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Moderate Cardiorespiratory Fitness Is Positively Associated With Resting Metabolic Rate in Young Adults

Robin P. Shook, PhD; Gregory A. Hand, PhD; Amanda E. Paluch, PhD; Xuewen Wang, PhD; Robert Moran, PhD; James R. Hébert, ScD; Carl J. Lavie, MD; and Steven N. Blair, PED

Abstract

Objective: To determine whether moderate cardiorespiratory fitness (CRF) or moderate to vigorous physical activity (MVPA) is associated with elevations in resting metabolic rate (RMR) similar to findings previously observed in endurance athletes.

Participants and Methods: Using a cross-sectional design, we measured CRF, RMR, body composition, energy expenditure, and time in MVPA via an arm-based activity monitor in 423 young adults (mean age, 27.6 years). Based on the results of a fitness test, participants were classified into CRF tertiles (low, moderate, or high) by sex.

Results: There were significant differences among the low-, moderate-, and high-CRF groups for mean ± SD body mass index (calculated as the weight in kilograms divided by the height in meters squared) (28.1±4.1, 25.1±3.4, and 23.6±2.5, respectively; *P*<.001) and fat mass (28.8±9.7, 20.5±8.2, and 14.8±6.5 kg, respectively; *P*<.001) but not fat-free mass (53.1±11.5, 53.5±12.4, and 54.7±12.1 kg, respectively; *P*=.49). There were no differences in mean ± SD unadjusted RMR among the groups (1533.2±266.2, 1519.7±267.6, and 1521.9±253.9 kcal/d, respectively). However, after statistical adjustment for differences in body composition, the moderate- and high-CRF groups had a higher RMR compared with low-CRF individuals by 39.7 and 59.9 kcal/d, respectively (*P*<.05). After further adjustment for MVPA, RMR was higher in the high-CRF group compared with the low-CRF group by 51.2 kcal/d (*P*<.05).

Conclusion: In this large sample of young adults representing a range of CRF, there was a positive stepwise gradient in RMR across tertiles of CRF independent of body composition. Also, MVPA was independently associated with RMR, although this relationship was modest. These findings underscore the multidimensional role of CRF and MVPA on health.

Trial Registration: clinicaltrials.gov Identifier: NCT01746186

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There is no consensus on the specific causes of the current levels of overweight and obesity seen in most of the developed world and affluent sectors in the developing world.[1] Much of the research focuses on excess energy intake or deficient physical activity energy expenditure.[2-5] However, resting metabolic rate (RMR) represents the largest contribution to total energy expenditure (60%-80%)[6] and has been hypothesized as a potential predictor of weight gain.[7] Some analyses have found a low RMR to be predictive of weight gain,[7,8] and others have not,[9] and yet others have reported somewhat ambiguous results.[10]

Although RMR is relatively stable within individuals (<5% day-to-day variation), variability between individuals is much higher (±25%).[11] The RMR is primarily determined by fat-free mass (FFM) (approximately 63%), fat mass (FM) (6.7%), and age (1.7%), leaving more than 25% of the variability unexplained.[12-14] Identifying other determinants of RMR is important to understand energy balance and, concomitantly, the etiology of obesity.[15]

Levels of physical activity and cardiorespiratory fitness (CRF) have long been considered to influence RMR, beyond known postexercise increases in oxygen consumption, and may partially explain the large interpersonal variability

From the Department of Exercise Science (R.P.S., G.A.H., A.E.P., X.W., S.N.B.), Department of Epidemiology and Biostatistics (R.M., J.R.H., S.N.B.), and South Carolina Cancer Prevention and Control Program (J.R.H.), Arnold School of Public Health, and Department of Family and Preventive Medicine (J.R.H.), University of South Carolina, Columbia; John Ochsner

Affiliations continued at the end of this article.

of RMR previously described. Most studies previously conducted indicate a 5% to 20% higher RMR in individuals who participate in regular activity compared with sedentary controls,[16,17] and CRF is significantly correlated with RMR in middle-aged men and women (r=0.79, P<.001).[18] However, studies have typically examined the role of physical activity on RMR in the context of highly fit individuals (eg, endurance runners),[19,20] which limits the translation to the broader public health context. It is unclear whether moderate amounts of physical activity or CRF significantly explain any of the interpersonal variance found in RMR.

Given recent technical advancements, it is now possible to assess objectively an individual's daily physical activity level with great accuracy and reliability in terms of absolute total energy expenditure and time spent at a given level of intensity (eg, moderate-intensity activity).[21] Pattern recognition monitors worn on the body integrate information from multiple sensors to provide a highly sensitive and valid assessment of structured exercise and complex lifestyle tasks, such as carrying loads, walking up grades, and nonambulatory activities.[21,22] These technical advances now permit the assessment of physical activity energy expenditure in large samples of individuals over extended periods.

The purpose of the present study was to examine the role of CRF and objectively measured physical activity in explaining interpersonal variance of RMR in a cohort of young adults across a broad range of activity and CRF levels.

PARTICIPANTS AND METHODS

Participants and the Enrollment Process

The design and rationale for this study have been described in detail previously.[23] Briefly, recruitment occurred between August 1, 2011, and July 31, 2012, and all the participants were required to have a body mass index (calculated as the weight in kilograms divided by the height in meters squared) between 20 and 35 and an age of 21 to 35 years. The exclusion criteria included the use of medications to lose weight, starting or stopping smoking in the previous 6 months, and planned weight loss surgery. Furthermore, individuals were excluded for resting blood pressure greater than 150 mm Hg systolic or greater than 90 mm Hg diastolic, for an ambulatory blood glucose level greater than 145 mg/dL (to convert to mmol/L, multiply by 0.0555), or if currently diagnosed as having or taking medications for a major chronic health condition. Individuals with a history of depression, anxiety, or panic were excluded, as were those taking selective serotonin inhibitors for any reason. All the women were eumenorrheic. Informed consent was obtained from each participant before data collection.

Anthropometric Characteristics

A dual-energy X-ray absorptiometer (DXA) provided data on bone mineral density, FM, and FFM, overall and for various body regions (arms, legs, etc). The scan was completed using a Lunar DPX system (version 3.6; Lunar Radiation Corp). Skeletal muscle mass was calculated from appendicular lean soft-tissue (ALST) mass using the following linear regression equation:

$$\text{Skeletal muscle mass} = (1.13 \times \text{ALST}) - (0.02 \times \text{age}) + (0.61 \times \text{sex}) + 0.97$$

where sex = 0 for women and 1 for men.[24] This equation was developed (n=321) and validated (n=93) with ethnically diverse men and women using magnetic resonance imaging and DXA, and correlations between skeletal mass derived from the equation and magnetic resonance imaging were high (R^2= 0.96, P<.0001).[24] Residual mass, including brain, liver, kidneys, heart, gastrointestinal tract, and other organs and tissues, was then calculated using the following equation[25]:

$$\text{Residual mass} = \text{body weight} - \text{fat mass} - \text{skeletal mass} - \text{bone mass}$$

Cardiorespiratory Fitness

Fitness testing was conducted using a treadmill (Trackmaster 425; CareFusion Corp), with respiratory gases sampled using a TrueOne 2400 metabolic measurement cart (Parvo Medics) and a modified Bruce protocol. Given that no broadly accepted criteria exist to categorize fitness levels, participants were classified as low if they were in the bottom tertile for CRF among the entire cohort for each sex, as moderate if they were in the middle tertile, or as high if