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Skeletal muscle mass and body fat in relation to successful ageing of older adults: The multi-national MEDIS study

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ABSTRACT

Background: The determinants that promote successful ageing still remain unknown. The aim of the present work was to evaluate the role of skeletal muscle mass and body fat percentage (BF%), in the level of successful ageing.
Methods: during 2005–2011, 2663 older (aged 65–100 years) from 21 Mediterranean islands and the rural Mani region (Peloponnesus) of Greece were voluntarily enrolled in the study. Appendicular skeletal muscle mass (ASM), skeletal muscle mass index (SMI) and BF% were calculated using population formulas. Dietary habits, energy intake, expenditure and energy balance were derived throughout standard procedures. A successful ageing index ranging from 0 to 10 was used.
Results: The mean ASM mass was 24 ± 6.0 kg, the SMI was 0.84 ± 0.21 and the BF% was 44%. Females had lower SMI and higher BF% in comparison with males, respectively [(SMI: 0.66 ± 0.09 vs. 1.03 ± 0.11; BF%: 51% vs. 34%, ($p < 0.001$)]. High successful agers had better rates in ASM ($p = 0.01$), SMI ($p < 0.001$) and BF% ($p < 0.001$), compared with the medium and low successful ones. Changes in SMI [b-coefficient (95% CI):2.14 (1.57 to 2.71)] were positively associated with successful ageing, while changes in BF% [b-coefficient (95% CI): −0.04 (−0.05 to −0.03)] were inversely associated with successful ageing. Results from sensitivity analysis showed that the effects of variations on body composition were consistent, less pronounced in the positive energy balance group and more pronounced among the oldest old.
Conclusions: Body composition changes seem to be associated with lower quality of life in the older adults, as measured through successful ageing.

1. Introduction

It is well known that ageing is associated with various physiological changes. Changes in body composition and especially in muscle mass tissue as well as in the body fat are associated with advanced age (Sakuma & Yamaguchi, 2013). It has been reported that the muscle mass loss is almost 2% for the middle aged populations while for the octogenarians this muscle tissue loss is around 50% in comparison with younger populations (Baumgartner et al., 1998). Skeletal muscle mass consists almost the half of body mass and has an important role in mobility as well as in various body's metabolic functions (Cesari et al., 2009; Newman et al., 2006). Taking into account its aforementioned role, any

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decline in the skeletal muscle mass has an inverse effect on human health. Muscle mass decline has been related with various disability patterns, with mental health disorders (i.e. cognitive problems) as well as with increased mortality (Cesari et al., 2009; Newman et al., 2006; Hsu et al., 2014). The decline in muscle mass is often replaced by increase in the body fat mass (Sakuma & Yamaguchi, 2013). Moreover it has been reported that not only the muscle mass loss but also the increase in body fat has been related with various co-morbidities, for the older adults. It is well known that high body fat (i.e. central obesity, excess waist circumference) is associated with various metabolic disorders such as, diabetes mellitus, hypertension, metabolic syndrome, cardiovascular diseases (CVDs), cancer and low quality of life (Tyrovolas et al., 2011).

Determinants that promote successful ageing still remain not well understood and appreciated. Clearly the process of ageing is quite complex and is associated with a variety of factors, not only with physical health. Successful ageing is a concept which is considered as low probability of disease and disability, high cognitive and physical capacity, active participation throughout various social activities and represents the aforementioned complexity in the ageing process (Graham, Mitnitski, Mogilner, Mogilner, & Rockwood, 1999; Tyrovolas, Haro, Mariolis et al., 2014). A variety of factors have been associated with successful ageing such as high waist circumference, alcohol consumption as well as various co-morbidities (Tyrovolas, Haro, Mariolis et al., 2014). However until now, the role of skeletal muscle mass and BF% in the level of successful ageing has never been explored in the past.

Given the complexity of ageing pathway, the association of skeletal muscle mass and body fat with elder's health and with the ageing process, together with the lack of data among Mediterranean populations, the aim of the present work was to evaluate the role of skeletal muscle mass and BF%, in the level of successful ageing of a random sample of older adults living in the Mediterranean basin and who participated in the MEDIS (MEDiterranean ISlands) study. Specifically, it was hypothesized that those with higher skeletal muscle mass and lower body fat percentage would be more likely to have higher successful ageing levels compared to those individuals with lower skeletal muscle mass and higher body fat percentage. Additionally, the older Mediterranean's had rarely been studied in the past; a fact that makes this survey of major importance, as it included islands (i.e., Corfu and Crete, known from the historical Seven Countries Study and Ikaria, known from the Blue Zones) where others have previously reported determinants of healthy ageing and long-living (Keys, Menotti, & Aravanis, 1984).

