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Original/*Valoración nutricional*

Assessment of body composition, through anthropometric and non-anthropometric methods, of University students from Valencia (Spain)

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Abstract

Introduction and objective: **The valuation of anthropometric and nutritional status of the university population is important to detect risk groups and so make nutritional recommendations. The aim of the study was to analyze the body composition and the fat component in a group of university students and to evaluate their basal metabolism to see if there was a correlation with the body composition. The study was carried out through different methods, to determine if the results obtained are comparable.**

Subjects and method: **The sample were 16 students (4 males and 12 females) from the University of Valencia, 20-33 years old. To all of them was carried out the study of body composition, and to 6 of them was carried out also a metabolic study.**

Results**: It was found that 75% of the studied subjects are normal weight, 12,5% are underweight and 12,5% are overweight. The percentage of subjects with body fat higher than the normal values are: 68,75% according to BFMNU, 25% through ISAK method and 7,69% with BIA.**

Conclusions: **Our study reflected that the data obtained through the different methods are not directly comparable because they are based on different principles and assumptions. It was noticed the importance of considering not only fat mass, but the whole body composition to have a complete picture of the subject. Furthermore, we it was found that Indirect Calorimetry and the predictive equations are not able to estimate it correctly. In contrast BFMNU method is the one that gives more information and allows to thoroughly investigate the metabolism.**

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Key words: *University students, body composition, percentage of body fat, anthropometry, basal metabolism.*

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EVALUACIÓN DE LA COMPOSICIÓN CORPORAL, A TRAVÉS DE MÉTODOS ANTROPOMÉTRICOS Y NO ANTROPOMÉTRICOS, DE ESTUDIANTES DE LA UNIVERSITAT DE VALÈNCIA (ESPAÑA)

Resumen

Introducción y objetivo: **La valoración del estado antropométrico y nutricional de la población universitaria es importante para detectar grupos de riesgo y realizar recomendaciones nutricionales. El objetivo fue analizar la composición corporal y el porcentaje de grasa en un grupo de estudiantes universitarios y evaluar su metabolismo basal para ver si había una correlación con la composición corporal. El estudio se llevó a cabo a través de diferentes métodos, para determinar si los resultados obtenidos son comparables.**

Sujetos y método: **La muestra fueron 16 alumnos (4 hombres y 12 mujeres) de la Universidad de Valencia, 20-33 años de edad. A todos se hizo el estudio de la composición corporal y a 6 de ellos se hizo también un estudio metabólico.**

Resultados: **Se encontró que el 75% de los sujetos estudiados tienen un peso normal, el 12,5% tienen bajo peso y 12,5% tiene sobrepeso. El porcentaje de sujetos con grasa corporal superior a los valores normales son: 68,75% según BFMNU, el 25% a través del método ISAK y 7,69% según BIA.**

Conclusiones: **Nuestro estudio mostró que los datos obtenidos a través de los diferentes métodos no son directamente comparables, ya que se basan en diferentes principios y supuestos. También se ha observado la importancia de considerar no sólo la masa grasa, si no toda la composición corporal para tener una visión completa del sujeto. Además, se ha podido notar que la calorimetría indirecta y las ecuaciones de predicción del metabolismo basal no son capaces de estimarlo correctamente. En cambio el método BFMNU es el que da más información y permite investigar a fondo el metabolismo.**

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Palabras clave: *Población universitaria, composición corporal, porcentaje de grasa corporal, antropometría, metabolismo basal.*

Introduction

Currently malnutrition, either deficient or excessive is one of the major public health problems[1]. Adolescence and young adulthood is a time of risky health behavior initiation and experimentation: poor nutrition, risky drinking, physical activity, smoking, that often become established in early adulthood[2].

The valuation of anthropometric and nutritional status of the student population is an indicator of health status to detect risk groups with dietary deficiencies and excesses and so make nutritional recommendations with the goal of preventing mortalities barely controlling feeding behaviors[3,4]. Particularly in Spain remain poor eating habits and sedentary lifestyles among the student population[5,6] and only globally evaluating body composition and nutrition of this population we can plan interventions.

