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Bioimpedance: a new approach for studying longevity

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Abstract

Centenarians are the best model to study successful ageing. Unfortunately, they are rare and do not have an aged-matched control population to compare their exceptional characteristics with non-longevous people.
Considering the complexity of molecular studies, the opportunity to analyse the centenarian phenotype with anthropometry could be an easy and no invasive interesting solution to identify peculiar measurable variables. In addition to the classic measurements, the bioelectrical impedance could be considered. This method permits to analyse the body composition, in terms of fat free mass and fat mass. Ageing is related to reduced fat free mass and increased body fat. The

reduction of the first one is directly responsible for the onset of frailty and sarcopenia. These are typical conditions in elderly that leads to reduced physical strength and loss of immune competence. Thus, it is mandatory to identify specific values and range and perform multiple measurements in aged people and centenarians to address to weight variation modifiable causes, preventing premature death and avoiding diseases.

Key Words

Bioimpedance, Elderly, Life Style, Longevity.

State of the Art

On 2012, a scientific consensus meeting to summarize knowledge and develop a consensus statement on ageing and intervention to slow it was held [Longo et al., 2015]. Although many molecular aspects have been revealed, the actual policy demonstrates that we do not have action plan to guarantee long-lived people needs. So, it is necessary to develop new studies to characterize this population, also from the anthropometric point of view.

In fact, disorders related to body fat accumulation, especially abdominal fat mass, are known risk factors for all-cause and cardiovascular mortality [Carmienke et al., 2013; Cerhan et al., 2014; Hotchkiss & Leyland, 2011]. Although, it has been highlighted a possible inverse or null relationship between overweight and obesity with mortality in old people [Beleigol et al., 2012; Flegal et al., 2013]. It is likely that, in certain population, such as elderly, fat accumulation protects from death. This is the so-called obesity paradox that implies an inverse correlation between body mass index (BMI) and mortality, as demonstrated by several studies. Consequently, it is associated with low specificity of BMI for certain population and for body fat distribution [Gallagher et al., 1996; Kouvari et al., 2017; Romero-Corral et al., 2000; Snijder et al., 2006]. In elderly it is possible to observe reduction of lean mass and redistribution of adipose tissue, maintaining the same weight and the same BMI [De Lorenzo et al., 2013].

To solve this problem, direct and indirect measurements can be made: waist circumference, waist-hip ratio and waist-to-height ratio, percentage of fat free mass and fat mass to assess fat accumulation in abdomen and in other districts.

However, studies have shown opposite results exposing uncertainties regarding the predictive ability of anthropometric measurements in the elderly [de Hollander et al., 2012; Katzmarzyk et al., 2013]. The differing conclusion from the available evidence could be explained by the great heterogeneity between studies, including the wide age range and the clinical characteristics [Chang et al., 2012]. Next to the bias linked to anthropometric measurement due to operator and cut-off point for variables, there is consensus about the inappropriateness of the use of the same weight and abdominal circumference range values for adults and elderly [de Hollander et al., 2012; Donini et al., 2012; Molarius et al., 2000].

Indeed, in aged people the abdominal fat accumulation is often a marker of resilience, better functional reserve and lower subclinical

diseases prevalence, characterizing the so called "healthy cohort" effect [Lopez-Jimenez, 2009]. Changes in body composition, together with specific characteristics in relation to health conditions, make the long-lived a peculiar subgroup.

Therefore, the results found in studies with adults and younger elderly individuals can create an over- or underestimation of risk in this population.

Associations between overweight, abdominal obesity, and mortality have been less studied, in elderly population over 80 years old, especially taking into account important confounding factors that may interfere with the associations between body fat and mortality [David et al., 2017]. In fact, a meta-analysis developed on 2014, showed a greater mortality risk for old people with a BMI under 23 compared with younger people in the overweight range (over 24.9) [Winter et al., 2014].

Understanding the changes in body size, shape and composition with ageing and their health implications is important for nutritional support, pharmacologic treatment and development of appropriate health guidelines targeting the well being of the elderly.

Discussion

Role of life style in attaining healthy ageing

Considering the growing interest in identify possible strategies to improve health in ageing and to live longer in active condition and considering the difficulty to understand molecular aspects of life, possible approaches to prevent age-related disease with daily habits are under study. One of the easiest and more studied approach is the dietary modulation of oxidative stress and inflammation that constitute the basis of ageing process and associated pathologies [Caruso et al., 2012].

Many studies demonstrated the power of different dangerous dietary compounds in the promotion of these events and, on the contrary, the power of the use of dietary restrictions or nutraceutics in the promotion of health-span and in the increase of lifespan in model organisms, form yeast to mice [Aiello et al., 2016].

Unfortunately, the conduction of the same studies in humans are not easy so we need to analyse measurable biomarkers and, when these are not present, we can only analysed retrospectively the best outcome, in this case, the centenarian phenotype.

Worldwide exist five hot spots of longevity, the so called blue zones. These are located in California (Loma Linda); in Japan (Okinawa); in Italy (Sardinia); in Greece (Ikaria); and in Costa Rica (Nicoya). People living in these areas present different cultural traditions but a common characteristic: the healthy lifestyle. Some of them are vegetarians, others follow occasionally fasting and live the life with a positive mood, socially engaged and physically active [Buettner, 2008].

Similar situation was observed in a mountainous zone in Sicily, the Sicani Mountain area, where a group of scientists evidenced, in 2012, the presence of a blue zone-like. It is located in the country side of the island and showed a great number of centenarians: 10.38 on 10000 inhabitants versus 2.4 on 10000 in the rest of Italy [Vasto al., 2012a].

