Biological Maturation, Physical Activity, and Sedentary Behaviour among Korean Adolescents

by

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ABSTRACT

The purposes of this thesis were to (1) examine the role of pubertal timing in sex differences in physical activity and sedentary behaviour in a representative sample of Korean adolescents, (2) investigate the roles of psychosocial correlates of the relationship between pubertal status and physical activity among Korean girls, and (3) test links between pubertal timing and screen-time among Korean adolescents. Three studies were conducted to achieve these research purposes.

Study 1 examined whether pubertal timing mediates the relationship between sex and physical activity, and sedentary behaviour. Though pubertal timing mediated the relationship between sex and sedentary behaviour, sex was an important predictor of physical activity and sedentary behaviour, regardless of the variations in pubertal timing among Korean adolescents.

Study 2 examined whether body fatness (i.e., body mass index and % body fat), sport competence, perceived barriers to physical activity, and self-efficacy mediated, and parental support moderated the relationships between pubertal status and physical activity among Korean adolescent girls. Body fatness, perceived barriers to PA, and self-efficacy mediated the relationship between pubertal status and PA. Parental support did not moderate the relationship between pubertal status and physical activity.

Study 3 tested links between pubertal timing at Grade 8 and screen-time at Grade 9 among Korean adolescent boys and girls. No direct effect of pubertal timing on screen-time was found. An indirect effect of pubertal timing on screen-time through BMI existed among boys. Among girls, pubertal timing negatively predicted BMI; however, no mediation effect of BMI

between pubertal timing and screen-time was observed. No mediation effect of self-esteem or depression was found among boys and girls.

PREFACE

The three studies presented in this thesis are the original work of Eun-Young Lee in collaboration with other researchers. Detailed information about the co-authorship of each study are presented below. The co-authors included Dr. John Spence (studies 1 to 3), Dr. Wendy Rodgers, Dr. Vicki Harber, Dr. Justin Jeon, and Kiyong An (Study 2), and Dr. Valerie Carson (Study 1).

Chapter 3: Study 1. The role of pubertal timing in sex differences in self-reported physical activity and sedentary behaviour among Korean adolescents.

Eun-Young Lee developed the research questions, conducted the literature review, designed and analyzed the study, interpreted results, and wrote the initial draft of the manuscript. Dr. Spence assisted with designing the study, provided guidance on the interpretation of the results, and revised the manuscript. Dr. Carson provided guidance on statistical analysis and revised the manuscript for important intellectual content.

Chapter 4: Study 2. Pubertal status and physical activity in Korean adolescents: The role of self-efficacy and perceived barriers.

Eun-Young Lee developed the research questions, conducted the literature review, received ethics approval from the University of Alberta Research Ethics Board (Project Name "The relationship between biological maturation and physical activity among adolescents", No. Pro00039992, October 16, 2013), recruited schools and participants and collected data in Korea, designed and analyzed the study, interpreted results, and wrote the initial draft of the manuscript. Dr. Spence assisted with designing the study, provided guidance on the interpretation of the results, and revised the manuscript. Dr. Rodgers and Dr. Harber revised the manuscript for

important intellectual content. Dr. Justin Jeon and Kiyong An assisted with recruitment and data collection.

Chapter 5: Study 3. A Longitudinal Examination of the Influence of Pubertal Timing on Screen-time among Korean Adolescents.

Eun-Young Lee developed the research questions, conducted the literature review, designed and analyzed the study, interpreted results, and wrote the initial draft of the manuscript. Dr. Spence assisted with designing the study, provided guidance on the interpretation of the results, and revised the manuscript.

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Thanks to my friends and colleagues in the Faculty of Physical Education and Recreation for creating a wonderful work environment and for your ongoing encouragement. A million thanks to my family for their never-ending support and patience over the past seven years. I would also like to thank my Canadian family. I feel incredibly fortunate to have them in my life. Lastly, a special thanks to Crystal. Without her love and support, I could not have finished my PhD program.

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Chapter 1: Introduction

The benefits of physical activity (PA) on physical and psychological health are well known (Malina, Bouchard, & Bar-Or, 2004; Warburton, Nicol, & Bredin, 2006). For adults, engaging in regular PA is related to reduced incidence of obesity, lowered risk of several chronic diseases, enhanced functional capacity and psychological well-being (US Department of Health and Human Services, 2008; Warburton et al., 2006). For children and adolescents, PA leads to increased biological and psychosocial health, and is a positive predictor of healthy body weight and psychosocial adjustment (Janssen, & LeBlanc, 2010; USDHHS, 2008). Thus, regular involvement in PA is important from an early age to optimize health benefits throughout the lifespan.

Despite the numerous health benefits of PA, considerable evidence suggests that the rate of participation in PA among children is low in most developed countries (Colley, Garriguet, Janssen, Craig, Clarke, & Tremblay, 2011; Craig, Cameron, Griffiths, & Tudor-Locke, 2010; Malina & Katzmarzyk, 2006; Telama & Yang, 2000). Furthermore, PA declines by as much as 50% during adolescence (Caspersen, Pereira, & Curran, 2000; Colley et al., 2011; Goran, Gower, Nagy, & Johnson, 1998; Trost, Pate, Freedson, Sallis, & Taylor, 2000; van Mechelen, Twisk, Bertheke, Snel, & Kemper, 2000). In a representative sample of Canadian children, for example, boys took more steps per day than girls, and the number of steps per day was about 20% lower among the oldest age group, as compared with the youngest (Colley et al., 2011; Craig et al, 2010). Furthermore, in a combined sample of the National Health and Nutrition Examination Survey (NHANES) from 2003-2004 and 2005-2006 (Belcher, Berrigan, Dodd, Emken, Chou, & Spruijt-Metz, 2010), participation in moderate to vigorous PA (MVPA) was twice as much

among 6- to 11-year-olds compared to 12- to 19-year-olds. Similarly, girls experience a decline in PA at twice the rate of boys among high school students (Grunbaum et al., 2004).

South Korea (hereafter Korea) is not immune from the global pattern of age- and sex – related decline in PA among adolescents. Though no longitudinal evidence is available, age-related variances in PA have been observed in several Korean studies: younger adolescents were more physically active than older ones (e.g., Byun, Dowda, & Pate, 2012; Lee, 2011). Sex differences in PA are even more evident. Boys showed higher self-reported (Byun et al., 2012) and pedometer-determined PA than girls (Chun, & Oh, 2007; Lee, & Kim, 2007; Lee, 2011). These results reflect that age and sex are two important determinants of PA among young people in Korea, as in most developed countries (Janssen, & LeBlanc, 2010; USDHHS, 2008).

However, Thompson and colleagues (2003) reported that sex differences in PA disappeared when maturity-related variation between sexes (i.e., girls experience puberty approximately 2 years earlier than boys) were controlled. Three other subsequent studies, conducted in the UK, Canada, and Portugal, also confirmed the potential role of biological maturity on adolescents' participation in PA (Cumming, Standage, Gillison, & Malina, 2008; Rodrigues et al., 2010; Sherar, Esliger, Baxter-Jones, & Tremblay, 2007). Thus, rather than chronological age or sex differences per se, biological maturation may lead to decreases in PA involvement in both sexes. Consequently, a number of scholars have emphasized the importance of taking individual differences in maturity into account in examining PA among children and adolescents. Doing so entails a study not just of maturity, but also of its associated multi-level factors.

A Biocultural Perspective on Physical Activity among Adolescents

Malina (2008), who introduced the "a biocultural perspective" to the sphere of PA research, emphasizes the importance of integrating biological components (i.e., age, sex, maturity status, ethnicity, and genetics) with social, psychological, and environmental components to better understand and promote PA among adolescents (see Figure 1 below). The biological perspective suggests a holistic approach to the study of PA, in which all influencing factors in PA are viewed as being coordinated and not isolated.

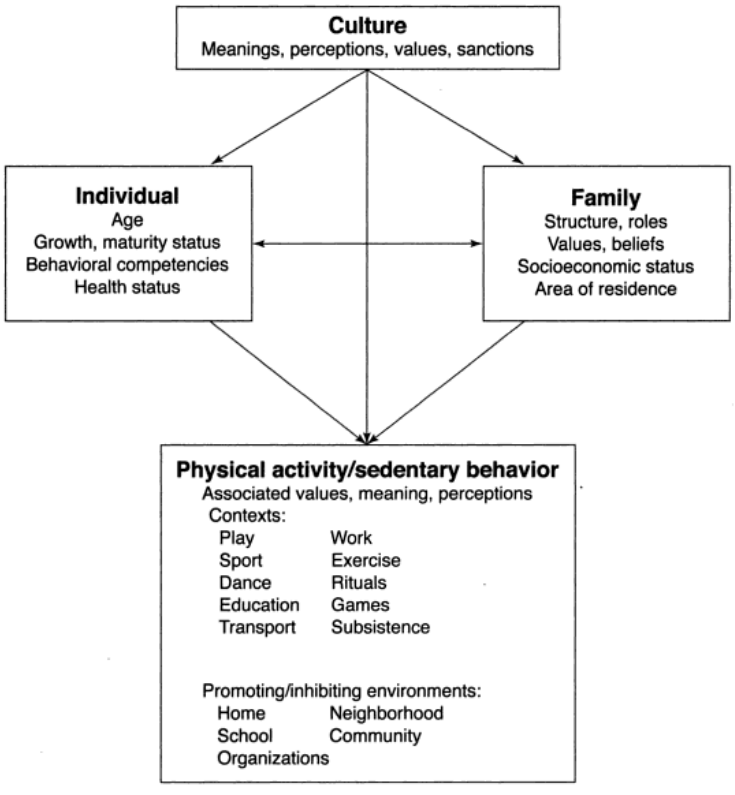

Figure 1. Interrelationships among culture, the individual, family, and physical activity and sedentary behaviour. Adapted from Chapter 6: Biocultural factors in developing physical activity levels (p. 143) by R. M. Malina. *The Youth Physical Activity and Sedentary Behavior: Challenges and Solutions* by A. L. Smith and S.J.H, Biddle Champaign, 2008, Champaign, IL: Human Kinetics.

The Ecological Model of PA (EMPA) is one such approach. In developing the model, Spence and Lee (2003) hypothesized that biological factors are likely to moderate the

relationship between extra-individual factors (e.g., cultural ideals, social values, environments) and PA (see Figure 2), whereas psychological factors (e.g., attitudes, efficacy, perceived norms) are likely to serve as mediators of the relationship between extra-individual factors and PA. These factors appear to contribute to sex differences in PA. Spence, Blanchard, Clark, Plotnikoff, Storey, and McCargar (2010), for example, found that self-efficacy partially explains these differences among adolescents. Spence et al. (2010) added that other factors that may contribute to sex differences in PA, such as the onset of puberty, must be recognized. For example, physiological consequences associated with puberty (e.g., breast development for girls) may lead to a positive or negative environment, encouragement and support from others in PA settings.

