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Original article

Identification and comparison of the predictors of maximal inspiratory force and handgrip in a healthy elderly population. The proof study

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S U M M A R Y

Background: A severe weakness of peripheral muscles occurs in half of the persons aged 80 years or older. The common factors between muscle depletion and reduced respiratory strength have not yet been established.
Objective: In the subjects of the Proof cohort, we aimed to identify, among body composition, pulmonary function and energy expenditure parameters, the predictors of maximal inspiratory pressure (MIP) as an index of respiratory muscle strength and handgrip (HG) as an index of peripheral muscle strength.
Subjects and methods: In 375 healthy elderly subjects aged 72 ± 1 years, fat mass (FM) and fat free mass (FFM) were assessed by DEXA, the last being also indexed to height (FFMI). Spirometry was performed and daily energy expenditure (DEE) was estimated by a questionnaire. After three years, MIP and HG of the dominant arm were determined and the predicting value of pulmonary function tests, body composition and DEE on these parameters was tested.
Results: Mean MIP and HG were 77 ± 26% and 106 ± 19% of the predicted value (%pred) with 90 (24%) and 30 (8%) subjects below standards, respectively.
There was a significant but weak correlation between MIP%pred and HG%pred ($r = 0.175$, $p < 0.001$). Logistic regression showed that low MIP was predicted by trunk FFM and FFMI in women, and DEE in men. Low HG was predicted by trunk FM in men only.
Conclusions: The predictors of a reduction of MIP in the elderly differ from those of HG, suggesting a differential regulation of respiratory muscle and arm strength.

1. Introduction

Lung function declines with age and in particular maximal respiratory muscle strength decreases [1], determining an increase in the occurrence of pulmonary infections and mortality. Body composition also influences lung function with an inverse relationship between Forced Expiratory Volume in one second (FEV1) or Forced Vital Capacity (FVC), and indices of adiposity as measured by bioimpedance or waist circumference [2]. A low muscle mass and a high abdominal fat mass measured by Magnetic Resonance Imaging were also found to be associated to a poorer lung function (FVC and FEV1) in the elderly [3].

Sarcopenia, defined by decreased muscle mass and strength [4], affects up to 50% of the elderly of more than 80 years old, leading to decreased quality of life, loss of autonomy and increased mortality. In clinical practice, handgrip strength (HG) is a convenient surrogate for body muscle strength and correlates well with lower limb strength [5]. In addition, the decrease in maximal inspiratory pressure (MIP) influences the relationship between extremity muscle strength and mortality [6]. Not surprisingly, MIP was also found to be significantly lower in prefrail and frail subjects [7].

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Moreover, when frailty is associated with respiratory impairment, the mortality risk is increased by 3.9 [8]. Taken together, these data suggest that preserved respiratory strength is beneficial in older populations, while its determinants remain incompletely understood.

As a matter of fact, the relationship between peripheral and respiratory muscle forces have been poorly studied and the factors explaining the respective decreases in handgrip and maximal inspiratory pressure have not been specifically studied in healthy old subjects.

The aim of the study was to identify, among body composition, pulmonary function and energy expenditure parameters, the predictors of maximal inspiratory pressure (MIP) as an index of respiratory muscle strength and handgrip (HG) as an index of peripheral muscle strength. In a three-year follow-up, we looked for these predictors in a cohort of healthy elderly subjects living, in the community, in their eighth decade. Since pulmonary function tests and muscle strength are influenced by gender, we also separately analyzed these predictors in males and females.

2. Subjects and methods

2.1. Subjects

The subjects included in this study came from the PROOF cohort study which was constituted via the electoral rolls of the inhabitants of the city of Saint-Etienne [9]. Between November 2003 and September 2005, 375 subjects, 166 men and 209 women, aged 72 ± 1 years entered the present study and participated in a series of evaluations, including lung function, body composition and daily energy expenditure (DEE). After three years, from April 2006 to June 2008, they underwent muscle strength assessment. The PROOF study was approved by the local ethical committee (CCPRB Rhône-Alpes Loire).A written informed consent was obtained from all subjects.