Currently more than one and a half million students are enrolled at the Spanish University and 5% of them are foreign students; in particular Valencia University enrolled more than 160000 students and accommodates 1700 students participating in the Erasmus program[7]. The students at the University of Valencia thus constitute a large and heterogeneous group, interesting to study. Previous studies on the students of the University of Valencia have revealed some imbalances in their diet[8], and next to a poor diet it is added lacking physical activity and sedentary lifestyle. This certainly has an impact on the level of physical well-being; in particular, an unhealthy diet and a lack of physical activity can lead to an increase in body weight and specially of fat component.

Fat is a normal component of the human body that is stored in adipose tissue but the adverse health consequences of excess body fat are well documented and measurements of body fat are used in medical research as a marker of future risk.

Techniques of body composition assessment are nowadays an essential tool for the diagnosis of malnutrition and especially for the assessment of obesity, as this is defined not as a overweight, but as abnormal or excessive fat accumulation that may be injurious to health[1].

The techniques of analysis of body composition are varied and based on many different aspects, it is therefore necessary to determine whether the results obtained for each of them can be compared. It is also necessary to establish international criteria for diagnosing the nutritional status from estimators of body composition obtained by the different methods.

The aim of the study was to analyze the body composition and the fat component in a group of university students to assess their nutritional status. Furthermore, another objective was to evaluate their basal metabolism to see if there was a correlation with the body composition. The study was carried out through different methods among those currently available, with the purpose to determine if the results obtained are comparable between them.

Objective

The aim of the study was to analyze the body composition and the fat component in a group of university students and to evaluate their basal metabolism to see if there was a correlation with the body composition. The study was carried out through different methods, to determine if the results obtained are comparable.

Subjects and method

Study population

A sample of 16 students from the University of Valencia, enrolled in different undergraduate courses of the university (campus of Burjassot, Tarongers and Blasco Ibáñez) was used; of them, 4 were males and 14 were females, aged between 20 and 33 years, and 10 were Spanish and 6 were foreign, participants in the Erasmus program. The study was realized during the academic year 2013-2014. To each participant was explained the nature and purpose of the study obtaining informed consent from all of them, according to the existing legislation[9]

The sample was divided into two groups: one of 10 people to which was carried out only the study of body composition, and the other one of 6 people to which, in addition to it, was carried out also a metabolic study.

Body composition assessment

All subjects were measured by the same person and in the same environmental conditions. The study of body composition, was realized through three methods: BFMNU, ISAK that are anthropometric methods and BIA that is a no anthropometric method; all of them require the measurement of stature and body mass. For measuring stature was utilized a Stadiometer SECA 220 (SECA, Hamburg, Alemania) designed by the SECA (Sociedad Española de Calidad Asistencial) with precision of 1 mm.

After was measured the body mass with a Body Composition Analyzer (BC 418) designed by Tanita[10].

Then the study was carried out separately for the three methods, depending on the protocol of work provided.

BFMNU

The method BFMNU (Biologia e Fisiologia Modellistica della Nutrizione Umana) was developed by Pietro Marco Boselli with the aim to propose an alternative method to the existing ones of planning nutritional intervention and has been patented in 1995; the patient, with its current features is the centre of the

analysis and the main purpose of the method is to optimize the health with a proper nutrition, that means to find the diet that is able to produce a combined change in body mass, its composition and the useful energy to the body to improve its performance. For this reason it must be known the composition of the body mass of departure (current) to orient the final result towards a stable state (goal), in which the body mass, its composition and the energy fall in the normal range or are to them more forthcoming. The perfect body composition is indicated in the literature[11] as: 13,12% of proteins, 10,25% of lipids and 0,528 of glucids.

To know the current body composition the method provide the measurements of circumferences and lengths[12] and by starting from these measures can be calculated volume (V), surface (S) and pseudo thickness (Sp) of the body according to a geometric model based on the decomposition of the body in the different parts that constitute it, and considering these as geometric solids. From the data held (age, volume, surface and pseudo thickness), that describe the subject, then can be calculate the current body composition through the following formulas developed by Boselli[13]

$$M_w = -25{,}254 + 19{,}231 * e^{-0{,}781 * t} + 43{,}096 * S$$
$$M_p = + 0{,}018 + 0{,}117 * V$$
$$M_l = -9{,}589 + 1{,}888 * e^{-0{,}305 * t} + 4{,}326 * Sp$$
$$M_g = 0{,}003606 + 0{,}004539 * V ;$$

where M_w, M_p, M_l, M_g are the masses of water, protein, lipid and carbohydrate in the body, expressed in kg, t is the age in years, S is the body surface in m^2, V is the volume in dm^3 and Sp is the pseudo thickness in cm.