Recent studies suggest that physical and psychological changes accompanying puberty may mediate the relationship between biological maturation and PA among adolescent girls (e.g., Cumming, Sherar, Pindus, Coelho-e-Silva, Malina, & Jardine, 2012; Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, 2010). In particular, girls who mature early compared to their peers may be more sensitive to physical changes as they experience puberty, and in turn, they may be more susceptible to negative reactions from others. For instance, increased body fat mass, which is highly associated with early puberty (Davison, Susman, & Birch, 2003; Kaplowitz, Slora, Wasserman, Pedlow, & Herman-Giddens, 2001; Kaplowitz, 2008), and the ensuing psychological changes (e.g., feeling self-conscious about their physical appearance and concerned with what others think when they engage in PA) may discourage or prevent adolescent girls from being physically active.

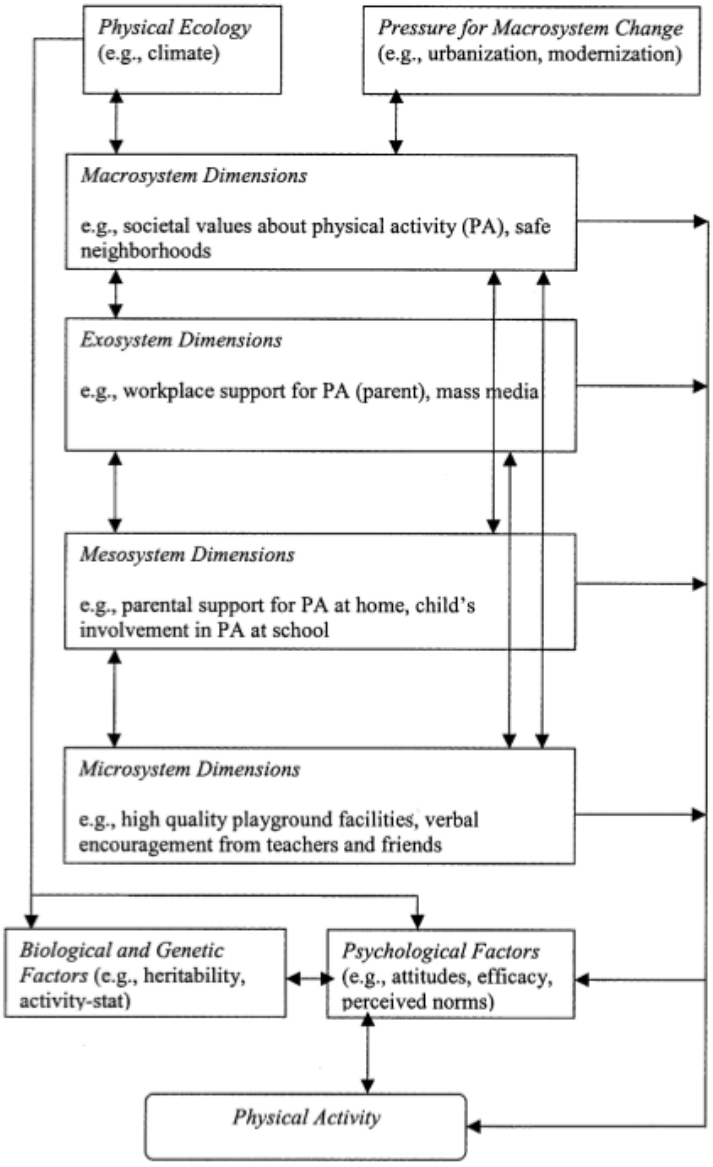

Figure 2. Ecological model of physical activity. Adapted from "The comprehensive model towards physical activity" by J. C. Spence and R. E. Lee, 2003, *Psychology of Sport and Exercise*, 4(1), p. 15.

Subsequently, a growing number of studies have focused on examining the potential role of physical self-concept in the relationship between maturation and PA among adolescent girls (e.g., Craft, Pfeiffer, & Pivarnik, 2003; Cumming et al., 2011; Davison, Werder, Trost, Baker, & Birch, 2007; Jackson, Cumming, Drenowatz, Standage, Sherar, & Malina, 2013; Knowles, Niven,

Fawkner, & Henretty, 2009; Niven, Fawkner, Knowles, & Stephenson, 2007). The findings of these studies include: negative associations between advanced maturation and physical self-worth (Davison et al., 2007; Niven et al., 2007), self-perception of body attractiveness (Cumming et al., 2011; Jackson et al., 2013; Niven et al., 2007), and perceived sport competence (Craft et al., 2003; Cumming et al., 2011; Jackson et al., 2013). Notably, employing Petersen & Taylor's (1980), "Mediated Effects Model of Psychological and Behavioural Adaptation to Puberty" (see Figure 3), Cumming et al. (2011) measured physical self-concept to explain the mechanism between biological maturation and decline in PA among 407 British adolescent girls in Grades 7 to 9. Though their findings only partially explained an inverse relationship between pubertal status and PA through physical self-concept (i.e., perceived sport competence, body attractiveness, and physical self-worth), the authors concluded the model provides a proper conceptual framework for research examining the potential mediating role of psychological factors associated with puberty on the relationship between biological maturation and PA.

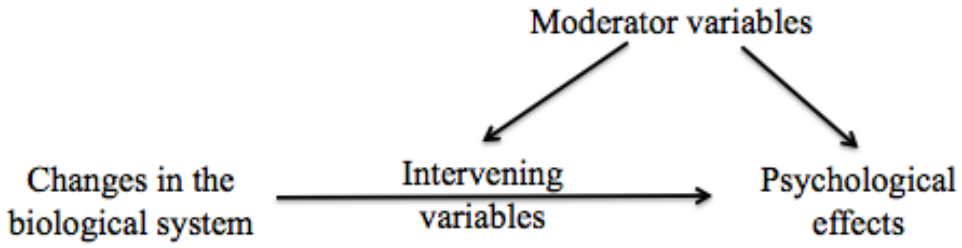

Figure 3. Mediated-effects model of psychological adaptation to puberty. Adapted from "The biological approach to adolescence: biological change and psychological adaptation" by A. C. Petersen and B. Taylor, 1980, *Handbook of Adolescent Psychology*, p. 134.

Accordingly, Cumming and colleagues proposed a biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012) (see Figure 4). In this model,

physical self-concept, body image satisfaction, attitudes and feelings towards growth, adulthood, and PA, self-esteem, self-efficacy, social physique anxiety, and autonomy are suggested as potential mediators; and social support and acceptance, cultural ideals, competing demands, opportunities for PA, and nature/demands of sport are suggested as moderators.

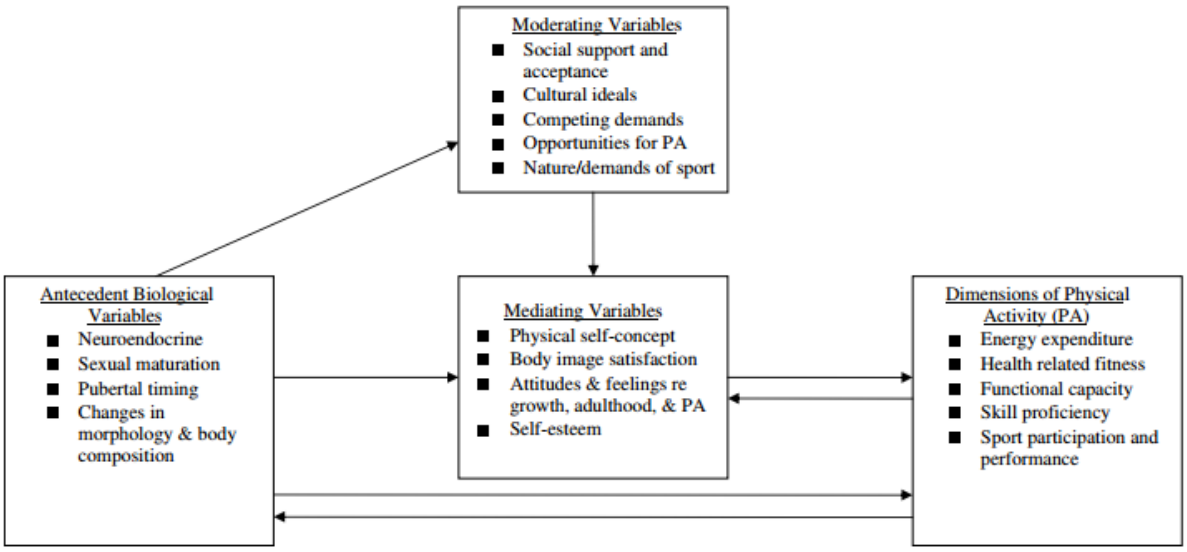

Figure 4. A biocultural model of maturity-associated variation in adolescent physical activity. Adapted from "A biocultural model of maturity-associated variance in adolescent physical activity" S. P. Cumming, L. B. Sherar, M. J. Coelho-e-Silva, R. M. Malina and P. R. Jardine, 2012, *International Review of Sport and Exercise Psychology*, 5(1), p. 29.

Sedentary Behaviour

Sedentary behaviour (SB), which is independent from PA, is another key behavioural determinant of adolescent health (Ekelund, Luan, Sherar, Esliger, Griew, & Cooper, 2012; Salmon, Tremblay, Marshall, & Hume, 2011; Tremblay et al., 2011). As such, an increasing number of researchers have recently focused on studying SB as well as PA. SB refers to any activities that require ≤ 1.5 METs in a sitting or reclining posture during waking hours (Sedentary Behaviour Research Network [SBRN], 2012). People who spend most of their time

sitting are more susceptible to cardiometabolic risk than those who do not, regardless of their PA levels (Ekelund et al., 2012). Though limited evidence exists, it has been suggested that biological maturation also potentially influences SB among adolescents. For instance, in a study examining sex differences in SB among 302 Portuguese adolescents, such differences disappeared when biological maturation was controlled (Rodrigues et al., 2010).

The Korean Context

The relationship between biological maturation and PA, or maturation and SB, has not yet been tested among Korean adolescents. Given that age and sex differences in SB, as well as those in PA, also have been reported among Korean adolescents (Byun et al., 2012; Kang, Lee, Shim, Shin, Park, & Lee, 2010), it is possible that biological maturation may play a role in these behaviours similar to what has been observed among youth in Western countries. However, the cultural context specific to Korea may outweigh the potential influence of biological maturation on PA and SB among adolescents. For example, regular participation in PA is not as valued as it is in Western countries, particularly among girls. According to a number of Korean scholars, the influence of the Confucian value attached to women is preventing girls from becoming physically active (e.g., Kim, 2014; Won, & Jung, 1999).

