International Journal of Cardiology 186 (2015) 186–195

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

The combined effect of physical activity and sedentary behaviors on a clustered cardio-metabolic risk score: The Helena study

Tara Rendo-Urteaga [a,b,*], Augusto César Ferreira de Moraes [a,b], Tatiana Sadalla Collese [a,b], Yannis Manios [c], María Hagströmer [d], Michael Sjöström [e], Anthony Kafatos [f], Kurt Widhalm [g], Jérémy Vanhelst [h,i], Ascensión Marcos [j], Marcela González-Gross [k,l], Stefaan De Henauw [m,n], Donatella Ciarapica [o], Jonatan R. Ruiz [e,p], Vanesa España-Romero [q], Dénes Molnár [r], Heráclito B. Carvalho [a], Luis A. Moreno [b,s], on behalf of the HELENA study group

[a] *Youth/Child and cARdiovascular Risk and Environmental (YCARE) Research Group, School of Medicine, University of São Paulo, São Paulo, Brazil*
[b] *Growth, Exercise, NUtrition and Development (GENUD) Research Group, School of Health Science (EUCS), University of Zaragoza, Zaragoza, Spain*
[c] *Department of Nutrition & Dietetics, School of Health Science & Education, Harokopio University, Athens, Greece*
[d] *Division of Physiotherapy, Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Huddinge, Sweden*
[e] *Unit for Preventive Nutrition, Department of Biosciences and Nutrition, Karolinska Institutet, Huddinge, Sweden*
[f] *Department of Social Medicine, School of Medicine, Preventive Medicine and Nutrition Clinic, University of Crete, Crete, Greece*
[g] *Department of Pediatrics, Private Medical University, Salzburg, Austria*
[h] *INSERM U995, University Lille Nord de France, Lille, France*
[i] *CIC-PT-1403-INSERM-CH&U, University Hospital, Lille, France*
[j] *Inmunonutrition Research Group, Department of Metabolism and Nutrition, Instituto del Frío, Institute of Food Science and Technology an Nutrition (ICTAN), Spanish National Research Council (CSIC), Madrid, Spain*
[k] *ImFINE Research Group, Department of Health and Human Performance, Faculty of Physical Activity and Sport-INEF, Technical University of Madrid, Madrid, Spain*
[l] *Institut für Ernährungs- und Lebensmittelwissenschaften — Ernährungphysiologie, Rheinische Friedrich Wilhelms Universität, Bonn, Germany*
[m] *Department of Public Health, Ghent University, Ghent, Belgium*
[n] *University College Ghent Vesalius, Ghent, Belgium*
[o] *Agricultural Research Council, Research Centre for Food and Nutrition (CRA-NUT), Rome, Italy*
[p] *PROFITH "PROmoting FITness and Health through physical activity" Research Group, Department of Physical Education and Sports, Faculty of Sport Sciences, University of Granada, Granada, Spain*
[q] *Department of Physical Education, School of Education, University of Cádiz, Puerto Real, Cádiz, Spain*
[r] *Department of Pediatrics, Medical Faculty, University of Pécs, Pécs, Hungary*
[s] *School of Medicine of the University of São Paulo, Department of Preventive Medicine, São Paulo, Brazil*

ARTICLE INFO

Article history:
Received 28 November 2014
Received in revised form 9 February 2015
Accepted 16 March 2015
Available online 17 March 2015