All calculations were performed by a software specially designed and dedicated to the execution of the entire modeling method BFMNU, called DIES3, using the visual basic language.

In this way, knowing the total weight, can be traced to the percentages of the individual components.

ISAK

Using procedures established by ISAK[14] anthropometric assessment was conducted through a experienced assessor (level II) by measuring skinfolds, girths, length and breadths. The data were entered into an Excel form developed by GREC belonging to FEMEDE[15] for ISAK which directly calculated percentages of fat with different formulas depending on the subject analyzed. For the sample was utilized the formula of Durnin-Womersley[16] with which is obtained the value of body density (BD):

$$BD = a - b * \log_{10}(\text{Tri Sk} + \text{Bic Sk} + \text{Sub Sk} + \text{Iliac Sk})$$

where a=1,16131 and b=0,0632 in men 20-29 years old, a=1,1599 and b=0,0717 in women 20-39 years old and a=1,1423 and b=0,0632 in women 30-39 years old; Tri Sk is the triceps skinfold; Bic Sk is the biceps skinfold; Sub Sk is the subscapular skinfold; Iliac Sk is the iliac crest skinfold. Then the value obtained was utilized to calculate the percent of fat in the body (% FM) with the equation of Siri[17] :

$$\% FM = (495/BD) - 450.$$

Bioimpedance

The third method used to detect the body composition, was Bioimpedance; was utilized a Scale (Tanita) BC-418[10], Octopolar. The scale was set on the basis of height, age and sex of the subject and, after he had removed all metal objects and clothes not necessary[18], the test was started. The estimate of the fat mass (FM) is done through the initial measurement of the volume of total body water (TBW)[19].

Metabolic assessment

The second part of our study was the evaluation of the basal metabolism rate through three methods, that are: BFMNU, BIA and Indirect Calorimetry.

BFMNU

Following the protocol of the method BFMNU, the six people who made up the sample filled in the food diary for three days, representative of their eating habits in recent months and note the volume of urine and stool weight.

In this way, having the current body composition and the percentage of nutrients of the present diet, the program can calculate the constant of metabolic speed by using the equation that solves the one-compartment model[13] for which the entry is represented by the mass of the food and the output is the metabolic consumption: $K_m [h^{-1}] = -(1/24) \ln[M_b - M_a)/M_b]$,

where M and M_a are respectively body mass and mass of food in kg. Applying it to all the pairs of values of M_b and M_a (M_w, M_p, M_l, M_c, M_m, M_e) we calculate all the constants (K_m of water, protein, lipids, carbohydrates, body mass and energy). The values of the current K_m can be compared with the normal ranges of the constants[12] to see in what condition is the functional status of the subject.

Bioimpedance

The second method utilized was Bioimpedance (BIA); the Scale BC-418 calculates BMR with a formula developed by the manufacturer, based on their research, and works by multiple regressive analysis using FFM (Fate Free Mass).

Indirect Calorimetry

The third method was Indirect Calorimetry; it was used a Calorimeter, FITMATE (COSMED) that measures the Oxygen Consumption (VO_2) and calculates Resting Metabolic Rate (RMR).

Measurement were performed at least four hours after eating and tests were carried out with the subject lying in rest conditions with multi-purpose silicone mask.

To calculate resting metabolic rate from measured oxygen consumption Fitmate, uses the abbreviated version of the Weir Equation[20]

$$\mathbf{RMR= [(3.941)(VO_2) + (1.106)(VO_2)(RQ)]}$$

where RG=0,85.

Results

It has been calculated the BMI (BMI=weight(kg)/ height^2(m^2)) and results reflected that, according to the reference values recommended by the World Health Organization[1], 75% of the studied subjects are normal weight, 12,5% are underweight and 12,5% are overweight. In particular 16,67% of women are underweight, while 66,67 and 16,67% are normal weight, and overweight, respectively.

Table I
Values of mass of lipids (kg) and of percentage of lipids in the subjects.

