (0.0)	0.0 (941.50)	0.025*
Total (kcal/week)	0.0 (462.64)	1087.43 (3954.30)	< 0.001*

Data are presented as mean ± SD. F (frail); NF (non-frail); CI (confidence interval); IQR (interquartile range); kcal = kilocalories. *Statistically significant difference between F and NF.

have shown a lower association between BMI and higher frailty risk[22,23], while others have shown higher frailty risk with higher BMI[24,25]. Furthermore, BMI can be affected by body size and muscle weight and for this reason may not reflect the distribution of body fat[21].

Although it was not the objective of this study to analyze sarcopenic obesity, the results lead us to believe that the higher values for endomorphy and the lower value found for mesomorphy (skeletal muscle) and ectomorphy (relative linearity) in older adults F and NF may reflect sarcopenic obesity, which is characterized by a significant reduction in appendicular muscle mass with loss of strength and function, combined with an excessive increase in the amount of fat in the abdominal region[26]. For the older adults population, especially those with frailty, it can mean a synergistic condition in the risk of unfavorable clinical outcomes to health, and can confer a higher risk of cardiometabolic complications, reduced functional capacity, falls, fractures, disability, recurrent hospitalization, and death.

Ochoa et al.[27] studied older adults women with metabolic syndrome, and found a lower performance in agility and dynamic balance when compared to the control group; the results were attributed to higher values of endomorphy. However, body composition monitoring and somototype assessment may be an alternative to be used in older adults F and NF because they may reflect health or disease status.

The second and third predominant somatotype component in F and NF older adults was mesomorphy (skeletal muscle), followed by ectomorphy (relative linearity), the result could lead us to believe that older adults did not present a loss of lean mass. Furthermore, this behavior conflicts with sacorpenia and frailty with advancing age. However, this does not seem to be true; researchers believe that this may be related to the increase in intramuscular fat, which would directly affect arm and leg circumferences, and by the reduction in height with aging. This observation is important because the measurements of height, arm and leg circumference are used in the determination of mesomorphy. In addition, a cross-sectional study by Buffa et al.[9], found stability in mesomorphy in older adults men and women at different ages. The authors believe that stability in the mesomorphic component with aging may be an indication of muscle mass loss and that this may have a direct effect on frailty.

This result is corroborated by the study of Spira et al.[28] the authors demonstrate that low appendicular muscle mass is associated with difficulties in performing ADLs and were 2.4 times more likely (95% CI 1.7-3.5) to become pre-fragile and frail.

On the other hand, the results obtained in the IPAQ 28 older adults (84.7%) F were classified as sedentary and insufficiently active A and B, and 21 older adults (53.8%), NF were classified as active and very active.

This difference in physical activity level explains the higher total caloric expenditure (kcal/week) found in NF older adults (median 1,087.43; IAQ = 3,954.30) compared to frail older adults (median = 0.0; IAQ = 462.64). The energy produced by the body is important for independent living, but with aging, total caloric expenditure declines by 7.5% per decade for men and 6% for women. The consequence of this reduction is that a high percentage of energy is used to perform ABVDs, which can be near 100% of maximum oxygen consumption, and over time, this can contribute to loss of functional capacity and frailty[29].

On the other hand, Tribess et al.[30] analyzed the application of IPAQ (long version) in 622 older adults and determined that moderate or vigorous physical activity accumulated in different domains, during 145 min/week for women and 140 min/week for men, or even 85 min/-week for women and 112.5 min/week for men of activities in the leisure time domain, presented the best cut-off point to predict the absence of frailty. To maintain or reverse the frail condition, the authors suggest that older adults increase their total caloric expenditure per week, regardless of whether the intensity of physical activity is light, moderate, or vigorous. Therefore, a simple goal of physically active lifestyle modification should be encouraged.

Finally, interventions aimed at managing the adverse consequences of frailty focus on minimizing the risk of disability and dependence or treating pre-existing conditions. In this sense, physical activity can be an effective strategy for the prevention and treatment of frailty, because it can act on four of the five criteria commonly used in its determination, such as weakness, reduced level of physical activity, slow motor performance, and poor exercise tolerance[10,36].

Conclusions

The study has demonstrated tha endomorphy was the predominat somatotype in F and NF older adults, followed by mesomorphy and actomorphy. Furthermore, we can conclude that F older adult lower levels of physical activity and caloric expenditure per week. The Somatotype can be an important reference for the study of the mechanisms envolved with frailty.

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Conflict of interest

The authors have no conflicts of interest to declare.

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