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Anthropometric measurements and mortality in frail older adults

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ABSTRACT

Background: As the number of older adults increases, so does the number of frail older adults. Although anthropometry has been widely used as a way to stratify the overall mortality risk of a person, the significance of these measurements becomes blurred in the case of frail older adults who have changes in body composition. Therefore, the aim of this study is to determine the association of anthropometric measurements (body mass index, knee-adjusted height body mass index, waist-to-hip ratio and calf circumference) with mortality risk in a group of older Mexican adults.

Methods: This is a longitudinal analysis of the Mexican Health and Aging sub-sample (with biomarkers, $n = 2573$) from the first wave in 2001, followed-up to the last available wave in 2015. Only frail 50-year or older adults (Frailty Index with a cut-off value of 0.21 or higher, was used) were considered for this analysis ($n = 1298$). A survival analysis was performed with Kaplan-Meier curves and Cox regression models (unadjusted and adjusted for confounding). Socio-demographic, health risks, physical activity and comorbidities were variables used for adjusting the multivariate models.

Results: From the total sample of 1298 older adults, 32.5% ($n = 422$) died during follow-up. The highest hazard ratio in the adjusted model was for calf circumference 1.31 (95% confidence interval 1.02–1.69, $p = 0.034$). Other measurements were not significant.

Conclusions: Anthropometric measurements have different significance in frail older adults, and these differences could have implications on adverse outcomes. Calf circumference has a potential value in predicting negative health outcomes.

1. Introduction

In addition to the growing demand of health care services by older adults, a specific subgroup of this age group particularly burdens the system, especially when not properly managed: the frail older adults (Cesari et al., 2016b). Although there remains controversy (Bergman et al., 2007; Hogan and others, 2003) as to a precise definition or clinical characterization of frailty, it is generally accepted that when frailty remains undetected, the risk of an acceleration in the functional decline of an older adult increases exponentially, such that, even minimal stressors, may trigger catastrophic outcomes (Aalen et al., 2014; Cesari, 2011), including death. Thus, in spite of a lack of precision in its definition, it is important to seek indicators of enhanced mortality risk in frail elders in order to implement adapted care models which target the multidimensional and heterogeneous complexity of these individuals (Cesari et al., 2016a).

Anthropometric measurements are commonly used in clinical practice; in particular, body mass index (BMI) is widely accepted and used in these settings (Dent et al., 2015). In recent years, such assessments have strongly supported the risk stratification of an individual for adverse cardio-metabolic outcomes and any-cause mortality (Kim et al., 2015). However, when it comes to frail older adults, results of these

Abbreviations: BMI, Body Mass Index; WHR, Waist-to-hip ratio; CC, Calf Circumference; MHAS, Mexican Health and Aging Study; FI, Frailty Index; HR, Hazard Ratios; CI, Confidence Intervals; IQR, Inter-Quartile Range; SD, Standard Deviation

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anthropometric measures are often misleading (Oreopoulos et al., 2009; Zunzunegui et al., 2012).

Indeed, there is an ongoing debate regarding the role of BMI and, for example, its alleged U-shape relationship with mortality in older adults (Hubbard et al., 2010; Zunzunegui et al., 2012). In particular, there is a lack of evidence as to how this measure may work in the prediction of mortality risk in frail older adults. Moreover, other anthropometric measures of similar interest, such as waist-to-hip ratio [WHR] or calf circumference [CC], have little literature to their name (Landi et al., 2014; Welborn et al., 2003), even though they could also be potentially used for risk stratification.

Understanding the role that anthropometric measures may have in the risk stratification of frail elders is crucial (Abellan van Kan et al., 2008), especially in low and medium income countries where a more sophisticated initial screening may not be feasible. As easy-to-administer screening and assessment tools are particularly needed (Elder, 2013), such measurements could provide simple tests which can be quickly carried out by a healthcare professional in any consultation and which would be particularly useful in settings where human resources specialized in older adult healthcare are scarce (Gutierrez-Robledo, 2002).

The aim of this study is to determine which anthropometric measurement (BMI, knee-adjusted height BMI, WHR and CC), better predicts mortality in a group of older Mexican adults. We hypothesize that BMI will not be as good a mortality predictor as it is in non-frail older adults, and, further, that calf circumference and/or WHR will be better mortality predictors in frail older adults.