Consistent findings on the ethnic variations of girls' PA may also support the potential cultural influence on PA. For instance, Asians and Pacific Islanders residing in California showed less participation in competitive team sports and had a lower frequency of participation in vigorous PA than their Caucasian counterparts (Sallis, Zakarian, Hovell, & Hofstetter, 1996). Furthermore, in a study examining maturity-related ethic differences in PA among 191 girls aged 9 to 12 years reported that Caucasian girls engaged in almost twice as much loaded PA as the same maturity, height and weight Asian girls (Mackelvie, McKay, Khan, & Crocker, 2001).

Furthermore, the importance of regular participation in PA is not emphasized as much as it is in Western countries. One of the examples of not prioritizing PA in adolescents' daily life can be found in the Korean national curriculum for physical education (PE). According to Lee and Cho (2014), PE class is placed on the edge of the education curriculum in Korea, and often replaced with free study time, in which students focus on studying more core subjects such as English or Mathematics.

The education system in Korea, combined with the influence of the Confucian value towards girls, may buffer the influence of biological maturation on health behaviour among Korean adolescents. As Malina (2008) suggested, it is important to consider cultural factors (e.g., meanings, perceptions, values, and sanctions of PA) inclusively as well as biological, psychological, social and environmental factors in the study of children and adolescents because they grow, mature, and develop within the complex interrelated domains of individual, family, and culture (see Figure 1).

Research Gaps and Significance of the Study

Current evidence on explaining the relationships between biological maturation and PA is limited, as it is generally focused on testing physical self-concept as a mediator on the relationship between biological maturation and PA. A review by Cumming and colleagues (2012) revealed other factors of interest that likely mediate or moderate this relationship. To date, physical self-concept (Craft et al., 2003; Cumming et al., 2011; Jackson et al., 2014; Niven et al., 2007), body image or body dissatisfaction (Finn, Bucksch, Lampert, & Kolip, 2011), and attitudes and feelings towards growth, adulthood, and PA (Davison et al., 2007; Sherar et al., 2009) have been tested as mediators. Other potential mediators suggested, but not yet tested, include self-esteem, self-efficacy, social physique anxiety, and autonomy (Cumming et al., 2012).

Given that an extensive literature suggests sport competence (Cumming et al., 2011; Knowles et al., 2009), parental support (Beets, Pitetti, & Forlaw, 2007; Saunders, Motl, Dowda, Dishman, & Pate, 2004), perceived barriers to PA (Allison, Dwyer, & Makin, 1999; Dishman, Dunn, Sallis, Vandenberg, & Pratt, 2010), and self-efficacy (Spence et al., 2010; Trost, Pate, Ward, Saunders, & Riner, 1999) as major psychosocial correlates of PA participation among adolescent girls, it may be possible that these factors will help researchers to further explain the mechanisms linking biological maturation and PA.

In addition, though one study reported the influence of biological maturation on SB (Rodrigues et al., 2010), no study has examined the potential mediators explaining the mechanisms linking biological maturation and SB. Because SB, as well as PA, is also a key determinant of adolescents' health, it is important to explore this particular behavioural construct to have a deeper understanding of how biological maturation may or may not influence SB among adolescents.

Last, many of the studies on the topic are limited by small sample size and cross-sectional designs. Furthermore, only a few population groups in Britain (e.g., Cumming et al., 2011; Jackson et al., 2013; Knowles et al., 2009; Niven et al., 2007), Canada (Sherar, Gyurcsik, Humbert, Dyck, Fowler-Kerry, & Baxter-Jones, 2009), Portugal (Rodrigues et al., 2010), and Germany (Finn et al., 2011) have been examined. The influence of biological maturation on PA and SB among Korean adolescents may differ from those of their peers in Western countries because the cultural values and meanings towards PA, SB, and biological maturation are more likely to vary (Malina, 2008; Sherar et al., 2010).

Intent of the Research

This thesis seeks to (1) examine the relationship between biological maturation and PA, and SB among Korean adolescents, (2) extend current understandings of the potential influence of biological factors and to assess the roles of sport competence, perceived barriers to PA, self-efficacy, and parental support on PA and SB among adolescent girls, and (3) examine the potential influence of biological and psychological factors on screen time among Korean adolescents. These objectives were based on the biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012). The results of these studies may help researchers to better understand the developmental decline of PA among adolescents. Hence, health professionals, policy makers, and educational institutions may develop more effective intervention programs to promote PA among girls based on the results of this work. It is expected that, although specific to Korea, the potential findings will be valuable in understanding similar phenomena worldwide.

Organization of the Thesis

This thesis is submitted as a multiple-manuscript, journal-article format (i.e., paper-based thesis) in accordance with the Faculty of Graduate Studies and Research Thesis Formatting Requirements at the University of Alberta. Chapter 1 outlines the introduction of the study, while Chapter 2 reviews the relevant literature and provides definitions of key terms. The methodology and its rationale, and the results are presented across three separate studies (i.e., chapters 3 to 5). Last, Chapter 6 provides a comprehensive interpretation and discussion of three studies as well as the overall strengths and limitations of this thesis and recommendations for future research.

Chapter 2: Review of Literature

This chapter provides a narrative review of relevant literature and outlines conceptual frameworks associated with three empirical studies undertaken for this thesis. The key component of this chapter is a description of the literature explaining potential mechanisms linking biological maturation and health behaviours, that is, physical activity (PA) and sedentary behaviour (SB) in this thesis. In addition, potential mediators of the relationship between biological maturation and PA are discussed. To enhance readers' understanding of these subjects, hormonal and physical changes associated with puberty are also discussed, as is potential influence of Korean cultural context on adolescent behaviours.

Definitions of Common Terms

Broadly, PA refers to "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, & Christenson, 1985). Exercise is also viewed as a part of PA. It refers to "a subset of PA that is planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness" (American College of Sports Medicine, 2014). Physical inactivity, on the other hand, refers to "a PA level that is lower than in healthy individuals of similar age, gender, cultural, and socioeconomic background (i.e., an insufficient level of PA)" (Bar-Or, & Rowland, 2004). Though often used interchangeably with SB, the behaviours are distinct. SB specifically refers to "any behaviour that requires energy expenditure $\leq$ 1.5 METs while in a sitting or reclining position during waking hours" according to the currently accepted definition (SBRN, 2012).

From an energy expenditure perspective, both PA and SB are on the continuum of body movement and can be classified by frequency, intensity, duration, type, and domain (Marshall, & Welk, 2008). Frequency refers to a number of times a certain behaviour is performed within a

specific period (e.g., bouts per week, month, or year). Intensity refers to the magnitude of the physiologic response to PA and is quantified by the amount of metabolic work performed (e.g., kilocalories expended). Intensity can be measured using physiologic surrogates (e.g., heart rate) or perceptual ratings (e.g., very light, light, moderate, hard, very hard). Duration refers to the length of time the certain activity is performed. Type can refer to the main physiologic systems used (e.g., aerobic, anaerobic) to perform, though it can also refer to features of the behaviour (e.g., walking, jumping, running). Last, domain refers to the context or setting in which PA occurs such as in PE classes, during leisure time, or while transporting (Marshall, & Welk, 2008). PA and SB can be assessed using criterion measures (e.g., indirect calorimetry and doubly labeled water, direct observation), objective/direct measures (e.g., pedometry, accelerometry, heart rate monitoring, multichannel activity monitors) or subjective/indirect measures (e.g., questionnaires, interviews, activity logs) (Cumming et al., 2012; Marshall, & Welk, 2008).

Another important term to note in this thesis is biological maturation. It indicates progress towards the mature state in humans, and can be measured in skeletal, dental, reproductive, and/or neuroendocrine systems (Cumming et al., 2012). The timing and tempo of maturation varies between biological systems. For example, sexual maturity is defined as a fully functional reproductive system, whereas skeletal maturity refers to a fully ossified skeleton. Common measures of biological maturation are skeletal, sexual, and somatic and these measures are reasonably well related (Tanner, 1990). Measures of maturation assess either status or timing. Status refers to the level of development reached by an individual in terms of physical changes at a given time, whereas timing is either relative to expected pubertal maturation at a given chronological age or within specific reference groups such as school class (Brooks-Gunn, Petersen, & Eichorn, 1985; Coelho-e-Silva, Valente-dos-Santos, Figueiredo, Sherar, & Malina,

2013). Though all measures of biological maturation have limitations, skeletal age, secondary sex characteristics, menarcheal status, and/or somatic characteristics are most often used in the literature (Baxter-Jones et al., 2005; Shear et al., 2010). Radiograph of the skeleton (i.e., skeletal age) is commonly known as the best measure of maturity status (Sherar et al., 2010).

Because sexual maturation (i.e., the development of secondary sex characteristics) or skeletal maturation may have a greater effect on energy expenditure or sport participation, than dental maturation for example, literature examining the relationship between biological maturation and PA has predominantly used the timing of Peak Height Velocity (PHV), secondary sex characteristics (e.g., Tanner stage, Pubertal Development Scale [PDS]), or menarcheal age to estimate biological maturity (Sherar et al., 2010). Among these measures, PDS, stage of development of secondary sex characteristics, as well as skeletal age estimate pubertal status whereas age at PHV and menarcheal age estimate pubertal timing.

Age and Sex Differences in Physical Activity and Sedentary Behaviour among Adolescents

Despite the well-established evidence on health benefits of regular participation in PA among school-aged youth (Janssen, & LeBlanc, 2011), one of the most consistent findings in the relevant research is that the level of PA declines with increasing age, particularly during adolescence (Caspersen et al., 2000; Sallis, Prochaska, & Taylor, 2000; Telama & Yang, 2000). Sex, at least of first glance, also appears to be related to the decline of PA among adolescents. Grunbaum et al. (2004) found that the rate of decline in PA among girls is double that of boys across their high school years. In addition, in a 10-year longitudinal study of PA among 9-19-year-old girls (Kimm et al., 2002), participation in PA declined by 83% from year 1 (ages 9-10 years) to year 10 (18-19 years).

The conclusions on the age and sex differences in PA suggested by these results, however, are more complex than they appear. For instance, sex differences in self-reported PA disappeared when age at PHV was controlled (Thompson et al., 2003). Three other studies found consistent findings as Thompson and colleagues (2003), suggesting that the sex differences in PA during adolescence are primarily due to differences in pubertal timing between sexes (i.e., girls experience puberty 18-24 months earlier than boys; Baxter-Jones, Eisenmann, & Sherar, 2005; Sherar et al., 2010) (Cumming et al., 2008; Rodrigues et al., 2009; Sherar et al., 2007). These results lead us to question the well-established age differences in PA among school-aged youth. Decline in PA may be due more to biological maturation, than chronological age per se. Similarly, one study reported that sex differences in SB were attenuated when biological maturation was controlled (Rodrigues et al., 2009). These consistent results may indicate that age and sex differences in PA among adolescents may be a misconception; and that biological maturation may be another key determinant of PA and SB among adolescents as well as age and sex. There are a number of important measurement issues to take into consideration in a research pertaining to PA, SB, and biological maturation among adolescents.

