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ORIGINAL ARTICLE

Timing of Spermarche and Menarche are Associated with Physical Activity and Sedentary Behavior Among Korean Adolescents

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Abstract
Objectives: This study examined the timing of menarche and spermarche and their associations with physical activity (PA) and sedentary behavior (SB) after controlling for body mass index (BMI).
Methods: Multiple logistic regression analyses were conducted to determine whether the timing of menarche in girls and spermarche in boys is associated with PA and SB independent of BMI in a nationally representative sample of Korean adolescents (13–18 years; $N = 74{,}186$).
Results: After controlling for age, family economic status, and BMI, early timing of spermarche among boys was associated with a higher likelihood of engaging in PA and a lower likelihood of engaging in SB for $<$ 2 hours during weekdays. By contrast, boys with late timing of spermarche were less likely to engage in PA and more likely to engage in SB for $<$ 2 hours. Among girls, early or late timing of menarche was associated with a higher likelihood of engaging in PA and a lower likelihood of engaging in SB.
Conclusion: Timing of menarche in girls and spermarche in boys could be a marker for PA and SB among Korean adolescents. To promote PA and discourage SB among Korean adolescents, school-based, grade-specific interventions can be tailored by the absence or presence of menarche/spermarche.

1. Introduction

Puberty is a complex transition that involves dramatic changes in several domains of human development including biological, physical, psychological, and social development [1]. Although puberty is a universal phase of adolescents, timing of puberty varies by genetic (e.g., sex, race, parental influence), environmental (e.g., body fatness, nutrition), and socioeconomic/cultural factors (e.g., immigration status) [2]. For example, girls generally experience puberty 18–24 months earlier than boys, and overweight/obese status in early childhood is

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associated with advanced pubertal maturation [2,3]. The individual variations in puberty can be viewed by three aspects, namely, timing, status, and tempo [4,5]. Timing refers to relative or expected pubertal maturation at a given chronological age or within specific reference groups such as school class, whereas status refers to the level of development reached by an individual in terms of physical changes at a given time. Tempo of puberty describes how quickly or slowly individuals progress toward full sexual maturity. Among these concepts, the majority of literature that examined the relationship between puberty and physical and/or psychological development used pubertal timing as an indicator of biological maturation [5].

Individual variations in the timing of puberty may influence the adoption of unhealthy behaviors. Specifically, a comparison between those who mature on time and those who mature late shows that adolescents who mature early are at a higher risk of exposure to several psychological, social, and health disadvantages [6]. For example, girls who experience puberty earlier than their counterparts are more susceptible to adverse health behaviors such as earlier alcohol use [7], cigarette smoking [8], and eating disorder [9]. Furthermore, evidence suggests that early timing of puberty among girls is also associated with decline in physical activity (PA) [10–13], and an increased time spent in sedentary behavior (SB) [14]. Although supporting evidence for boys is lacking, Cumming and his colleagues [15] proposed a biocultural model of maturity, which suggests that antecedent biological variables (e.g., sexual maturation, pubertal timing, changes in body composition) influence different contexts of PA (e.g., energy expenditure, health-related fitness, skill proficiency, sport participation, and performance) directly and indirectly via psychosocial variables (e.g., physical self-concept, body image dissatisfaction, self-esteem).

One of the potential mechanisms explaining the association between high endogenous sex hormone (i.e., estrogen/testosterone) and early puberty is overnutrition in early childhood [2,16]. It is particularly well-documented among girls that increased adiposity may trigger estrogen production and lead to the early onset of menarche [2,3]. Only a few studies have examined the relationship between puberty and body mass index (BMI) among boys by using different measures [e.g., voice break, age at onset of pubertal growth spurt, peak height velocity, public hair growth, testicular volume, and/or penis length], and the results reported have been inconsistent [17–21]. However, a recent study examining the trend of age at spermarche and its association with BMI among Chinese school boys found that a higher BMI or BMI-for-Age *z*-score was associated with an increased likelihood of having reached spermarche, indicating the overlapping trend of earlier age at spermarche with increase in BMI over the past 15 years among Chinese boys [3].

While much of the research is conducted in the European and North American contexts, studies among Korean adolescents are limited. In Korea, health-care costs associated with precocious puberty (i.e., the onset of signs of puberty before the age of 7–8 years in girls and 9 years in boys) have increased remarkably since the past decade. The total cost of health care for precocious puberty was approximately US $2.3 million in 2006 and US $17.9 million in 2010 [22]. This trend overlaps with the increasing trend of childhood obesity in Korea, the prevalence of which doubled from 5.4% in 1998 to 10.8% in 2008 [23,24]. Greater understanding of the associations between pubertal timing, PA, and SB, independent of weight status among Korean adolescents may help researchers and policy makers to develop health-promotion strategies for adolescents during these formative years (i.e., adolescence). Therefore, the purpose of this study was to examine the associations between pubertal timing, PA, and SB after controlling for BMI. It is hypothesized that adolescents who experience menarche and spermarche earlier or later than their peers will show negative outcomes.

2. Materials and methods

2.1. Data/sample

Data collected from the eighth Korea Youth Risk Behavior Web-based Survey (KYRBS) in 2012 were used for the analysis. KYRBS is an annual, cross-sectional, nationwide school-based web survey that monitors health risk behavior among Korean adolescents in Grades 7–12; respondents were recruited using a stratified multistage probability sampling design [25]. Before survey administration, consent was obtained from the participating school boards, individual schools, and teachers. In June 2012, students completed a self-administered, 129-item questionnaire in a computer laboratory under the supervision of teachers assigned by principals in each school during regular school hours. Before beginning the online survey, students were asked to read the research information letter, which indicated that the participation in this survey is anonymous and voluntary. The survey is designed to take approximately 40–45 minutes to complete. All surveys included a set of questions that were supplemented with additional focus questions to gain further information on specific issues. The core information collected includes demographic background (e.g., age, sex), health behaviors (e.g., smoking, alcohol use, PA), and health outcomes (e.g., self-reported health, obesity). A total of 76,980 students from 400 middle and 400 high schools participated (response rate: 96.4%). In this study, 74,186 students (48.5% of girls) who completed the survey were included in the analysis after excluding those with missing scores in height and weight, and those aged $<$ 12 years or aged $>$ 19 years (n = 2,794). Weights were