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Interactions of physical activity and body mass index with age at menarche: A school-based sample of Chinese female adolescents

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ABSTRACT

Background: To test the independent and interactive associations of physical activity (PA) and body mass index (BMI) with age at menarche among Chinese adolescence.
Methods: We conducted a cross-sectional survey in two elementary schools in September 2015 in Shaoxing city, Zhejiang province, China. We used self-administered questionnaires to collect the information of the participators. Analyses were performed with logistic regression models, and the relative excess risk due to interaction (RERI), the attributable proportion because of the interaction (AP), and the synergy index (S) were used to evaluate the biological interaction.
Results: A total of 1530 middle school students from grade 1–3 were selected for this study, and we collected 1505 (98.366%) valid questionnaires for the last analyses. The mean age of menarche is 11.603 (SD = 0.447) years. Students with overweight/obesity and without SMPA had the highest risks of early age of menarche (OR = 3.507, 95%CI: 1.929–6.376) compared with women both with a normal BMI and with SMPA, and the RERI was 1.846 (95% CI: 0.415–4.107), meaning that there was positive interaction on the additive scale.
Conclusion: Insufficient PA can significantly modify the association between obesity and early menarche risk. Therefore, the government and society should pay more attention to the promotion of PA throughout childhood and adolescence.

What is already known on this topic

1. Several international studies during recent decades have presented a remarkable downward secular trend in age at menarche.

2. Age at menarche reflects numerous health aspects of a population, and may also represent a potential health risk if it deviates from its nominal values.

3. There were many factors affecting the age at menarche, such as genetics, obesity, geography, dietary habits, physical exercise, and even climate.

What this paper adds

1. Body mass index (BMI) is significant negatively correlated with age at menarche, and their correlations was modified by physical exercise (PA).

2. Especially, there was about 52.612% of the risk of early age at menarche in students attributed to the interaction between overweight/obesity and insufficient PA.

3. Comparing with vigorous PA, moderate PA may play a more important role in the moderating Effect model.

Introduction

The onset of menarche is an important milestone in reproductive life, and changes in the age at menarche have been an area of great research interest for decades. Several international studies during recent decades have presented a remarkable downward secular trend in age at menarche. For example, a study in Europe reported a significant decrease of the median age at menarche from 13.66 years to 13.05 years during the half century [1]. In the United States, the proportion with early menarche (<11 years) increased from 4.00% to 11.80% over the last 50 years [2]. While, in China, the average age at menarche also showed a downward trend from 13.41 years in 1985 to 12.47 years in 2010, and this decrease has been approximately 4.50 months per decade [3,4].

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Age at menarche reflects numerous health aspects of a population, and may also represent a potential health risk if it deviates from its nominal values. Recent studies reported that age at menarche may affect the risk of various diseases in adulthood. Epidemiologic evidence have provided the supports for the conclusion that earlier menarche is associated with detrimental health effects; for example, early menarche may be associated with increased risks of cardiovascular disease, gestational diabetes mellitus, asthma, nonalcoholic fatty liver disease, as well as the risky sexual behaviors among adolescent females [5–9]. While, other studies have showed the associations of increasing age at menarche with some health problems such as infertility and post-menopausal depression [10,11].

There were many factors affecting the age at menarche, such as genetics, geography, dietary habits, physical exercise, and even climate. Body mass index (BMI) has been shown the most important factor that associated with the age at menarche, and the inverse correlation between BMI and age at menarche was statistically significant (R = 0.49) [4]. A recent systematic review revealed that physical activity (PA) might also influence the onset of puberty, and age at menarche delay was well documented for females exposed to regular high intensive physical exercises in childhood and adolescence [12].

Although PA and BMI were separately associated with the age at menarche, the interactions of PA and BMI with age at menarche have been less studied, particularly in general Chinese samples. The main purpose of this study was to examine (i) the relationship between PA, BMI and age at menarche; and (ii) the interactive effects of PA and BMI on age at menarche among Chinese middle school students.