Measurement issues in adolescents' physical activity and sedentary behaviour

The accurate measurement of PA is critical in order to obtain precise results. Fairclough, Boddy, Ridgers Stratton, & Cumming (2011) investigated the relationship between biological maturation and PA among 175 children (average age = 10.6 years old) using two different measures for PA. When PA levels among boys and girls of the same chronological age were compared, boys reported significantly higher PA levels than girls in both self-report and objective measures of PA. However, when the individual maturational variances were controlled, sex differences in objectively-measured PA disappeared, while the differences in self-reported PA heightened.

These results suggest that the results may significantly differ by a measurement used. Over- or under-estimating PA may also contribute to inaccurate results of research. For example, McMurray and colleagues (2008) found that overweight girls tend to overestimate their PA levels due to social desirability.

SB has been used interchangeably with other activities such as television viewing or video-game playing. However, it is important to note that television viewing or other types of screen-time do not accurately represent SB, but they are correlated with SB (Pate, O'Neill, & Lobelo, 2008; Spence, & Dinh, 2015). Furthermore, if a person can stand up while engaging in a certain activity, they are not being sedentary. The SBRN (2012) recommended that researchers should use the term and definition consistently to avoid falsely interpreting results. For example, "sedentary lifestyle" can indicate both physical inactivity and excessive sitting time, which creates further confusion in the literature.

Measurement issues for biological maturation

Measuring biological maturation among children and adolescents is often difficult because of the invasive nature of assessing maturation timing or status associated with the development of secondary sex characteristics. Sherar and colleagues (2010) reviewed the strengths and limitations of available maturity indicators. The two most widely used indictors of pubertal status are skeletal age and stage of development of secondary sex characteristics (i.e., breast development and pubic hair among girls; genital development and public hair among boys) (Coelho-e-Silva et al., 2013; Sherar et al., 2010). Timing can be presented as absolute or perceived depending on the measurement tool. For example, age at menarche is the indictor of absolute pubertal timing, while individual perception of girls' age at menarche relative to their peers (early, average, or late) is the indictor of the relative pubertal timing. Another measure

commonly used to indicate pubertal timing is age at PHV (Coelho-e-Silva et al., 2013; Sherar et al., 2010).

There are several limitations associated with the aforementioned measures mainly due to the complexity of the process of maturation and individual differences. First, it is often difficult to categorize this continuous process, and misclassification of pubertal status likely is a threat to study validity. For example, secondary sex staging (e.g., breast development for girls, genital development for boys, pubic hair development) is associated with possible flaws in aligning individuals regardless of gender. However, there are considerable differences in timing and tempo of somatic and sexual development between genders during pubertal years, thus, it is inappropriate to align boys and girls on the same secondary sex characteristics when comparing between them. In addition, the tempo of maturation also greatly varies by individuals. Some individuals may experience puberty for five years while others may experience it for less than two years (Marshall, & Tanner, 1969). Age at menarche is the most commonly used measure of pubertal timing among girls. There are three common methods to establish age at menarche: prospective, status quo, and recall. The prospective method obtains normative values by following individuals and recording the date at which menarche occurs. In the status-quo method, the mean and standard deviation for age of menarche are calculated in a large number of girls. Last, the recall method uses a simple questionnaire to ask females if they have experienced menarche, and when (date or month and year). No corresponding maturity indicator exists for boys, however, semenarche has been used to provide comparative data to girls (i.e., average age of first ejaculation) (Patton, & Viner, 2007).

Overview of the Issues in Adolescence

Given that PA dramatically decreases across adolescence, and that sex differences in PA levels no longer exist when variations in pubertal timing between sexes are controlled, the developmental decline in PA is likely to involve a combination of social, psychological, and physical changes associated with puberty rather than biological maturity per se. Thus, it is important to understand the psychological factors related to puberty to better explain the influence of biological maturation on PA among adolescents. This section describes the interactions of biological and psychological development and models of influence that present particular aspects of adolescents' psychological and behavioural adaptation to biological maturation.

Biological and psychological interactions in adolescence

During puberty, adolescents experience more dramatic biological changes than any other phases of their life cycle (Petersen & Taylor, 1980). Puberty is a momentous hormonal event developing reproductive capacity and remarkable somatic change (i.e., great increase in height and weight); overall pubertal change takes about 4 to 5 years on average for a single individual (Tanner, 1974). The onset of puberty varies by sex (i.e., girls experience puberty 18-24 months earlier than boys; Patton & Viner, 2007); and the timing and tempo of puberty differs in each individual (Lerner & Steinberg, 2009). Biological development may be indexed by chronological age-related changes (Lerner & Foch, 1987), yet great individual differences in the rate and amount of growth, as well as in the timing of particular changes, make somatic development important to consider apart from chronological age.

One of the most important types of maturation associated with puberty is endocrinological maturation, which leads to the increase in fat mass in girls and fat free mass in

boys (Malina et al., 2004). Though Frisch (1974) argued that achieving critical weight or critical threshold of fatness is necessary to trigger menarche in girls, other literature (e.g., Cheek, 1974; Donovan, 1974; Trussel, 1980) has generally rejected Frisch's hypothesis, arguing that critical weight is one of the indications rather than the cause of menarche. Nonetheless, a positive relationship between weight status and timing of puberty in girls has been found, such that girls who are overweight initiate their pubertal development earlier than their normal-weight counterparts (Kaplowitz et al., 2001; Kaplowitz, 2008; Morrison, Barton, Biro, Sprecher, Falkner, & Obarzanek, 1994). This was evident in the findings of Davison et al. (2003), who reported that the overlapping trends of increased obesity and advanced pubertal timing in girls raise the possibility that increased fatness may be driving the current pattern of earlier initiation of pubertal development among girls.

The consequences of pubertal onset are likewise complex, psychological and social contextual changes also occur following biological changes during puberty. Specifically, it has been reported that some psychological variables are more strongly linked to biological changes in pubertal girls than boys, within various sociocultural contexts (Petersen & Taylor, 1980). For example, both early timing of puberty and being overweight among girls have been found to be strongly associated with negative mental health (Brooks-Gunn et al., 1985; Caspi & Moffitt, 1991; Petersen & Taylor, 1980). In summary, girls with advanced puberty are not only susceptible to increased body fatness, but they are also exposed to the potential psychological health risks associated with advanced puberty. The effects of pubertal changes on psychological adjustment can be considered from three different perspectives: biological frameworks (e.g., effects of changes in endocrine system), individual points of view (e.g., coping with normative

and/or non-normative developmental tasks; Alsaker, 1996), and the social context (e.g., social rules or cultural influences).

Petersen and Taylor (1980) proposed the Mediated-Effects Model to measure the relationship between pubertal development and psychological adaptation. They proposed that the effects of pubertal changes on psychological development are mediated by intervening variables, or are moderated by other exogenous or contextual factors (see Figure 4). In the model, intervening variables represent internalized psychological factors (e.g., desired body image) that directly mediate an individual's adjustment to puberty; moderators may be thought of as factors exogenous to the individual (e.g., sociocultural contexts and socialization practices) that influence intervening psychological variables or modify psychological adaptations. In other words, an intervening personality variable may mediate one's reaction to pubertal changes as well as social (e.g., evaluations, reactions, and impressions imparted by parents and peers) and cultural (e.g., cultural standards of attractiveness) ideas of puberty.

Figure 5 shows important hypothetical pathways explaining how pubertal changes affect an individual's beliefs and behaviour through the sociocultural context of puberty (Petersen & Taylor, 1980). The left side of the model presents biological factors (e.g., genetic potentials, endocrine changes, secondary sex characteristic development, and time of pubertal onset). Genetic potentials, which determine the timing of pubertal events, cause endocrine changes that lead to secondary sex characteristic development. The timing of puberty and the morphological changes then interact with various sociocultural variables (e.g., attractiveness standards, stereotype of early or late maturers), and these variables influence the individual directly as well as through parents and peers. Lastly, the way each individual perceives these influences affects psychological factors such as body image, self-image, self-esteem, and gender identity.

In conclusion, from the perspective of Petersen and Taylor (1980), biological maturation is an important factor to recognize in the research of adolescents' health, not only for what it contributes to the individual's physical and psychological health, but also for how it interacts with social and cultural values attached to maturation, and in turn, affects adolescent development. For instance, physical changes in pubertal girls (e.g., increased body fat mass, breast development) may play a role in developing negative perceptions of their physique (e.g., poorer body image and physical self-concept) through sociocultural ideals (e.g., lean body type that is considered to be attractive) and social norms (e.g., as represented by peers, parents) in a culture they live in. In particular, the variation in pubertal timing appears to be strongly associated with girls' psychological development. Indeed, it is reasonably well documented that overall self-worth and self-esteem declines during the transition into puberty among American girls, and the decline is especially marked in girls who enter puberty early compared to their on-time or later counterparts (Brooks-Gunn & Petersen, 1983; Simmons & Blyth, 1987).

Models of influence

Three models are available regarding the influence of pubertal timing on psychological and behavioural development. These models differ in their claims on whether the timing of maturation itself causes risks for potential issues, or whether the context of maturation plays a greater role. Among the theories that adopt the former view, Maturational Deviance hypothesis proposes that off-time maturers (i.e., early or late maturers compare to their average peer group) are at a greater risk for psychosocial issues, and assumes that advanced or delayed maturation causes emotional stress and extends the risk for psychological problems compare to on-time counterparts (Alasker, 1995; Brooks-Gunn et al., 1985; Caspi & Moffitt, 1991; Petersen & Taylor, 1980; Tschann, Adler, Irwin, Millstein, Turner, & Kegeles, 1994). Off-time puberty may

be more challenging without necessary parental support or resources to cope with earlier or later maturation. Specifically, emotional and social resources may not yet be in place for younger adolescents if maturation starts earlier. Alternatively, if maturation is late, social and family resources might be available, but not at the time when they are most needed. Thus, adjustment problems are more likely to occur for either the earlier or the later maturer.