Analysing the life of these people, similar characteristics to blue-zone inhabitants were found. They lived an active life, socially involved, they ate seasonally food, especially fruit and vegetables, and whole grain and they had low calorie intake. Overall, they followed Mediterranean life-style and, consequently, the traditional Mediterranean diet [Vasto et al., 2012b].

Recent Istat data (http: //www.istat.it) showed that in Sicily we have more than 1000 centenarians. Their analysis could be done by the use of specific nutritional and habit questionnaire that could highlight peculiarities of this population. These could constitute the starting point for the identification of a longevity phenotypic signature but measurable variables are needed: anthropometry and bioimpedance could give interesting information.

Anthropometric measurements

Range to classify body composition exists but not specific for longevous people, often characterized by significant changes in mass distribution and nutritional status. Moreover, information about the nutritional status of very old people, such as centenarians, is limited and, probably, the existing range related to BMI, measured as weight in kilograms divided by the square of the height in meters, is not suitable. It is not an exception because it is well known BMI cannot be used for athletes, presenting high percentage of the weight composed by muscle mass, so high BMI, similar to the one of obese people.

Ageing is related to reduced fat free mass and increased body fat, especially in the trunk. The fat free mass or lean mass is composed by all

masses except the fat. Its reduction is directly responsible for the onset of frailty and sarcopenia, typical conditions in elderly, that leads to reduced physical strength and loss of immune competence [Cesari et al., 2016].

Today is possible to analyse body composition using a no invasive method: the bioimpedance. Also called bioelectrical impedance, it provides a measurement of body composition, in terms of free fat mass and fat mass. It is the measure of resistance and reactance of the body. The total impedance is the total sum of impedance of different tissues. When we exposed human cell membrane to an alternating current, we can measure two values: resistance and reactance. Theoretically, the first is an indirect measure of the intracellular volume or body cell mass. The electric resistance is a force opposed by body fat, total body water and extra cellular water to electrical current [Foster & Lukaski, 1996].

The relationship between resistance and reactance give a phase angle that could be used as measurement of health status and diseases. In fact, lower phase angles appear to be consistent with low reactance and either cell death or a breakdown in the selective permeability of the cell membrane. There is a significant difference in phase angle between healthy and disease states. The higher is phase angle valued the better is the healthy condition [Cowen et al., 1998; Guglielmi et al., 1999; Gupta et al., 2004; Schwenk et al., 2000].

So, anthropometric analysis by bioimpedance could be an interesting choice in centenarian and old people but reference values are needed, since the change in body composition seem to be involved in decreased ability to perform daily life activities.

The bioimpedance

To obtain informative and reproducible body composition analysis, the body scan technology or bioimpedance have to be conducted by trained professionals. In particular, for elderly these data might be useful to prevent or evaluate the muscular decline and hydroelectrolytic changes.

Special skin electrodes are placed on the hand and foot of one body side, connected to the device by electrode cables, the red and the black. Detecting electrode edge is placed on an imaginary line bisecting the ulnar head and medial malleolus. The signal electrode is placed on the first joint of the middle finger and on the base of the second toe of the foot. It is important to choose the same side of the body, i.e. right hand and foot, not right foot and left hand.

When a low-voltage is applied within seconds, two values are measures: resistance and reactance of human tissue. Phase angle and body compartments are derived using specific software through medically validated algorithms, adding the resistance and reactance measured.

Then, results are reported in an impressive report that contain information about body composition but also analysis of nutrition and hydration states [Khalil et al., 2014] (Figure 1).

Moreover, using a dynamometer, it is possible to obtain an evaluation of the muscle strength, so an estimation of the onset of sarcopenia.

This method is a direct measurement, differently from the determination of body compartments based on co-predictors such as weight, age, and gender.

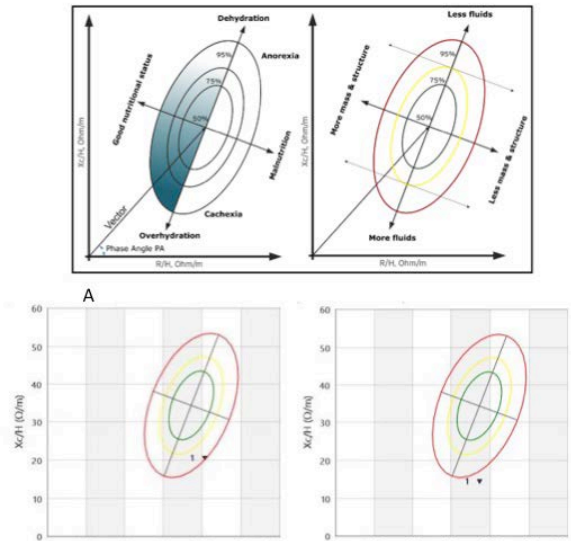

Figure 1. Nomogram of centenarians. The nomogram, or nomograph, is a two-dimensional diagram designed to allow the approximate graphical computation of a mathematical function. It is a graphical, qualitative representation of a bi or multiple variables function. The figure shows reference nomograms (A) and two nomograms of centenarian female, 104 (B) and 101 (C) years old. The first patient was frail and fully assisted in daily activity. Differently, the second one was autonomous. Comparing (B) and (C), referring to (A), it is possible to speculate that both are affected by cachexia. Moreover, in C we can see that the patient have more fluid and more mass and structure.

Conclusion

The lifestyle constitutes an important modifiable risk factor and growing evidence demonstrates the reduction of onset of pathologies improving the quality of the diet. Centenarians and nonagenarians are populations with much peculiarity, including reduced metabolic rate and fat distribution. For this reason, it is fundamental to fix anthropometric range that permits to identify risk factor to classify the population. Notwithstanding, these features might be informative to allow the implementation of adapted programs to optimize centenarians quality of life.

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