Method

Participants

We conducted a school-based cross-sectional survey in two elementary schools in Shaoxing city, Anhui province, China. This study was conducted in September 2015 and was approved by the Ethics Committee of Anhui Medical University. Written informed consents were obtained from all of the participants. We used self-administered questionnaires to collect the information of the participators, and the questionnaires needed to be completed within 30 min in the classroom independently. Teachers remained in the classroom and took charge of collecting questionnaires and checking the quality of questionnaires. Teachers also answered the student questions about the study when necessary. A total of 1530 middle school students from grades 1–3 were selected for this study, and we collected 1505 (98.40%) valid questionnaires.

Measure of primary outcomes

BMI

The weight and height of participators were measured by trained interviewers according to a standardized protocol. Weight was measured to the nearest 0.1 kg with lever scales, and height was measured to the nearest 0.1 cm, using metal column height measuring stands. BMI was calculated as the weight (kg) divided by the height squared (m^2). Overweight and obesity were classified according to the international standard by Cole at al [13].

Physical activity (PA)

PA was assessed by the Youth Risk Behavior Surveillance (YRBS). The following two questions were used:

(1) Moderate physical activity (MPA): during the past 12 months, on how many of the past 7 days did you take part in physical activity or exercise for at least 30 min where you heart did not beat fast or you did not breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors? (The responses range from 0 to 7 days)

(2) Vigorous physical activity (VPA): during the past 12 months, on how many of the past 7 days did you exercise or take part in physical activity that made your heart beat fast and made you breathe hard for at least 20 min, such as basketball, soccer, running or jogging, fast dancing, swimming laps, tennis, fast bicycling, or similar aerobic activities? (The responses range from 0 to 7 days)

Sufficient vigorous physical activity (SVPA) was defined as no less than three days of VPA with 20 min each week. Sufficient moderate physical activity (SMPA) was defined as no less than five days of MPA with 30 min each week. Insufficient physical activity (IPA) was defined as participating in <2 days of 20 min of VPA and in <4 days of 30 min of MPA in the week preceding the survey [14].

Age at menarche

The age at menarche was determined using the recall method. The participators were requested to state to the nearest whole year, how old they were when they first experienced menstrual flow. Age at menarche was measured to the nearest 0.1 years. We set the cutoff at 25% of the maximum as early age at menarche and the cutoff at 75% of the minimum as late age at menarche.

Statistical analysis

The Pearson chi-square was performed to assess differences in the characteristics between rural and urban participants. The multivariable logistic regression model was performed to explore the independent and interactive relationship between BMI and PA on age at menarche. We also used the relative excess risk due to interaction (RERI), the attributable proportion because of the interaction (AP), and the synergy index (S) to evaluate the biological interaction based on the additive interaction of BMI and PA, which are often considered the standard measure for interaction on the additive scale. If there was no biological interaction, the confidence interval (CI) of RERI and AP included 0, and the CI of SI contained 1.0 [15,16]. All statistical analyses were conducted using SPSS version 13.0 (Statistical Package for the Social Sciences). A $P < 0.05$ was considered to be statistically significant.

Result

Characteristics of the study sample

Table 1 presents the characteristics of the sample stratified by resident area. Overall, 1505 students participated in the assessments. Participants from grade one (n = 465) accounted for 30.897% of the total sample; grade two (n = 519) accounted for 34.485% of the total sample. The mean age of all participants was 13.726 years (standard deviation [SD] = 1.003). The mean age of menarche is 11.603 (SD = 0.447) years. Overall, 7.708% of the students were overweight/obesity, and 43.854%, 15.216%, and 52.027% of the students had SVPA, SMPA, and IPA during the past one year, respectively.

Independent association of BMI and PA with age of menarche

Table 2 presents the independent association of BMI and PA with age of menarche. Students without SMPA (OR = 1.937, 95% CI: 1.305–2.877), without SVPA (OR = 1.719, 95% CI: 1.323–2.234), and with IPA (OR = 1.718, 95% CI: 1.329–2.220) was associated with an