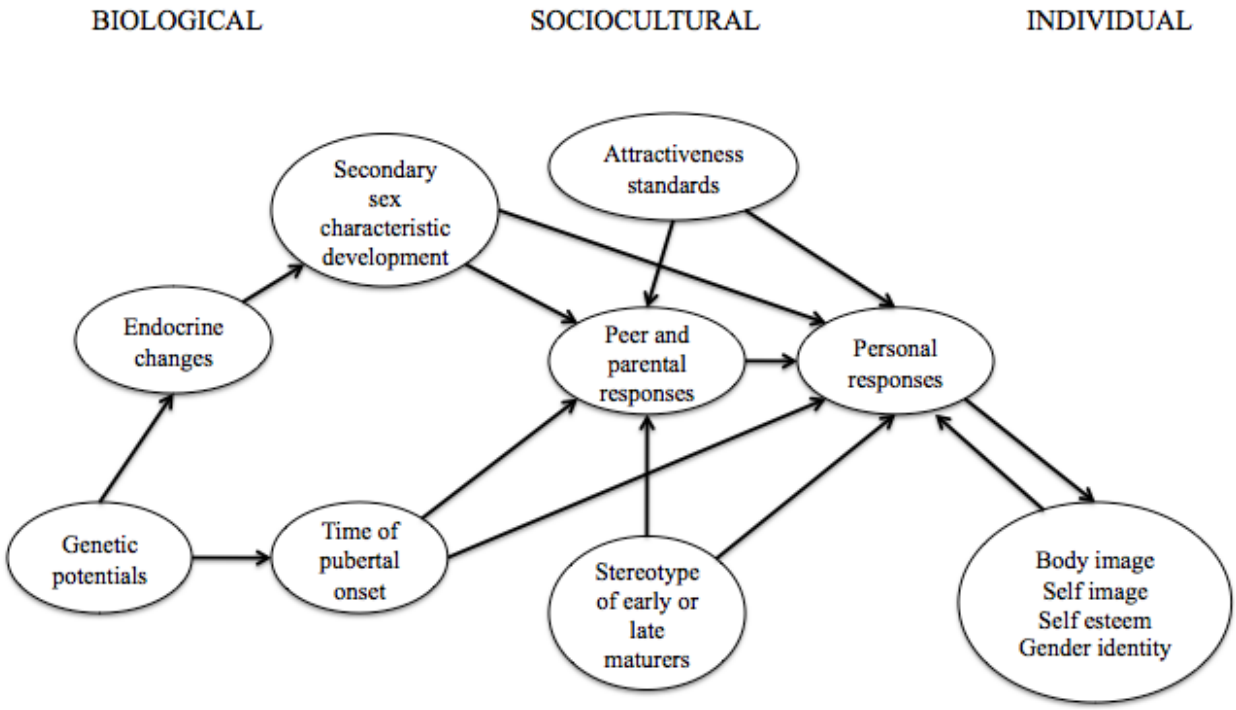

Figure 5. Hypothetically important paths between pubertal changes and psychological responses. Adapted from "The biological approach to adolescence: biological change and psychological adaptation" by A. C. Petersen and B. Taylor, 1980, *Handbook of Adolescent Psychology*, p. 147.

The second hypothesis is the Early Maturational or Early Timing hypothesis (Brooks-Gunn et al., 1985; Caspi & Moffitt, 1991; Petersen & Taylor, 1980; Tschann et al., 1994), which proposes that only early maturers, particularly among girls, are at a higher risk for psychological problems and engagement in unhealthy behaviours. The hypothesis assumes that advanced physical maturers may not have achieved a consistent level of psychological and psychosocial

development. This mismatch between physical development and cognitive and emotional development may make early maturers more susceptible to emotional stress and social pressure than their on-time and late maturers.

Last, the Goodness of Fit Model is based on the assumption that a person and a context are distinct entities with their specific characteristics (Lerner, 1985). In this hypothesis, a good fit between the characteristics of adolescents and inherent traits in any given context are considered a prerequisite for psychological adjustment. For instance, due to the association between menarche and the ability to become pregnant, even though on-time maturers who may be generally satisfied with the rate and timing of their pubertal changes, may be at risk of negative reactions (e.g., maturity fears, anger, worry) to the reality of their menarche (and puberty in general) at this stage of their life cycle. In addition, girls who feel poorly prepared for menarche, even if it occurs on-time, may perceive their pubertal processes and development much more negatively than those who feel prepared for menarche.

To date, research examining the associations between pubertal timing and psychological and behavioural consequences generally support the Early Timing Hypothesis (Ge, Brody, Conger, Simons, & Murry, 2002). Findings include that early physical maturation is associated with negative body image (Niven, Fawkner, Knowles, Henretty, & Stephenson, 2009) and initial reactions to puberty (Ruble, & Brooks-Gunn, 1982); increased mental issues such as stress, anxiety, and depression (Graber, Lewinsohn, Seeley, Brooks-Gunn, 1997; Graber, Brooks-Gunn, & Warren, 1999; Siegel, Yancey, Aneshensel, & Schuler, 1999); and poorer athletic or sport competencies (Davison et al., 2007). Early-maturing girls are also found to have more school-related behavioural problems (Simmons & Blyth, 1987; Stattin & Magnusson, 1990), earlier alcohol use (Magnusson, Stattin, & Allen, 1986) and cigarette smoking (Wiesner & Ittel, 2002).

Advanced maturation in girls may produce a large gap between actual psychological maturity and the expectations of others (e.g., expect girls to behave more mature); perhaps this mismatch causes psychological problems among girls and lead them to engage in unhealthy behaviours. Recently, Davison and colleagues (2007) reported that advanced maturers at age 11 showed lower level of PA, had more depression, poorer global self-worth, and weight-related maturity fears at age 13 compared to later maturers in 178 non-Hispanic U.S. white girls.

In contrast to girls, the relationship between pubertal timing and psychological and behavioural outcomes in boys is inconclusive. Some studies showed early maturing boys tends to have more psychological issues (Crockett & Petersen, 1987; Susman et al., 1985) and engage in unhealthy behaviour such as higher rates of alcohol consumption and cigarette smoking (Wiesner & Ittel, 2002) while other studies suggested that late-maturing boys are at a greater risk for psychological problems (Alsaker, 1996; Ge et al., 2002; Siegel et al., 1999) and a significantly higher rate of alcohol consumption than on-time and early maturers (Wiesner & Ittel, 2002). In other studies, both early and late matureres were found to be more depressed than their on-time peers in some other studies (Alsaker, 1992; Graber et al., 1997; Kaltiala-Heino et al., 2003).

To summarize, emotional complexities accompanying physical changes during puberty may fuel feelings of self-consciousness and body-related issues, particularly in early maturing girls, and may also further affects their health behaviours including PA.

Understanding Girls' Physical Activity: A Biological Perspective

To gain a comprehensive understanding of girls' PA, it is important to first understand potential influences on PA among girls. This section discusses the concept of puberty and associated endocrinological and physical changes that may influence girls' PA. In addition, obesity has been closely linked to early pubertal timing, energy imbalance, and a low level of PA.

Puberty

Puberty is the developmental process during which a child becomes a young adult, characterized by the maturation of gametogenesis, secretion of gonadal hormones, and development of secondary sexual characteristics and reproductive functions (Bordini & Rosenfield, 2011). Timing and tempo of this developmental process varies across individuals; however, regulatory gene networks controls the timing and tempo of puberty with the interactions of environmental factors (Choi & Yoo, 2013) such as light, geographic location (Parent, Teilmann, Juul, Skakkebaek, Toppari, & Bourguignon, 2003); nutrition, chronic diseases, frequent infectious disease, pollution (Phillip & Lazar, 2005); body weight and exercise (Davison et al., 2003; Frisch, 1974; Frisch et al., 1981; Kaplowitz, 2008; Malina et al., 2004); stressful events and interfamilial relationships (Matchock & Susman, 2006); and exposure to endocrine-disrupting chemicals (Den Hond, & Schoeters, 2006).

Terminology

Adolescence is used widely as a generally synonymous term for puberty, but the term often is used to convey an added connotation of cognitive, psychological, and social change, while *puberty* specifically refers to the physical and physiological changes from childhood to adulthood. *Adrenarche* refers to the onset of the adrenal androgen production that contributes to pubarche. *Gonadarche* refers to the onset of pubertal function of the gonads, which produce most of the sex hormones that underlie the pubertal changes in secondary sex characteristics. *Thelarche* denotes the onset of breast development, an estrogen effect. *Pubarche* denotes the onset of sexual hair growth, an androgen effect. *Menarche* indicates the onset of menses among girls, while *semenarche* or *oiarche* indicates the onset of ejaculation among boys.

Endocrinological changes during puberty

Before the physical signs of puberty such as breast development and pubic hair growth, the hypothalamus secretes a hormone called gonadotropin-releasing hormone (GnRH) (Divall & Radovick, 2009). GnRH regulates the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from pituitary gonadotrophs (Divall & Radovick, 2009; Root, 1973). LH induces androstenedione production, testosterone and smaller amounts of progesterone, in the ovarian theca cells (Divall & Radovick, 2009). FSH induces an increase in aromatase activity, which converts most of the testosterone to estradiol for secretion into blood circulation (Divall & Radovick, 2009). While estradiol, the hormone that dominates female development, promotes growth of the breasts and uterus, it is also the principal hormone driving the pubertal growth spurt and epiphyseal maturation and closure. Estradiol levels rise earlier and reach higher levels in women than they do in men (Root, 1973). The remaining testosterone from the secretion of LH, together with adrenal androgens, is responsible for the typical androgenic changes of female puberty: pubic hair, other androgenic hair, body odor, and acne (Divall & Radovick, 2009). Rising levels of estradiol produce the characteristic estrogenic body changes of female puberty: growth spurt, acceleration of bone maturation and closure, breast development, increased fat composition, growth of the uterus, increased thickness of the endometrium and the vaginal mucosa, and widening of the lower pelvis (Divall & Radovick, 2009; Root, 1973).

Leptin and Insulin-like Growth Factor 1 (IGF-1) have been reported to control GnRH secretion, but their role in the timing of puberty remains unknown (Parent et al., 2003). However leptin, a hormone known for regulating appetite and energy expenditure (Loomba-Albrecht & Styne, 2009), has been proposed to play a role in the initiation of puberty (Cunningham, Clifton, & Steiner, 1999). It is produced largely from adipocytes and secretes proportionate to fat mass

(Apter, 2006). According to Hassink, Sheslow, de Lancey, Opentanova, Considine, and Caro (1996), leptin concentrations are highly correlated with adiposity (r=0.88)—leptin is much higher in obese children than in children with normal BMI and pubertal girls have higher level of concentrations than in pubertal boys after controlling for BMI. Growth hormone rises steadily throughout puberty. IGF-1 levels rise and then decline as puberty ends. Growth finishes and adult height is attained as the estradiol levels complete closure of the epiphysis.

Physical changes during puberty

Dramatic changes are taking place on the outside of the body while the hormones are changing inside the body during puberty. In general, girls experience puberty an average of two years earlier than boys (Marshall & Tanner, 1970). With respect to physical changes in female adolescents during puberty, breasts begin to develop (*thelarche*); pubic hair begins to grow (*pubarche*); the hips enlarge and the waist hip ratio decreases with advancing pubertal stage, even after controlling for age and adiposity (Hammer et al., 1991). Girls attain reproductive maturity approximately 4 years after the first physical changes of puberty appear. By early adulthood, sex differences in body composition are maximal (Wells, 2007). Females generally have gynecoid body fat distribution, or fat centered on the hips and thighs (Loomba-Albrecht & Styne, 2009). Rapid weight gain is also seen in pubertal girls; natural hormonal changes at this age lead to increased adiposity, which is age-appropriate for girls. Weight gain during puberty is likely an obligate requirement to develop the physiologic capacity for reproduction (Kaplowitz et al., 2001).