BFMNU					
			BMI=18,5	*BMI=24,9*	
n	*Kg L*	*% L*	*Kg L*	*Kg L*	
1	7,6	12,28	5,41	7,3	>
2	6,04	12,26	4,42	5,94	>
3	7,62	12,92	4,6	6,2	>
4	6,69	11,73	4,81	6,46	>
5	6,69	11,52	5,54	7,46	∨
6	5,47	11,46	4,97	6,69	∨
7	6,65	12,17	4,91	6,62	>
8	7,73	11,89	5,39	7,26	>
9	8,4	11,77	5,86	7,89	>
10	5,96	10,87	5,35	7,21	∨
11	6,66	10,98	5,61	7,57	∨
12	5,78	11,33	5,52	7,44	∨
13	8,64	12,4	5,67	7,64	>
14	9,01	12,14	5,94	8	>
15	8,95	13,19	4,89	6,58	>
16	10,28	12,56	5,29	7,12	>

Where: ∨ = values that fall within the normal range; > = values higher than the normal; < : values slower than the normal

According to the BFMNU method, the mass of lipids of the body and the corresponding percentage relative to the actual total body mass demonstrated that all the subject have values higher than 10,25 % of lipids which is the percentage consider to be perfect[11]. However, it is important to consider the weight corresponding to the normal range of BMI (18,5-24,9) and to calculate the 10,25 % of the minimum and maximum weight, to see how many lipids the subject may have to be normal weight; so it has been found for each subjects a range of normal values of mass of lipids. According to this second criterion it can be said that 68,75 % of the subjects have values of body lipids higher than the normal values and 31,25 % of the sample have values that fall within the normal range, in particular amongst them 40 % are underweight (subjects n 6 and 12) and 60 % are normal weight (subjects n 5, 10 and 11).

It has been made de same with the mass of protein and has been found that all the subject have less than 13,12 % of protein that is the percentage consider to be perfect[11]; but by considering the weight corresponding to the normal range of BMI and by calculating the 13,12 % of it, it has been found that 68,75 % of the sample falls into the range of normal values of mass of protein, 18,75 % have lower values than normal (amongst them 66,66 % is underweight and 33% is normal weight) and 12,50% have higher values than the normal range (amongst them 100 % is overweight).

Finally, repeating the same reasoning with the mass of water it has been seen that in terms of percentage of water, relative to the actual total body mass, 87,5% of the subjects have values lower than 76,10 % and 12,50 % have values higher than 76,10%, that is the percentage consider to be perfect[11]. According to the range of normality it has been found that 75 % have values included in this range, 12,25% have low values (subjects n 6 who is normal weight and n 12 who is underweight) and 12,25% have high values (subjects n 15 and 16 who are both overweight).

Then the results obtained have been compared with BMI of each subject to see from where comes the condition of their normal weight, overweight or underweight and it has been found that: both subjects who are underweight have lower values of protein and water mass than that which would allow them to be normal weight; both subjects who are overweight have all the components higher than the normal; with regard to the condition of normal weight this derives from normal values of lipids, proteins and water in 25 % of them (subjects n 5 and 11) (Table II).

Through anthropometric measurements obtained with the method ISAK and through the formula of Siri[17], it has been calculated the percentage of fat mass; comparing it with the reference values[21], it can be said that 68,75 % of them have healthy percentage of body fat, 25 % have high percentage of body fat

Table II
Current situation of each subject according to BFMNU method

		BFMNU			
n	*BMI*	*State*	*L*	*P*	H_2O
1	21,7	Normal weight	>	∨	∨
2	21,2	Normal weight	>	∨	∨
3	24,2	Normal weight	>	∨	∨
4	22,6	Normal weight	>	∨	∨
5	19,8	Normal weight	∨	∨	∨
6	18,2	Underweight	∨	<	<
7	21,1	Normal weight	>	∨	∨
8	22,9	Normal weight	>	∨	∨
9	23,1	Normal weight	>	∨	∨
10	19,5	Normal weight	∨	<	∨
11	20,3	Normal weight	∨	∨	∨
12	18,4	Underweight	∨	<	<
13	23,3	Normal weight	>	∨	∨
14	23,7	Normal weight	>	∨	∨
15	26,4	Overweight	>	>	>
16	29,3	Overweight	>	>	>

Where: ∨ = values that fall within the normal range; > = values higher than the normal; < : values slower than the normal.