Keywords:
Physical activity
Sedentary lifestyle
Cardiometabolic risk
Adolescents

ABSTRACT

Background/objective: Increased physical activity (PA) and decreased sedentary behaviors (SBs) may have beneficial effects on cardio-metabolic risk in adolescents. The aim of this study was to examine the associations between independent/combined effects of PA and SB with individual/clustered cardio-metabolic risk factors.
Methods: A sample of 769 adolescents (12.5–17.5 years) from the HELENA cross-sectional study (Healthy Lifestyle in Europe by Nutrition in Adolescence) and with valid data on metabolic risk factors were included.
Results: Concerning moderate-to-vigorous-PA (MVPA) and vigorous-PA (VPA), measured with accelerometers, girls tended to do more MVPA (36%) and VPA (114%) than boys. Unadjusted analyses show a positive association between "PA $\geq$ 60 min/d; SB $\geq$ 2 h" and the ratio TC/HDL-c ($\beta = 0.27$; 95%CI 0.01 to 0.52; $p < 0.05$), and a negative association between "MVPA $\geq$ 60 min/d; SB < 2 h" with the $\sum$4Skinfolds ($\beta = -0.32$; 95%CI -0.61 to -0.02; $p < 0.05$). Moreover, "SB $\geq$ 2 h/d" was associated with increased cardio-metabolic risk (PR 1.59; 95%CI 1.05 to 2.39; $p < 0.05$), while "PA $\geq$ 60 min/d; SB < 2 h" had a protective effect against cardio-metabolic risk (PR 0.48; 95%CI 0.25 to 0.91; $p < 0.05$). After adjustment for potential confounders, a positive association between SB and $\sum$4Skinfolds was shown ($\beta = 0.28$; 95%CI 0.04 to 0.53; $p < 0.05$). Furthermore, VO_2max (mL/kg/min) tends to increase in those participants who do higher VPA and less SB ($p = 0.042$), and there was a protective effect of "VPA $\geq$ 30 min/d; SB < 2 h" against cardio-metabolic risk (PR 0.24; 95%CI 0.07 to 0.85; $p < 0.05$).
Conclusion: The current study suggests that adolescents should be encouraged to decrease sedentary lifestyle and increase physical activity, especially vigorous physical activity, in order to reduce cardio-metabolic risk.

* Corresponding author at: Department of Preventive Medicine, School of Medicine of the University of São Paulo, Av. Dr. Arnaldo, 455, 2° andar, São Paulo, SP, Brazil.
E-mail address: trendo@usp.br (T. Rendo-Urteaga).

http://dx.doi.org/10.1016/j.ijcard.2015.03.176
0167-5273/

1. Introduction

Increased physical activity (PA) and decreased sedentary behaviors (SBs) are important contributors to adolescents' health. On the one hand, SB defined as sitting or lying activities associated with low levels of energy expenditure, has recently been identified as an important contributor to low cardio-metabolic health [1], and adiposity in children [2–4]. On the other hand, PA is an important determinant of obesity and associated comorbidities in young people [5–9].

Several studies concluded that low levels of PA and high levels of SB have been associated with increased overall cardio-metabolic risk [10–13] and overweight [14,15] among children. Some of them have analyzed the associations between PA and single cardiovascular diseases risk factors [13,14,16], and have shown that these associations are often very weak. In this sense, clustering of cardiovascular diseases risk factors has proved to be a better measure of cardiovascular health in children than single risk factors [17,18].

Although, there are studies assessing the independent associations of PA and SB with cardio-metabolic risk factors, little is known about the combined association of PA and SB with individual or clustered cardio-metabolic risk factors [19].

Accurate measurement of these behaviors is important for investigating the associations with health outcomes. Accelerometry is now widely applied for the objective assessment of PA and sedentary time in children [20] with known validity and reliability [21]. Despite the advantages of accelerometers, they have also some short-comings that can be addressed by using survey instruments such as questionnaires. Accelerometers are not able to provide contextual information about children's PA and SB. They do not provide information on the type of PA (e.g. structured vs. unstructured) or specific SB (e.g. television viewing, computer use, painting) and the setting in which it was performed (e.g. at school or at home) [22]. Questionnaires provide a subjective estimate of overall levels of PA and SB during the reference period, as information derived from self-reports is potentially subject to response bias [23]. Nevertheless, improvements in questionnaire design have been thought to ameliorate such limitations.

The aim of this study was to examine the associations between independent and combined effect of PA (measured by accelerometry and by questionnaire) and SB (measured by questionnaire) with individual and clustered cardio-metabolic risk factors in adolescents form the HELENA study.

2. Methods

2.1. Study population

The HELENA study (Healthy Lifestyle in Europe by Nutrition in Adolescence) is a cross-sectional study aiming to describe the lifestyle and nutritional status of European adolescents [24,25]. Data collection took place between 2006 and 2007 in the following cities: Athens and Heraklion (Greece), Dortmund (Germany), Ghent (Belgium), Lille (France), Pecs (Hungary), Rome (Italy), Stockholm (Sweden), Vienna (Austria) and Zaragoza (Spain). A detailed description of the HELENA sampling and recruitment methodology, harmonization processes, data collection, analysis strategies and quality control activities has been published elsewhere [24]. Data were analyzed in August 2014.

