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Aerobic physical fitness in relation to blood lipids and fasting glycaemia in adolescents: Influence of weight status

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Abstract *Background and aims:* We explored the associations between aerobic physical fitness with blood lipids and a composite index of blood lipids and fasting glycaemia in adolescents, analysing possible interactions with weight status.
Methods and results: Body mass index and aerobic physical fitness was measured in 2090 adolescents (1034 males and 1056 females) 13–18.5 years by using the 20-m shuttle run test. Plasma glucose, total, high density lipoprotein (HDL) and low density lipoprotein (LDL) cholesterol, triglycerides, apolipoprotein (apo) A-I, apo B-100 and lipoprotein(a) [Lp(a)] were measured in 460 of the 2090 subjects. After adjustment for confounding factors, a continuously distributed summary score for blood lipids and fasting glycaemia was significantly related to aerobic fitness in males ($P = 0.018$) and females ($P = 0.045$, from the 2nd to the 4th quartile of aerobic fitness). After adjustment for gender, age, sexual maturation and economic status, aerobic fitness was related to the composite index of blood lipids and glycaemia in both overweight and non-overweight adolescents ($P < 0.05$). However, for the same level of aerobic fitness, the composite index of blood lipids and glycaemia was significantly higher in overweight adolescents ($P = 0.001$). After setting the minimal

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aerobic fitness standards to present a healthy lipid profile, about 50% of males did not reach such values.
Conclusion: Our data suggest that both aerobic fitness and weight management are associated with a composite index of blood lipids and glycaemia in adolescents. Our study also provides the minimal levels of aerobic physical fitness associated with a favourable lipid profile in male adolescents, a new tool which should be adopted by schools as ''aerobic fitness standards''.

Introduction

Cardiovascular disease (CVD) is the leading cause of death in developed countries. Although the clinical manifestations of CVD occur in middle adulthood, pathological data have shown that atherosclerosis begins in childhood and adolescence [1—3]. Disturbed plasma lipid profile is an important cardiovascular risk factor, capable of inducing atherosclerotic development [4,5]. This has been early shown in adults, but holds also for children and adolescents. In fact, it has been recently demonstrated that plasma low density lipoprotein (LDL) cholesterol levels measured in childhood are a consistent predictor of carotid artery intima-media thickness in young adults who are still too young to experience coronary events [6,7]. These, and other findings [8,9], suggest that a primary goal in CVD prevention should be to keep a healthy plasma lipid profile since childhood [10,11].

Fasting glycaemia also deserves some attention. In fact, fasting glucose has been proposed as a marker of loss of beta cell function and insulin response [12], and there are noticeable similarities in the cardiovascular risk factor profile in subjects with impaired fasting glycaemia and in subjects with impaired glucose tolerance [13].

Regular aerobic physical activity leads to a significant cardiovascular risk reduction, by improving the plasma lipid profile [14,15]. Along the same line, increased aerobic physical fitness (which is in part the result of regular practice of aerobic physical activity) during adolescence has been associated not only with healthier blood lipids during these years [16,17], but also later in life [18]. Therefore, it seems reasonable to initiate regular aerobic physical activity in childhood in order to prevent metabolic risk and CVD in adulthood.

The previous studies did not analyse possible associations with a metabolic composite index, but with single blood lipids. Therefore, our first aim was to explore associations between aerobic physical fitness not only with single blood lipids, but also with a composite index of blood lipids and fasting glycaemia in adolescents. Of note, only one study [19] analysed interactions between obesity measures and aerobic physical fitness in relation to a metabolic composite index, so we also tested a similar interaction in our population. Finally, to the best of our knowledge there are no studies providing minimal criterion standards of aerobic fitness in adolescents, associated with healthy metabolic outcomes. Therefore, we secondly aimed to set minimal criterion standards of aerobic fitness associated with a favourable lipid profile in adolescents.

Methods

Study population and design

This research was part of the AVENA study (Análisis y Valoración del Estado Nutricional en Adolescentes españoles [Assessment of Nutritional Status in Spanish Adolescents]), a population-based cross-sectional multicentric study of the aetiology and pathogenesis of obesity and related metabolic disorders during adolescence. The general methodology of the study, as well as the sample inclusion criteria, has been published elsewhere [20,21]. Briefly, 2851 Spanish adolescents (1354 males and 1497 females) aged 13—18.5 years were selected by means of a multiple-step, simple random sampling, taking into account the location (Madrid, Murcia, Granada, Santander and Zaragoza) and random assignment of the schools within each city. The inclusion criteria were: (1) not to be a consumer of alcohol, drugs or steroids, (2) not to have familial hypercholesterolaemia, (3) no history of CVD, (4) to be free of disease and medication at the time of the study, and (5) not to be pregnant. Socioeconomic status was assessed by examining paternal educational level and occupation. The subjects were accordingly classified into five categories: low, medium-low, medium, medium-high and high socioeconomic status.

Parents or supervisors were informed by letter about the nature and purpose of the study and they gave their written informed consent. The