Table III
Comparison between results obtained with the three methods

FAT	*BFMNU*	*ISAK*	*BIA*
Low	0%	6,25%	15,38%
Normal	31,25%	68,75%	76,92%
High	68,75%	25%	7,69%

and 6,25 % have low percentage. The average of percentage of fat mass is 17,57% in men and 29,32% in women. Comparing these results with those obtained by the classification according to BMI it result that 83,33 % of subjects that are normal weight for the BMI have also healthy percentage of body fat, but 16,66 % of them have high percentage of body fat; 50 % of subjects that are underweight for the BMI have healthy value of percentage of fat and the other 50 % have low values; 100 % of subjects that are overweight for the value of BMI have also high values of body fat.

Through the BIA analysis and considering the same reference value[21] it was found that 76,92 % of the sample have healthy body fat, 15,28 % have low values of body fat and 7,69 % have high values of body fat.

The comparison between the results obtained through the BIA analysis and that obtained by the ISAK method, shows that, despite the reference values are the same, the percentage of body fat with the two methods are different and the one obtained with the method of skinfold thickness is on average 4% higher than that obtained with BIA.

Summarizing the data obtained with the three methods as regards the percentage of fat (Table III) It can be seen that the data obtained through the three methods are different. Focusing on subject n 16, who is considered to have a high percentage of fat for all the three methods, it has been found that the excess of fat is of 3,83% according to BFMNU method, 3,82% according to ISAK method and 4,6% according to BIA analysis.

The study of basal metabolism in subject 11, 12, 13, 14, 15 and 16, gives different results (reported in Table IV) depending on the method used. According to all the three methods the subjects n 15 and 16, who are overweight, have a current caloric intake that is greater than the basal metabolism, while the subject n 11, despite is normal weight, has a current intake that is lower than the energy requirement and this could be explained by the fact that has a Km, found through BFMNU method, lower than the normal values. The basal metabolism of subjects n 12, 13 and 14 found through Indirect Calorimetry, BIA and Equation of Harris and Benedict is lower than that obtained through BFMNU method.

Focusing on the results obtained on subject n 12 through BFMNU method it can be said that he is underweight because the current intake of calories is lower than the energy requirement for basal and physical activity; according to the BFMNU method the subjects 13 and 14 are normal weight because have a current energy intake that satisfies their energy requirement and despite the caloric intake is slightly higher than the sum of calories required for basal metabolism and physical activity they are normal weight because have a constant metabolic speed relative to the energy (Km energy) higher than the normal values.

The BFMNU method also allows to know the constant metabolic speed of each nutrient: for example the subjects n 16 has a metabolism that works well so the overweight is due to a high ingest of foods, greater than the actual need; the subject n 12 who has a Km of lipids that is normal and Km of proteins and water that are greater than the normal has a body composition that is characterized by normal values of lipids, but low in protein and water (Table V). Comparing the results obtained with Indirect Calorimetry with that obtained through the equation of Harris-Benedict it has been found that there is not a perfect congruence: predictability ranges from 91 % to 121 %.

From our study does not appear to be a correlation between the basal metabolism, found by the consumption of oxygen, and the amount of fat mass or mass free of fat in the body.

Table IV
Metabolism of the subjects found through different methods, current caloric intake and current state

	Basal metabolism (Kcal)							
n	*BFMNU*	*Km energy*	*Indirect* Calorimetry	*BIA*	*Equation* H. and B.	*Energy for physical activity*	*Current intake (Kcal)*	*State*
11	1356	<	1392	1435	1436	64	1160	Normal weight
12	1937	∨	1326	1341	1374	163	1811	Underweight
13	2626	>	1955	1775	1728	304	2959	Normal weight
14	2689	>	2133	1918	1803	411	3136	Normal weight
15	1447	∨	1379	1439	1503	153	1869	Overweight
16	1755	∨	1976	1612	1643	245	2233	Overweight

Table V
Comparison between constant metabolic speed and current body composition.