A sample of 3528 adolescents met the HELENA general inclusion criteria. One-third of the participating school classes were randomly selected in each city for blood collection, resulting in a total of 1089 adolescents. For the purposes of our study, participants with valid data on cardio-metabolic risk factors (Homeostasis model assessment [HOMA] index, Systolic Blood Pressure [SBP], Triglycerides [TG], total cholesterol/high-density lipoprotein-cholesterol [TC/HDL-c], four skinfold thicknesses [$\sum$4Skinfolds] and maximal oxygen consumption [VO_2max]) were included into the analysis ($n = 769$) (Fig. 1).

The study was performed following the ethical guidelines of the Declaration of Helsinki 1964 as revised in 2000 and was approved by the Ethics Committee of each city involved [24,26]. All parents/guardians signed an informed consent form and the adolescents agreed to participate in the study.

2.2. Individual metabolic risk factors

Anthropometric measurements were measured following a standardized protocol [27]. Weight was measured in underwear and without shoes with an electronic scale (Type SECA 861) to the nearest 0.1 kg; height was measured barefoot in the Frankfort plane with a telescopic height measuring instrument (Type SECA 225) to the nearest 0.1 cm. Waist circumference and a set of skinfold thicknesses (biceps, triceps, subscapular and suprailiac) on the left side of the body were measured three consecutive times with a non-elastic tape (SECA 200) to the nearest 0.1 cm and a Holtain caliper, to the nearest 0.2 mm, respectively.

SBP was measured twice by OMRON®M6 (HEM 70001). Participants were seated in a separate quiet room for 10 min with their backs supported and feet on the ground. Two SPB readings were taken at 10 min intervals, and the lowest measure was used.

Cardiorespiratory fitness was measured using a field-based test (20 m shuttle run test) [28]. Participants ran between two lines spaced 20 m apart, keeping pace with audio signals. The initial speed was 8.5 km/h, and each minute speed was increased by 0.5 km/h. Participants had to run in a straight line and had to pivot on the lines. The test finished when participants stopped due to fatigue or when they failed to reach the end line concurrent with the signals on two consecutive occasions. The last completed stage or half-stage was recorded. Finally, the VO_2max in ml/kg/min was estimated by the Leger equation [28].

Blood samples were collected by venipuncture at school between 8:00 am and 10:00 am after a 10-h overnight fast. Blood was collected in heparinized tubes, immediately placed on dry ice and centrifuged within 30 min (3500 r.p.m. for 15 min) to avoid hemolysis. Immediately after centrifugation, the samples were stored and transported at 4–7 °C (for a maximum of 14 h) to the central laboratory in Bonn (Germany), and stored there at −80 °C until assayed [29]. TG, TC and HDL-c were measured using enzymatic methods (Dade Behring, Schwalbach, Germany). Insulin levels were measured from frozen serum using an Immulite 2000 analyzer (DPC Bierman GmbH, Bad Nauheim, Germany). The HOMA index calculation was used as a measure of insulin resistance [30].

2.3. Clustered cardio-metabolic risk

A clustered cardio-metabolic risk index was created from the following variables: HOMA index, SBP, TG, TC/HDL-c, VO_2max and the $\sum$4Skinfold. The standardized value of each variable was calculated as (value-mean) / standard deviation, separately for males and females and by 1-year age group. For variables characterized by lower metabolic risk with increasing values (HDL-c), z-scores were multiplied by −1. To create the cardio-metabolic risk score, all z-scores were summed, in which the lowest values were indicative of a better cardio-metabolic risk profile. Finally, all of those subjects at or above age- and gender-specific were classified as having metabolic risk when they accumulated ≥1SD, similar to previous studies [10,31,32].

2.4. Independent variables

The PA and SB levels were considered independent variables. SB was assessed by questionnaire and PA was assessed both by questionnaire and accelerometry. The questionnaire used for PA measurement was developed to assess PA levels (moderate-to-vigorous levels) in adolescents (IPAQ-A) [33].

PA was also objectively measured with accelerometers (Actigraph MTI, model GT1M, Manufacturing Technology Inc., Fort Walton