LONGITUDINAL CHANGES IN RESTING METABOLIC RATE IN THE ELDERLY

CHANGES IN RESTING METABOLIC RATE IN AN ELDERLY GERMAN POPULATION: CROSS-SECTIONAL AND LONGITUDINAL DATA

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Abstract: Background/Objectives: This study investigates age-dependent changes in resting metabolic rate (RMR) considering changes in body composition and fat distribution within the longitudinal study on nutrition and health status in an aging population in Giessen (GISELA). Germany, using three different approaches.

Subjects/Methods: In approach 1 cross-sectional data from 358 female and 155 male participants of the GISELA study were evaluated (mean age of 67.4 ± 5.9 and 66.9 ± 5.2 y, respectively). In approach 2 longitudinal data of 107 female and 55 male subjects who participated over a follow up period of 10 years were analysed. In approach 3 data were assessed measured at a total of 3033 visits from 363 women and 153 men between 1994 and 2006 were evaluated. The mean duration of follow-up was 8 years. RMR was assessed by indirect calorimetry. Results: Approach 1: RMR correlates significantly negatively with age in women and men. Considering fat free mass, fat mass, and WHR, age proved to be a significant predictor of RMR in both sexes in multiple regression analysis; RMR falls by 11.2 kJ/d and 34.1 kJ/d per year in females and males, respectively. Approach 2: In males but not in females RMR decreases significantly in the course of the follow up. After ten years measured RMR is significantly lower than expected RMR predicted on the basis of body composition and fat distribution in females and males. Deviations correspond to a decline in RMR by 11.4 and 27.5 kJ/d per year independently of changes in body composition and fat distribution. Approach 3: Results of the mixed linear model show that RMR decreases in the course of aging in both women and men; after considering changes in body composition and fat distribution respective decreases were 8.7 and 30.7 kJ/d per year independently of changes in body composition.

Conclusions: These results indicate that the decline in RMR with advancing age cannot be totally due to changes in body composition.

Key words: Resting metabolic rate, changes, cross-sectional, longitudinal, elderly.

Introduction

From several cross-sectional (1, 2) and some longitudinal studies (3, 4) it is well known that resting metabolic rate (RMR) declines with advancing age. Changes in RMR depend mainly on changes in body composition, especially in metabolic active fat free mass (FFM), but also in fat mass (FM) and fat distribution (5). As aging is accompanied by changes in FFM, FM, and fat distribution (6, 7), it is at present unclear whether the decrease in RMR is entirely a consequence of these age-related changes or whether it is additionally due to a decline in the metabolic rate per unit of tissue mass. This question has been addressed in several cross-sectional studies with inconsistent results (8–16). However, for accurate conclusions on age effects longitudinal surveys are mandatory because they make it possible to assess changes in individual subjects, cohort-specific and secular trends and other influencing factors (17). The few longitudinal studies available so far did not consider women and included only a few male participants over 60 years (3, 4), or they were performed over a relatively short period of time (four to six years) with a minor group of elderly people (18, 19).

In 1994, a longitudinal study in older adults over 60 years was initiated, aiming to investigate the nutrition and health status in a free living aging population in Giessen, Germany (GISELA study). The objective of the present investigation is to use the extensive data of the GISELA study collected over a period of twelve years (1994 to 2006) to analyze cross-sectional and longitudinal age trends in RMR with special consideration of changes in body composition and fat distribution by using three investigation approaches.

Subjects and methods

Study design

The GISELA study is a prospective cohort study in which the nutritional and health status of free-living elderly citizens in Giessen have been observed at annual intervals since 1994 and at every second year since 1998, respectively. Within the scope of this study anthropometric data, body composition, and RMR of the study participants are examined. All investigations took place in the Institute of Nutritional Science in Giessen, Germany, between July and October from 6:00 to 10:00 AM after an overnight fast by using always the same methods and equipment. The GISELA study is observational, non-intervening, and non-invasive. The study protocol was approved by the Ethical Committee of the faculty of medicine at the Justus-Liebig-University Giessen, Germany, and a written informed consent was obtained from each study participant.

Subjects

At enrollment study participants had to be at least 60 years of age, physically mobile, and available around Giessen on a
long term basis. From 1994 to 2002 subjects were recruited by physicians, notices, senior citizens’ meetings, advertisements in local newspapers as well as by recruitment through subjects who had already participated.