2.2. Methods

2.2.1. Data obtained at baseline

2.2.1.1. Lung function tests. Maximal flow/volume curves (Vmax SensorMedics, Yorba Linda, CA, USA) were performed in accordance with ERS recommendations [18], in a sitting position. Forced Expiratory Volume in 1 s (FEV1) and Forced Vital Capacity (FVC) were recorded from the best of three reproducible respiratory maneuvers. All measurements were expressed as a percentage of predicted value [19].

2.2.1.2. Measurement of body composition by DEXA. Regional (arms, legs, trunk, and head) body fat and lean body mass were measured using a whole-body DEXA scanner (Ho-logic QDR-2000, software version V5.67A, Hologic Inc., Bedford, MA), following standard procedures [10–13] and using a single scan mode [14–16]. The coefficient of variation of the instrument was less than 1% for in vivo measurements.

The body regions were then delineated by means of specific anatomical landmarks. Appendicular Fat Mass (AFM) was the sum of legs and arms fat mass, and Appendicular Lean Mass (ALM) the sum of legs and arms lean mass.

2.2.1.3. Daily Energy Expenditure. Daily energy expenditure (DEE) was assessed by a self-administered physical activity questionnaire describing seven main dimensions of everyday life, with specific emphasis on autonomy and perceived exertion [17]. This questionnaire has been evaluated over a wide range of activity levels, including populations with very low levels of physical activity. It provides a quantitative picture of the individual's mean habitual activities, based on calculation of DEE (kJ 24 h^{-1}) = sum of intensity of activity (J min^{-1} kg^{-}1) and duration of specific activity (min day^{-}1) according to age, weight, severity of the condition considered, and autonomy.

2.2.2. Data obtained during follow-up

2.2.2.1. Respiratory muscle strength. MIP was measured during an inspiratory maneuver against an occluding valve from residual volume to total lung capacity. The best of three reliable trials was retained. MIP values were compared to predicted equations [1].

2.2.2.2. Handgrip test. Maximal voluntary contractions of the dominant hand were performed in triplicate with a handheld dynamometer (Jamar®, USA), while the subject was seated with his/her elbow flexed at 90°, and the forearm and wrist maintained in a neutral position. The best of three reproducible measurements (±5%) was retained and the values compared to reference values [20].

3. Statistics

The population was separated into BMI and FFMI quartiles, group 1 being the lowest quartile and group 4 the highest. Abnormal MIP and HG values were those below the lower limit of normal (LLN) according to predicted normal values [1,20]. One-way ANOVA was used to compare MIP and HG values between the 4 BMI and FFMI groups; when significant, groups were compared in pairs with Bonferroni corrections.

The association between reduced MIP or HG and their respective potential predictors was explored by means of logistic regression modeling. We calculated the odds ratio of every predictor, first in univariate models and then by multivariate models, using a backward elimination procedure. During this procedure, all covariates were first introduced in the multivariate model, the least significant predictor being eliminated at each step until only significant predictors remained. Since we suspected a significant interaction term between gender and several potential predictors of the outcomes, we presented results for the entire population and stratified results according to gender. All the analyses were performed using Sigmaplot 12 or Stata release 13 Software. A P value <0.05 was considered as significant.

4. Results

We analyzed the data from 375 subjects in whom we obtained all the requested data. Their anthropometric characteristics and the results of their different measurements are given in Table 1. Compared to the entire cohort of 1011 subjects, the subset of subjects analyzed in the present study did not differ for BMI, pulmonary function results or muscle strength.

4.1. Body composition

BMI averaged 25.3 ± 7.1 kg m^{-2}, while 181 (48%) were overweight (BMI >25 kg m^{-2}). BMI quartiles were <22.9 (Q1), 22.9–24.8 (Q2), 24.9–27.1 (Q3) and >27.1 kg m^{-2} (Q4).

FFMI was within normal values while 105 (28%) had muscle depletion (<16 and <15 kg m^{-2}, in males and females respectively). FFMI quartiles were <14.8 (Q1), 14.8–16.3 (Q2), 16.4–18.3 (Q3) and >18.3 kg m^{-2} (Q4).

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