Endocrinological maturation is an important concept when explaining sex differences in physical changes during puberty (Malina et al., 2004). During the pre-pubertal period, both girls and boys gain fat mass and fat-free mass in a relatively similar pattern. However, girls begin to

gain more fat than boys while boys gain slightly more absolute fat-free mass around the age of eight years. Also, at about age 12, fat-free mass gain in females begins to plateau and males begin to gain fat-free mass at an increased rate. Sex differences in fat mass become more evident during puberty. When girls and boys are aligned by Tanner stage, leptin/fat mass in girls is significantly greater than it is in boys at tanner stages 4 and 5, and significant fat mass gain is observed in girls at tanner stage 5 compared to those at tanner stage 1, resulting in greater body fat percentage at the end of puberty and throughout adulthood in females. In males, the net effect of these changes is a decreased percentage of body fat throughout puberty to an adult value of approximately 13%. In females, the net effect of a plateau in fat-free mass and increased fat mass results in an increased percentage of body fat which averages 25% in adulthood (Malina et al., 2004).

Energy-conserving mechanism among girls during puberty

Kaplowitz (2008) provided an explanation of the tight linkage between energy availability and reproductive function in females from an evolutionary perspective. In the past, when caloric availability was limited due to low food supply, resulting in decreased body fat mass and thus, lower leptin levels. In recent years, however, food shortages have been replaced with food excess in the developed part of the world, resulting in increased body fat mass, leading to higher leptin levels, and as a consequence, the age of breast development and menstruation begins earlier than in the past. The link between energy and puberty in the female body was also explained by Goran and colleagues (1998); they found a significant decrease in total energy expenditure with no change in energy intake even with fat and fat-free mass gain. And these findings are explained by a 50% reduction in PA, which may suggest an energy-conserving mechanism in pre-pubertal girls to develop reproductive capacity.

Potential influence of endocrinological and physical changes during puberty on psychological correlates of physical activity among girls

Hamburg (1974) stated that "the psychological development of the individual is closely related to the course of his or her physical development", this view has received consistent and considerable empirical support over the years (e.g., Brooks-Gunn & Petersen, 1983; Crocker, Sabiston, Kowalski, McDonough, & Kowalski, 2006; Harter, 1999; Petersen & Taylor, 1980). Biological maturation manifests itself mainly through drastic alterations in morphology, but also through changes in body composition (Rogol, Roemmich, & Clark, 2002). Specifically, lean body mass, bone mass, and body fat mass are approximately equivalent in boys and girls prior to puberty, but different changes in body composition occur during puberty and at the end of puberty. The female body develops twice as much body fat as the male (Archibald, Graber, & Brooks-Gunn, 2008; Malina et al., 2004), which is at odds with desired body shape for girls (i.e., slender body type) (Martin, 1996). Furthermore, girls gain more body fat which may lead to a drop in sport performance, while boys experience a spurt in the growth of bones and muscles and a loss of fat in the limbs (Rogol et al., 2002) that is a more suitable body shape for sport performances (Malina et al., 2004). In addition, advanced maturation in females is generally associated with less proficiency in motor skills which is a predictor of PA during childhood and adolescence (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009; Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006), particularly in tasks that involve weight bearing and endurance (Malina et al., 2004). The most, in comparison to least, matured girls are less likely to possess a linear physique, which is generally considered to be more suitable for successful engagement in a sport or exercise-related activities, particularly those that involve elements of cardiovascular endurance, the transfer of body weight, and/or aesthetic movement (Malina et al., 2004; Southall,

Okely, & Steele, 2004). These maturity associated changes in functional competence and fitness followed by changes in body shape may also affect psychological development (e.g., self-perception, self-esteem, body image) of adolescent girls.

Pubertal girls are more likely to derive their sense of self from their physical appearance than boys (Harter, 1998) and thus, psychological and social response to the body can intensify their negative self-perceptions (Davis, 1997; Harter, 1999). Studies have found that actual body weight is negatively associated with general self-esteem among girls as young as five years of age (Davison & Birch, 2002), and that overweight and obese adolescents are likely to have both poorer overall self-esteem and physical self-concept than peers in other weight groups (Davison, & Birch, 2002; Kimm et al., 1997). On a related note, several studies reported that sport competence and physical appearance are scored lower in obese children than their normal weight counterparts (Franklin, Denyer, Steinbeck, Caterson, & Hill, 2006; French, Perry, Leon, & Fulkerson, 2012; Phillips & Hill, 1998; Southall, et al., 2004; Wardle & Cooke, 2005). Davison and Birch (2002) also found an inverse relationship between girls' weight status and body esteem, and perceived cognitive ability in the older American girls. These consistent results (i.e., obese girls have lower self-esteem, body-related issues, and sports-related skills) should not be a surprise considering the previous description of a positive relationship between maturity status and percent body fat, and an inverse association between weight status and girls' psychological health.

Longitudinal examinations on changes in body weight and physical self-concept among adolescent girls also support empirical evidence that body weight has an effect on girls' physical self-concept. For instance, girls who are more overweight at five are at risk for low self-concept at age seven. This relationship was mediated by peer teasing and parent criticism at age seven,

but not at age five (Davison, & Birch, 2002), Similarly, significant decreases in physical appearance ($p > .05$) and close friendship ($p > .05$) in the highest BMI compared to the lower BMI group was observed over time among 80 Australian girls (average age of 12.8 years) (O' Dea, 2006). Though there no significant interactions existed between groups (i.e., highest BMI group, lower BMI group) in the other self-concept subscale scores over the three-year period, the highest BMI group showed downward patterns in the other subscales between the second year and third year of the study while the lower BMI group showed relatively stable patterns.

Potential Mechanisms Explaining Developmental Decline in Girls' Physical Activity

As previously discussed, it is apparent that the decrease in PA levels across adolescence is coincident with the timing of biological maturation among both sexes (Armstrong, Welsman, & Kirby, 2000; Malina et al., 2004; Telama & Yang, 2000). Therefore, studies examining PA levels among adolescents require a biocultural approach (Malina, 2008) that allows comprehensive understanding on the interactions between psychological, social, environmental, and biological factors (See Figure 1).

Although the mediating or interacting factors of the relationship between biological maturation and decreased PA levels remains unclear (Sherar et al., 2010), research has provided preliminary evidence of possible independent and interactive effects of psychosocial factors on the association between biological maturity and PA among girls. In a sample of 5,595 British children, a negative association existed between pubertal status and PA participation in 11-year-old girls, but not in boys (Riddoch et al., 2007). Similarly, Baker, Birch, Trost, and Davison (2007) found the direct effect of advanced biological maturation on objectively measured PA, that is, early-maturing girls at the age of 11 had significantly lower MVPA ($d = .47$) and VPA ($d = .55$) levels at age of 13 compare to their on-time and late-maturing counterparts and significant

reverse relationship between maturity and MVPA and VPA remained after controlling for body fatness, self-reported PA, and family socio-economic status at the age of 11. However, no significant differences were found with self-reported PA at 11 years (d = .23). In addition, a study directly measured PA using pedometer among 10-to 12-year-old girls (Drenowatz, Eisenmann, Pfeiffer, Wickel, Gentile, & Walsh, 2009) found variations in body size and PA levels by maturity status that early maturing girls showing lower PA levels than normal- or late-maturing girls. However, this relationship disappeared after they controlled for body fat mass.

Research examining the interactive role of psychosocial variables associated with biological maturation further explained the linkage between maturity status and decrease in PA among girls. For example, pubertal development at age 11 had a direct effect on MVPA, and indirect effects through depression, global self-worth and maturity fears after controlling for socio-economic status, age, and body fat percentage at age 13 in 178 American girls (Davison et al., 2007). Additionally, Cumming and colleagues (2010) found an indirect effect of pubertal maturation on girls' PA through the mediating role of sport competence, body attractiveness, and physical self-worth in physical self-concept domain (See Figure 3).

Studies explaining the relationship between biological maturation and PA are few in quantity and results are inconsistent (Cumming et al., 2012). Some research reported inverse relationships between the two constructs (i.e., biological maturation and PA) (Baker et al., 2007; Cumming et al., 2011; Davison et al., 2007; Drenowatz, 2009) as we reviewed earlier, whereas other studies reported no association (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Niven et al., 2007; Sherar, Gyurcski, Humbert, Dyck, Fowler-Kerry, & Baxter-Jones, 2009; Wickel & Eisenmann, 2007; van Jaarsveld, Fidler, Simon, & Wardle, 2007) between maturity status and PA. Aside from inconsistent research outcomes, there is lack of evidence to explain the potential

mechanisms (e.g., mediating psychosocial factors) of the relationship between biological maturation and girls' PA.

A biocultural model of maturity associated variance in adolescent physical activity

PA among adolescents requires the consideration of biological, psychological, social, and environmental factors (Malina, 2008). Furthermore, it is important to understand the sources of variation in PA levels, or the correlates or determinants of the PA phenotype among youth (Eisenmann &, Wickel, 2009). In responding to these demands, Cumming and colleagues (2012) proposed a framework that conceptualizes the relationship between biological maturation and PA (see Figure 4). This model suggests potential mediating and moderating variables describing the possible mechanisms linking biological maturation and PA. Potential mediators of the relationship between maturation and PA include physical self-concept, body image, self-esteem, acceptance and/or self-presentation anxieties and attitude and feelings related to the body, PA, and/or the maturation process. Potential moderating variables suggested within the biocultural model include social support and acceptance, cultural ideals, competing demands (e.g., education, peer-group activities), opportunities for PA, and nature/demands of sport (Cumming et al., 2012). Mediators and moderators of interest specific to this thesis are discussed in the following section.

Sport competence

Sport competence is often used interchangeably with physical competence or perceived athletic competence and is defined as one's evaluation of his or her relative physical capacity (e.g., motor skills, athletic skills) regardless of their actual skills (Fox, & Corbin, 1989). It declines during early adolescence (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002) which often coincides with the onset of puberty among girls in particular (Niven et al., 2007). Specifically, sport competence is negatively associated with body fatness (Craft et al., 2003), and

pubertal status (Niven et al., 2007), and positively associated with overall self-esteem and global self-worth (Crocker, Eklund, & Kowalski, 2000), and participation in PA (Biddle, Whitehead, O' Donovan, & Neville, 2005; Crocker et al., 2000; Crocker et al., 2006; Trost et al., 1997; Welk & Eklund, 2005; Sollerhed, Apitzsch, Rastam & Ejlertsson, 2007).

Biological factors (e.g., breast development, body fatness, psychological changes) are negatively related to perceived sport competence (Baker & Davison., 2011; Craft et al., 2003; Jones, Okely, Caputi, & Cliff, 2010; Niven et al., 2007). Accordingly, the decline in sport competence occurs during early adolescence as a result of pubertal development rather than chronological age (Monsma, Malina, & Feltz, 2006; Baker et al., 2011). For instance, body fat percentage at age 9 was the significant predictor of perceived sport competence at age 11 in a sample of 143 American adolescent girls, breast development predicted relative change in perceived sport competence between ages 11 and 13, and predicted MVPA at age 13 in girls (Baker et al., 2011).