In approach 1 cross-sectional data of the GISELA study were analyzed. This approach includes baseline data from 358 female and 155 male subjects participating in the GISELA study between 1994 and 2006 with complete data on anthropometric measurements, body composition, and RMR.

In approach 2 the longitudinal data of 107 female and 55 male GISELA subjects with complete data on anthropometric measurements, body composition, and RMR at baseline (year 1994 or 1996) and after a period of 10 years (year 2004 or 2006) were analyzed.

Longitudinal data of the GISELA subjects were also analyzed in approach 3. In this approach data of those elderly subjects who returned for at least one follow-up-visit are considered. Between 1994 and 2006 a total of 3011 visits from 516 subjects (363 women and 153 men) were evaluated. On average six visits per participant were evaluated in both women and men. The mean duration of follow-up was eight years.

**Anthropometric data and body composition**

Body weight was measured with a calibrated digital scale (Seca, Vogel & Halke, Hamburg, Germany) to the nearest 0.1 kg after shoes, coats, and sweaters had been removed. Body height was determined by a height measurement device integrated in the scale to the nearest 0.5 cm. Waist-hip-ratio (WHR) was used as a marker for body fat distribution. Waist circumference was measured at the smallest point between the lower rib and the iliac crest and hip circumference at the widest point in the greater trochanter and buttocks area with a tape to the nearest 1 cm. Body composition was investigated by using a single frequency (50 kHz) bioelectrical impedance analyzer (Akern-RJL BIA 101/S, Data Input, Frankfurt, Germany) according to the manufacturers’ instruction. FFM and FM were calculated by applying the equation derived from the cross-validation study (Akern-RJL BIA 101 vs. dual-energy x-ray absorptiometry) from Kyle et al (20).

**Resting metabolic rate**

RMR was determined by an open-circuit indirect calorimeter (Deltatrac™ MBM-100, Hoyer, Bremen, Germany). Oxygen uptake and carbon dioxide production were measured for 25-35 min at intervals of one minute by respiratory gas analysis using a ventilated-hood system, with the subjects in a supine position and completely at rest in a thermoneutral environment. Data collected during the initial 10 min of the measurements were discarded. After this adaptation period coefficient of variation for oxygen uptake and carbon dioxide production was 0.7 % and 1.9 %, respectively. RMR was determined by using the equation derived by Weir (21). The Deltatrac metabolic monitor was shown to be accurate within 3 % for RMR (22).

**Calculation of predicted resting metabolic rate in approach 2**

In approach 2 expected RMR based on body composition and fat distribution was predicted. To determine the best predictors of RMR stepwise multiple regression analyses considering FFM, FM and WHR were performed in the subjects at baseline. The following regression equation was obtained in women: RMR [kJ/d] = 744 + 55.3 FFM [kg] + 31.0 FM [kg] + 1966 WHR (r² = 0.53; SEE = 416). In men the following regression equation was obtained: RMR [kJ/d] = -993 + 81.2 FFM [kg] + 14.6 FM [kg] + 2905 WHR (r² = 0.51; SEE = 512). These equations were used to predict RMR of the subjects from body composition and WHR ten years later. Then deviations between measured and predicted RMR were calculated.

**Statistical analyses**

In approach 1 and 2 statistical analyses were carried out with the SPSS/PC Statistical Package version 12.0 (SPSS Inc, Chicago, USA). Data were checked concerning normal distribution by Kolmogorow-Smirnow test and regarding homogeneity of variance by Levene test. In approach 1 Pearson products-moment correlations (R) were calculated to determine the associations between RMR and age. Multiple linear regression analyses were used to assess the effect of age on RMR considering body composition and WHR.

In approach 2 differences between variables at baseline and after a ten-year follow-up as well as differences between measured and predicted RMR were examined by using the Student’s test for paired samples. To test if deviations between measured and predicted RMR differ between sex groups Student’s unpaired test was used.

In approach 3 for computations SAS PROC MIXED (SAS version 8.02, SAS Institute, Cary, NC, USA) was used. To analyze the influence of age on RMR linear mixed models were used with subject as random effect (23). In contrast to conventionally used linear models for repeated measurements, mixed models do not require all subjects to have the same number of measurements (24). For parameter estimation the maximum likelihood method was used with unstructured covariance matrices (25). In these models age was analyzed as fixed effect beside the random subject effect. Because RMR varies depending on sex, sex group was analyzed as fixed effect beside the random subject effect. Due to the explorative character of this investigation no adjustments for multiple hypotheses testing have been performed (27). Results are considered statistically significant when P values are less than 0.05.