n	$K_m l$	$K_m p$	*Km w*	*Body L*	*Body P*	*Body* H_20	*State*
11	<	>	>	∨	∨	∨	Normal weight
12	∨	>	>	∨	<	<	Underweight
13	∨	>	>	>	∨	∨	Normal weight
14	>	>	∨	>	∨	∨	Normal weight
15	<	>	>	>	>	>	Overweight
16	∨	∨	∨	>	>	>	Overweight

Discussion

The values of BMI reflect that 75% of students are normal weight; this percentage is slightly lower than the 76,9% obtained by Mendonça[23], and greater than the one observed by Rebato[24], that was 60 %. The percentage of underweight and overweight in women of our sample is higher than the one obtained in the study of Martínez[25]

As regard the study of the body composition the average of percentage of fat mass obtained through ISAK method (17,57% in men and 29,32% in women) is a little greater than that obtained by Martínez[25], that were 16,5 % in men and 27,2 % in women of the University Alfonso X el Sabio of Madrid, and lower than that obtained in the study of Mendonça[23], that were 26,8 % in men and 29,9 % in women. The comparison between the values of body fat, obtained through ISAK, and the values of BMI shows that there is a little correlation between BMI and fat percentage in contrast to what have found Moreno-Romero[26], but it is true that BMI is not sufficient to obtain information about the current status of the subject because it does not provide information on body composition[12]; in fact subject n 6, that is underweight for the BMI, has healthy percentage of body fat.

Our study reflects that there is a correlation between body fat assessed by bioelectrical impedance and that assessed by the sum of the skinfold thicknesses, but this isn't so strong like that found by Diniz[27]. In particular through the method ISAK and BIA has been obtained a similar value of percentage of people who have normal fat, in agreement with previous studies[28], but different percentage of people who have low or high body fat, this could be because the BIA is said to be imprecise in case of underweight and overweight. With BFMNU method we have obtained a different percentage of people with normal fat because the reference values are not the same of that used by ISAK and BIA; nevertheless the excess of body fat found in subject n 6 is the same according to BFMNU and ISAK while that obtained through BIA is a little different and this could be because it is a non anthropometric method, while the other are anthropometric.

The fact that the data obtained through the different methods are not directly comparable, because they are based on different principles and assumptions and intervals of normality of fat mass are not the same, doesn't allow to draw, within the studied population, general conclusions that are valid for all methods; this is limiting to perform comparative studies and it should be find an agreement between the promoters of different methods to use the same reference values.

It can't be said with certainty which of these reference values are more correct to consider, however, the ones obtained from autopsy samples are probably the most real; a limitation of these reference values is the fact that they are single values and not reference inter-

vals, so even small deviations from the ideal value are considered significant. Furthermore, as fat accumulates predominantly in adipose tissue, but if present in excess can enter cells and cause loss of functionality, it would be reasonable to consider lower values as the most appropriate.

To see if, in spite of the principles on which they are based are different, the methods give the same results, could be performed a study on a population before and after a diet to find out if the change, in terms of percentage of reduction in fat mass, is the same for all the methods.

From our study result the importance of considering not only fat mass, but the whole body composition to have a complete picture of the subject and in particular the BFMNU method is the one that gives more information and allows to better understand the current body composition.

Regarding the methods available to investigate the basal metabolic rate we have found that Indirect Calorimetry and the equations that calculate it from a few parameters are not able to estimate it correctly and often give results that are contradictory and no probable. In contrast BFMNU method allows us to thoroughly investigate the metabolism and to understand with which constants of metabolic speed the body is working and this is important to detect if the state of underweight or overweight of the subject is due to an altered metabolism or an inadequate or excessive nutrition. In particular the importance of the study of the constants of metabolic speed is highlighted by the fact that from our study it is evident that there is not a direct correlation between dietary energy and body mass instead there is a correlation with the constants of metabolic speed.

From our study does not appear to be a correlation between the basal metabolism, found by the consumption of oxygen, and the fat mass or the fat free mass, in contrast to previous studies that had found an inverse relationship between basal metabolic rate and body fat[29] and a direct relationship[10] between the basal metabolism and the fat free mass.

This study is a preliminary one and the results obtained reflect that additional studies are needed; a future perspective would be to develop the diet for the six subjects on which the metabolic study was carried out and monitor over time the changes in their body composition and functional state with the purpose of obtaining further information.

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