2. Methods

2.1. The MEDIS study sample

During 2005–2011, a population-based, multi-national, convenience sampling was performed to voluntarily enroll $n = 2512$ older people from 21 Mediterranean islands: Republic of Cyprus (n = 300), Malta (n = 250), Sardinia (n = 60), Sicily (n = 50), Mallorca and Menorca (n = 111) and the Greek islands of Lesvos (n = 142), Samothrace (n = 100), Cephalonia (n = 115), Crete (n = 131), Corfu (n = 149), Limnos (n = 150), Ikaria (n = 76), Syros (n = 151), Naxos (n = 145), Zakynthos (n = 103), Salamina (n = 147), Kassos (n = 52), Rhodes and Karpathos (n = 149), Tinos (n = 129), as well as $n = 300$ older adults from the rural region of Mani (a southern Greek peninsula). The sampling scheme anticipated a target sample size of 300 older people from Cyprus and Malta and at least 100 from each of the other islands; according to an a-priori power analysis, a sample of 2500 participants is adequate to test two-sided hypotheses of odds ratios equal to 1.20 achieving statistical power >80%. According to the study's protocol, individuals were not eligible for inclusion if they resided in assisted-living centers, had a clinical history of cardiovascular disease (CVD) or cancer, or had lived away from the island for a considerable period of time during their lives (i.e., >5 years); these exclusion criteria were applied because the study aimed to assess lifestyle habits that were not subject to modifications due to existing chronic health conditions or by environmental factors, other than living milieu. A group of health scientists (physicians, dietitians and nurses) with experience in field investigation collected all the required information using a quantitative questionnaire and standard procedures.

The study followed the ethical considerations provided by the World Medical Association (52nd WMA General Assembly, Edinburgh, Scotland, October 2000). The Institutional Ethics Board of Harokopio University approved the design and procedures of the study (reference No. 16/19-12-2006). Participants were informed about the aims and procedures of the study and gave their consent prior to being interviewed.

2.2. Evaluation of clinical and anthropometric characteristics

All the measurements taken in the different study centres were standardized and the questionnaires were translated in all the cohorts' languages following the World Health Organization (WHO) translation guidelines for tools assessment (World Health Organization, 2016). Weight, height and waist circumference were measured using a standard protocol; body mass index (BMI) was calculated as the ratio of weight by height squared (kg/m^2). Overweight was defined as BMI between 25 and 29.9 kg/m^2 and obesity was defined as BMI > 29.9 kg/m^2. Moreover, waist circumference (WC) in cm was measured in the middle between the 12th rib and the iliac crest and hip circumference in cm was measured around the buttocks. Muscle mass was calculated throughout the appendicular skeletal muscle mass (ASM) based on the equation proposed by Lee et al. (Lee et al., 2000). Specifically, the equation was: $ASM = (0.244 \times weight) + (7.8 \times height) + (6.6 \times gender) - (0.098 \times age) + (race - 3.3)$. This indicator was further adjusted by BMI to create a skeletal muscle mass index (SMI) as the proportion of ASM/BMI (Cawthon et al., 2014). The percentage of body fat (BF%) was calculated based on a sex specific equation using the waist circumference measurements (Lean, Han, & Deurenberg, 1996; Santos Silva, Petroski, & Peres, 2012). Specifically for the males the equation was: $BF\% = (0.567 \times WC) + (0.101 \times age) - 31.8$ while for the females was: $BF\% = (0.439 \times WC) + (0.221 \times age) - 9.4$. Diabetes mellitus (type 2) was determined by fasting plasma glucose tests and was analyzed in accordance with the American Diabetes Association diagnostic criteria (glycated haemoglobin A1C $\geq$ 6.5 or fasting blood glucose levels greater than 125 mg/dl or 2-h plasma glucose > 200 mg/dl during an oral glucose tolerance test-OGTT- or a random plasma glucose > 200 mg/dl, or by a prior diagnosis of diabetes). Participants who had blood pressure levels $\geq$140/90 mmHg or used antihypertensive medications were classified as hypertensive. Fasting blood lipid levels (HDL-, LDL-cholesterol and triglycerides) were also recorded and hypercholesterolemia was defined as total serum cholesterol levels >200 mg/dL or the use of lipid-lowering agents according to the NCEP ATPIII guidelines (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults, 2001).

2.3. Evaluation of socio-demographic, dietary habits and other lifestyle characteristics of the participants

Basic socio-demographic characteristics, such as age, gender, years of school, financial status and lifestyle characteristics, such as smoking habits and physical activity status, were recorded. Regarding financial status, the participants were asked to report their mean income during the previous three years using a four-