Apart from increased body fatness and breast development among pubertal girls, sport competence seems to be negatively associated with weight status among both boys and girls (Franklin, Denyer, Steinbeck, Caterson, & Hill, 2006; Jones et al., 2010; Phillips & Hill, 1998; Southall et al., 2004). Similarly, Ulrich (1987) argued that children tend to avoid PA for which they lack confidence in favor of other activities in which they are more successful. Thus, girls might select out from sport or PA because of competency-related issues mainly derived from changes in physique (Malina et al., 2004). Given that girls have fewer mastery experiences, and that higher body fat percentage is correlated with lower sport competence, they may be less efficacious towards PA because they perceive their sport competence poorly.

Perceived barriers to physical activity

In addition to sports competence, perceived barriers to PA have been identified as one of the key correlates of PA and an important mediator of PA among children and adolescents (Allison et al., 1999; Sallis et al., 2000, Trost et al., 1999). Perceived barriers to PA, a major component of the Health Belief Model, refers to the obstacles that people experience when engaging in PA (Strecher & Rosenstock, 1977). The notion of perceived barriers is also conceptually related to Social Cognitive Theory (SCT), as it pertains to the association between the environment and a person's perceptions (Allison et al., 1999). Perceived barriers to PA may stem from environmental factors such as a lack of support from friends or family, lower resources, or a lack of time due to other responsibilities, particularly school work for school-aged children. Perceived barriers may represent more individual, psychologically based factors (internal barriers) such as a lack of motivation, other interests, or concerns about engaging in PA in public spaces (Allison et al., 1999). Also, perceived barriers to PA may reflect lower competencies and self-efficacy in PA (Trost et al., 1997).

Several cross-sectional studies have identified barriers impeding PA among children and adolescents, particularly among girls. For example, Sherar and colleagues (2009) measured PA, maturity status, and ecologically based perceived barriers among 221 girls aged between 8 to 16 years (Grades from 4 to 10) and found that interpersonal (i.e., social) barriers are the most reported among girls in Grades 4 to 6, while institutional (i.e., school) barriers to PA are the most reported among girls in Grade 9 to 10. When girls were aligned by maturity status, however, there were no significant differences existed between groups. In addition, negative meanings of PA were related to lower levels of social support and greater internal (i.e., lack self-discipline or willpower, injury, feeling stressed) and external barriers (i.e., lack of support from family and

friends, lack of time due to family responsibility) among 350 American middle school students (Hsu, Chou, Nguyen-Rodriquez, McClain, Belcher, & Spruijt-Metz 2011). Girls also reported higher levels of perceived internal barriers to PA and negative meanings of PA than boys. This gender differences in perceived barriers might be due to differences in motor skills, competence levels, social values that encourage less vigorous PA (VPA) for girls, or changes in body composition during puberty.

In addition, perceived lack of affordable and culturally appropriate neighborhood recreational programs and facilities was one of the barriers to PA among African-American girls (Gordon-Larsen, Nelson, & Popkin, 2004). However, the study also described active play and games such as jumping rope and dance that participants enjoy as part of a broader social experience. Furthermore, in a qualitative narrative inquiry, girls in transition from primary to secondary school experienced physical changes which contributed to the development of their identity and sense of physical self (Knowles, Niven, & Fawkner, 2014). The authors concluded that physical appearance is most important in developing a successful and socially acceptable stereotypical 'feminine identity', which is at odds with an 'active identity.' These results align with the findings from previous quantitative studies suggesting that physical changes during puberty are associated with PA among adolescent girls (e.g., Baker et al., 2007; Knowles et al., 2009). Sherar and colleagues (2007) emphasized the importance of identifying maturity-related barriers to PA to inform the design of interventions for adolescent girls.

Body-related issues tend to be the most predominant barrier to PA among female adolescents (Allison et al., 1999). These issues are particularly significant impediments to PA for overweight children, as they report lower levels of body esteem compared to their normal weight counterparts (Phillips & Hill, 1998). For instance, body consciousness and concern about others

seeing their bodies while they are engaging PA were the most common type of barrier to PA among girls (Zabinski et al., 2003). In addition, a longitudinal study observed 163 overweight and non-overweight girls and reported that overweight girls who internalize fat stereotypes (e.g., sloppy, stupid, lazy, and lonely) had significantly lower global self-worth and lower perceived physical appearance at age 11 and 13 (Davison, Schmalz, Young, & Birch, 2008). Given that overweight girls have a lower body esteem and physical self-concept and perceive greater barriers to the PA compared to their non-overweight counterparts, and that body fat percentage increases as girls get mature, it is important to observe perceived barriers across the weight spectrum among pubertal girls.

Self-efficacy

Self-efficacy, developed within the framework of SCT, refers to the confidence in one's ability to perform a certain task in a given situation (Bandura, 1986). Bandura emphasizes self-efficacy as the main, and the most proximal determinant of human behaviour (Conner & Norman, 2005). Self-efficacy perceptions are derived from four principal sources: mastery experiences, vicarious experiences (modeling), verbal persuasion, and emotional arousal (physiological factors). The experience of mastery is the most important factor in determining self-efficacy, for example, successes build a robust belief in one's self-efficacy. Previous successful experience in a certain task will increase self-efficacy in that specific task. Vicarious experience is the process in which an individual obtains knowledge from the experience of others (e.g., if she can do it, then I can do it as well). Verbal persuasion is provided by others. Basically, direct encouragement from others can increase one's self-efficacy, while discouragement can decrease one's self-efficacy. Finally, emotional arousal refers to one's belief in the implications of physiological response that changes self-efficacy (Bandura, 1986).

In the domain of PA, self-efficacy can be considered as a multidimensional construct (Bandura, 1997; Rodgers, & Sullivan, 2001; Rodgers, Wilson, Hall, Fraser, & Murray, 2008). For example, three domains of self-efficacy (i.e., task, coping, and scheduling self-efficacy) are associated with exercise across different population groups (Rodgers et al., 2008). The authors suggest that the specific subsets of self-efficacy (i.e., task, coping, and scheduling) are important to sustain long-term participation in PA. According to Rodgers and colleagues (2008), task self-efficacy refers to an individual's confidence in performing elemental aspects of PA (e.g., How confidence are you that you can complete your exercise using proper technique), while coping self-efficacy refers to confidence in engaging in PA under challenging circumstance (e.g., How confidence are you that you can exercise when you lack energy). Scheduling self-efficacy refers to the confidence in engaging in PA regularly even though there are other responsibilities (e.g., How confidence are you that you can arrange your schedule to include regular exercise?).

Self-efficacy has been identified as the strongest independent predictor of daily participation in MVPA among preadolescent youth (Trost et al., 1999), and adolescent girls (Allison et al., 1999; Dishman et al., 2005; Motl, Dishman, Saunders, Dowda, & Pate, 2007; Pate, Trost, Felton, Ward, Dowda, & Saunders, 1997). For instance, girls' self-efficacy positively correlates with the participation in PA (Allison et al., 1999). In addition, self-efficacy was the strongest mediator of the relationship between theory-based interventions and PA among youth aged 5 to 18 years (Lubans, Foster, & Biddle, 2008). Spence and colleagues (2010) found that self-efficacy partially mediates the association between gender and PA among adolescents. Boys showed higher levels of self-efficacy, while self-efficacy was more important to the PA of girls. Lower levels of self-efficacy for PA among girls might be derived from lack of opportunities to have mastery experiences, negative feelings associated with PA such as embarrassment, or

negative attitudes about skill levels on the part of teachers or coaches (Dwyer, Allison, Goldenberg, Fein, Yoshida, & Boutilier, 2006; Gilbert, 2001; Humbert, 1995), and higher perceived risk for injury from PA. Thus, self-efficacy appears to be a potentially important contributor to PA among pubertal girls.

Both sport competence and self-efficacy have been consistently reported as strong determinants of PA among girls. Sport competence is strongly linked to intrinsic motivation to engage in a certain task (Harter, 1985), which correlates with PA participation in children (Ferrer-Caja & Weiss, 2000; Fox & Corbin, 1989). Moreover, mastery experience (i.e., having successfully completed a task in the past) is one of the sources of self-efficacy. Therefore, it is reasonable to argue that girls who have successful experiences in certain skills will have higher sport competence in comparison to those who have negative, or not had, such experiences. At this stage, it is important for readers to understand the distinction between self-efficacy and self-concept which is the supra construct of sport competence. Self-efficacy involves cognitive perceptions of competence, while self-concept is typically seen as being comprised of affective perceptions (e.g., feelings, moods) as well as competency perceptions (Marsh, Walker, & Debus, 1991). Specifically, self-efficacy—"beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997)—is a context-specific judgment of capability to perform a task or engage in an activity. It is a judgment of one's own confidence that depends mostly on the task at hand and this is why they are typically tied to a specific domain or situation and likely to be based on mastery experiences of a task or activity (Bandura, 1997). In contrast, self-concept judgments are typically more general and less context dependent, and more likely to be based on environmental experiences, and social and self-comparisons (Marsh et al., 1991; Skaalvik, 1997). Moreover, self-concept is fairly stable and

enduring, whereas self-efficacy is relatively malleable and varies in response to individual learning experiences (Goetz, Cronjaeger, Frenzel, Ludtke, & Hall, 2010).

Self-efficacy is also inversely associated with perceived barriers for PA (Hofstetter, Sallis, & Hovell, 1990) and PA (Sallis et al., 1989; Yoshida, Allison, & Osborn, 1988) among adolescent girls. Perceived barriers are important predictors of self-efficacy when controlling for the effects of additional variables (Sallis et al., 1992). Furthermore, self-efficacy predicted PA regardless of the variations in external barriers (i.e., lack of time due to school, cost), but not internal barriers (i.e., not feeling in the mood, lack of energy) among 1,041 students in Grades 9 to 11 (Allison et al., 1999). These results suggest it is important to identify perceived barriers to PA in relation to self-efficacy among girls to understand their PA.

Parental support

Parental support is a potential moderating variable suggested within the biocultural model (Cumming et al., 2012). Though limited and inconsistent evidence is available, parents appear to play significant roles in explaining the maturation-PA relationship (Cumming et al., 2012). From an ecological perspective, adolescents grow up in a social environment shaped by factors such as history, economics, and technological changes. In addition, the adolescents' experience of growing up differs by socioeconomic background, ethnic culture, and/or racial discrimination (Kimmel, & Weiner, 1995). Within these varying environments, adolescents' interactions with their social network, primarily parents and peers, change dramatically (Kimmel, & Weiner, 1995). One example of such changes can be explained by the distancing hypothesis, which states that maturation produces a growing distance between adolescents and their parents (Steinberg, 1989). Accordingly, research on changes in parent-child relationships during adolescence has consistently suggested that the changes in relationships are triggered by pubertal status, rather

than chronological age (e.g., Hauser, 1991; Savin-Williams, & Small, 1986). Another example of the changes in adolescents' social network is their relationship with peers. As young people move from childhood into adolescence, they become more independent from their parents and expand their social network to their peers (Kimmel, & Weiner, 1995). Though parents do become replaced to some extent with the deepening friendships and increasing peer-group involvement, parent-child interactions remain significant (e.g., Jackson & Goossens, 2006).