2. Materials and methods

2.1. Design

The Mexican Health and Aging Study (MHAS) is based on a cohort of older adults aged ≥50-years with a follow-up of 14 years. The sample was designed to be representative of the whole country. Households were qualified to be in the sample if they contained at least one 50-year or older person; they were then invited face to face, and if they accepted, an appointment was made to perform the interview at home. The full description, objectives and database of the MHAS are available to the public (Wong et al., 2015), and it is from this database that the present longitudinal analyses were performed. In addition to socio-demographic and health-related measurements, the database contains a sub-sample of other objective measurements (i.e. serum biomarkers, physical performance tests and anthropometry).

2.2. Sample

The study sample was obtained from a subgroup of participants that underwent anthropometric evaluation in the first wave in 2001 (n = 2573). This subsample of interest was drawn from the overall cohort (n = 16,540) through a probabilistic and representative method from all the country's participating sites (Wong et al., 2007).

A 40-item Frailty Index (FI) was constructed, with deficits covering multiple health domains (see Supplementary Table 1), per the methods proposed by Searle (Searle et al., 2008). A FI cut-off point value of 0.21 is conventionally used for Mexican older adults, having been previously validated using this same dataset (Garcia-Gonzalez et al., 2009). This FI has been used as an operational definition of frailty, and has been shown to be useful for distinguishing individuals at higher risk of adverse outcomes (in particular, mortality and disability) (Jones et al., 2004; Mitnitski et al., 2002). This value of the FI (0.21) was used throughout to define frail participants, with the effect of reducing the study sample to 1298 older adults, who were then followed for a maximum of 168 months. A total of 124 older adults were lost to follow-up, with no survival data. The follow-up of these participants was censored at the last contact date. For the remaining 1174 frail older adults, complete data about follow-up was available.

2.3. Variables

We obtained the analyses' dependent variable, mortality of the subjects, through a next-of-kin informant. The date of death was recorded and used to calculate the length of survival (in months) from the baseline assessment.

Anthropometric measurements (independent variables of interest) were BMI, knee-adjusted height BMI, WHR, and CC. Given the possible non-linear relationship with mortality risk, the anthropometric variables were categorized using standard recommended cut-off points. BMI was categorized according to the World Health Organization standards into four groups (underweight, normal, overweight and obese) (Organization, 2017). Additionally, a second, non-standard BMI categorization was made in order to take into account potential height loss in older adults, by using knee-adjusted height and applying the available formulas for Mexican older adults (Carrillo-Vega et al., 2017; Mendoza-Nunez et al., 2002) (see Supplementary Table 2 for formulas). For WHR, calculated by waist measurement divided by hip measurement and used to define central obesity, a cut-off point of 0.8 was used for women and 1.0 for men (Salud, 1998). Finally, CC was applied for identifying individuals with possible malnutrition, using a cut-off point of 31 cm or less. This has been incorporated into nutritional assessment tools in a wide range of populations (Guigoz and Vellas, 1997).

Other variables included in the analysis were from different domains, such as socio-demographic (age, sex, living environment [urban vs rural], education in years), health risks (smoking [never smoked, used to smoke and currently smokes], physical activity [performed hard work or exercise at least three days a week last year]) and comorbidities (self-report of the following diseases: hypertension, type 2 diabetes mellitus, cancer, lung disease, heart attack, stroke, articular disease and tuberculosis). These variables were used to adjust the multivariate models.

2.4. Statistical analysis

For descriptive purposes, all the variables were contrasted according to survival status; with relative and absolute frequencies, as dichotomous variables. Ordinal variables were described with median and inter-quartile range (IQR), while continuous variables were described with means and standard deviations (SD). *t*-tests, Wilcoxon and Chi square tests for significance were used in the bivariate analysis. Survival curves were constructed for the different categories of the anthropometric measurements, using the log-rank test to contrast the differences between the curves. In order to adjust for confounding variables, Cox regression models were fitted for each of the anthropometric measurements, with the potential confounding variables: age, sex, marital status, education, living environment, smoking status, physical activity, and number of comorbidities. As a measure of association, hazard ratios (HR) with 95% confidence intervals (CI) were estimated. Lastly, the assumption of proportionality was checked with log-log curves (Hess, 1995). All statistical procedures were carried out utilizing the STATA® 14 (StataCorp 4905, Lakeway Drive, College Station, Texas 77845 USA) software.

2.5. Ethical issues

The Institutional Review Boards or Ethics Committees of the University of Texas Medical Branch in the United States, the Instituto Nacional de Estadística y Geografía, the Instituto Nacional de Salud Pública and the Instituto Nacional de Geriatría in Mexico approved the study. All study subjects signed an informed consent form.