A growing body of research supports the role of parental support and acceptance in the development of positive self-evaluation and PA throughout childhood to adolescence (Sallis et al., 2000; Davison, Cutting, & Birch, 2003). Parents are important sources of social influence for children thus, may play an important role in children's psychological development and health behaviours of children (Taylor, Baranowski, & Sallis, 1994). For example, parents can influence their child's health behaviours through a variety of mechanisms including direct modeling, rewarding desirable behaviours and punishing or ignoring undesirable behaviours, establishing or eliminating barriers, providing resources to perform healthy behaviours, and employing authoritative parenting procedures to help the child develop self-control skills (Baranowski, 1997). Indeed, parental support has been consistently reported as a correlate of PA among adolescent girls (Kohl, & Hobbs, 1998; Sallis et al., 2000).

Parents may support children's PA by providing transportation and encouragement (Biddle & Goudas, 1996; Dowda, Dishman, Pfeiffer, & Pate, 2007; Felton et al., 2002), as well as by participating in PA with their children (Felton et al., 2002). According to Saunders and colleagues (2004), parental support was a strong predictor of team sport participation and a modest predictor of MVPA among 8th Grade girls, and a significant predictor of VPA outside of school among girls in 9th and 11th Grades (Zakarian, Hovell, Hofstetter, Sallis, & Keating, 1994).

Moreover, higher family support seems to attenuate the age-related decline in PA in adolescent girls. For example, perceived family support in the years prior to 12th Grade may lay the foundation for maintaining an active lifestyle as girls move through adolescence into young adulthood (Dowda et al., 2007). Similarly, peer influence increases during adolescence, and both parent- and peer-provided social support for PA among girls influence immediate and long-term PA (Beets et al., 2007). Though it is unclear whether parents or peers hold more influence over activity levels among children and adolescents, it is likely that parents have more influence over the health behaviours of their children than peer groups throughout adolescence.

Summary

Research shows that physical changes during puberty among girls are strongly associated with psychological factors (e.g., perceived barriers to PA, parental support, and physical self-concept). Thus, it is important to examine major psychosocial correlates of PA to better understand the decline in PA among girls. The biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012) presents a useful theoretical framework for testing the role of these correlates.

The Korean Context

As previously discussed, age and sex differences in PA and SB also have been reported among Korean adolescents (Byun et al., 2012; Kang et al., 2010). Thus, it is possible that biological maturation may too play a role in the PA and SB of Korean youth. However, little is known in this population to determine the potential influence of biological maturation on PA and SB. Therefore, this study sought to first examine whether biological maturation influences PA and SB among Korean adolescents and if so, what are the mechanisms. A biological perspective proposed by Malina (2008) suggests that one's cultural environment may moderate the

relationship between biological maturation and PA among adolescents. This section discusses the context of Korea specific to school-aged youth that may have an impact on behaviour.

Cultural Context of Korea: Educational Pressures

According to a report from the Korea Development Institute (2011), the prestigious universities in Korea—so-called "SKY" universities (i.e., Seoul National, Korea, and Yonsei universities)—had only10,000 places each for admission in 2012 which accounts for approximately 1% of the total number of students who will apply for university admission. Furthermore, only 10% are expected to gain admittance to the universities in the capital city of Korea, Seoul; the remaining 90% who will graduate from universities outside of the capital can expect to earn 16.4% less on average than those who went to universities in Seoul (KDI, 2011).

These educational pressures may stem from the economic success Korea has gained after the Korean War (Strother, 2011). The country had one of the world's fastest growing economies from the early 1960s to the late 1990s, which was largely attributable to the willingness of individuals to invest a large amount of resources in education that would eventually lift it out of poverty. Thus, Koreans regard post-secondary education as the means to improve one's financial and social status (Strother, 2011; Lee, 2003). Studying, better grades, elite colleges, and high-paid jobs are the values that Korean children are raised with. Thus, school-aged youth are told from an early age that only being number one counts, which puts tremendous pressure on students and lead to a joyless adolescence for many young Koreans including high rates of suicides (Ahn & Baek, 2013). In a collectivist culture, such as Korea, self-esteem, self-confidence, and self-worth, which are components of happiness, are likely to be determined in comparison to other people (Diener, & Diener, 2009). Indeed, Korean school-aged youth scored the lowest in terms of happiness compared to 22 other OECD countries for the past five years

(Yun, 2014). Almost a quarter of Korean children have once felt the impulse to run away from home and 10% have had suicidal thoughts, a shocking rate of 26% of the 10% have actually attempted suicide (Yun, 2014). Furthermore, more than half of the students aged between 15 and 19 reported that they have suicidal thoughts because of poor grades and pressure of academic performances (Park, 2014).

Due to the highly competitive nature of Korean education, physical education (PE) class, which is considered a less important subject, is often neglected and replaced with classroom-based subjects (Lee, & Cho, 2014). Furthermore, it appears that many schools in Korea lack adequate space for proper PE class and extra-curricular PA—two qualitative studies identified constraining factors to PA found that the lack of facilities was one of the major reason for adolescents not engaging in PA in PE class and during recess time (Lee, Nam, & Yeo, 2013; Yoo, & Kim, 2002). Diminishing PE classes and the lack of exercise facilities may explain the low levels of PA and the deterioration of physical fitness among school-aged Korean youth. According to a report released by the Korean Ministry of Education, Science and Technology in 2009, only 31% of adolescents were placed in the top two levels out of five in the annual fitness test in the previous five years, in comparison to 41% in 2005. Apart from the decrease in physical fitness among Korean adolescents, considerable social and health issues were raised as a consequence of the highly competitive environment.

In the most recent education reform in Korea that emphasizes the elimination of inequality in education, PE is offered as an elective subject in secondary schools and the time allocated to PE has been reduced (Lee, & Cho, 2014). Furthermore, PE classes are often replaced by academic study time so that students spend more time studying core subjects such English or Mathematics in most secondary school. PE class is not offered at all to Grade 12 students (Lee,

& Cho, 2014). This is a concern because PE class may be the only opportunity to engage in PA for Korean students who spend most of their waking hours in schools (Lee, & Cho, 2014).

Contextual Social and Health Crisis for Korean School-aged Youth

On top of deteriorating physical fitness, Korean adolescents generally lack sleep. According to the Korea Centers for Disease Control and Prevention (KCDC; 2011), 7.2% of those in primary school, 11.5% in middle school and 42% in high school reported they sleep less than six hours per day. The average sleep time was 7.1 hours for middle school students and 5.5 hours for high school students.

Nutrition imbalance as a result of pressure in meeting the educational requirements set out by the Korean Ministry of Education is another potential issue for Korean youth. A study of dietary intake among 19,400 Korean students at 749 schools nationwide showed that the proportion of students who skip breakfast increased with age: 4.8% of elementary schoolchildren, 10.6% of middle school students and 14.3% of high school students reported that they skip breakfast every day (Korean Ministry of Education, Science and Technology, 2009). In addition, 49.9% of pupils in elementary school, 56.8% in middle school, and 60.2% in high school eat fast foods once or more per week; only 31.7% of children in elementary school, 26.7% in middle school and 25% in high school reported they eat vegetables every day (Korean Ministry of Education, Science and Technology, 2009).

Internet use among Korean adolescents also has been indicated as public and social problems as it has been shown to be strongly associated with psychological health issues including depression, suicidal ideation, or attention deficit hyperactivity symptoms (Ha et al., 2006; Jang, Hwang, & Choi, 2008; Kim et al., 2006; Park, Hong, Kem, Park, Ha, & Yoo, 2013; Yoo et al., 2004). Approximately 10-30% of Korean school-aged youth engage in excessive

Internet use (Ha et al., 2007; Heo, Oh, Subramanian, Kim, & Kawachi, 2014; Jang et al., 2008; Park, 2014; Park et al., 2013). It also appears that expose to Internet use occurs in the early years among Korean youth; 85.5% of children aged between 3-9 years reported they use Internet frequently (Korea Internet and Security Agency, 2010).

Though increased weight may be a sign of positive development for recent generations of Koreans, there is evidence that Korean youth are getting fatter and unhealthier than before. According to the Korean National Health and Nutrition Examination Survey (KNHNES), the prevalence of obesity in South Korean children and adolescents aged 10-18 years doubled from 1998 (5.8%) to 2007 (10.9%) (Korean Ministry of Health and Welfare, 2007), and is continuously increasing in parallel with the socio-economic progress (Kim, Ahn, & Nam, 2005). Childhood obesity may lead to excessive secretion of leptin in the body, which includes the emergence of secondary sexual characteristics, and this occurs especially among girls as it stimulates secretion of an enzyme called aromatase which turns male hormones into female hormones (Drenowatz et al., 2010).

Indeed, South Korean children seem to mature earlier than before (Park, Lee, Shin, Joung, & Cho, 2006) with the trend of increasing obesity (Moon, 2011). For instance, in a sample of 3,307 Korean girls aged 9-17 years, the average age of menarche was 11.98 years old while that of their mothers' was 14.41 years (Park et al., 2006). Moreover, overweight and obese girls experienced earlier menarche (average of 11.41 years old) than girls with normal- or under-weight (average of 12.35 years old). Also, the number of children who reached sexual maturity much earlier than the average (before 8 years old in female and 9 years old in male), increased 5.3 times from 2004 to 2008, 91.6% of children who experience precocious puberty were female

(Park, 2009). The rise in obesity may be one of the main reasons for the advanced maturation trend among Korean children.

Premature physical development associated with overweight and obesity among Korean girls may result in negative mental health (e.g., stress, self-esteem, body image). Girls are more likely to develop negative feelings about their athletic skills (Kolody & Sallis, 1995), and to face barriers in PA participation, such as feeling self-conscious (Robbins, Pender, & Kazanis, 2003) as they experience puberty, which in turn, may lead to disengagement in PA. Data does highlight Korean girls experiencing negative beliefs about their body image, which is likely to lead to barriers in PA participation. For example, 54.3% of girls considered themselves as overweight or obese, while actually having a normal weight among 72,399 Korean children and adolescents aged 12 to 18 years old (Lim & Wang, 2013). This misperception was more serious among girls; 33% of girls who said they were overweight when their weight was in fact normal.

In summary, Korean adolescents generally lack exercise and sleep, and engage in poor diet habit (e.g., skip breakfast, eat fast food). These, combined with excessive Internet use, may explain the current health issues that Korean children and adolescents face (e.g., decreased physical fitness, reduced somatic development, increased obesity rate, advanced puberty, and increase mental health issues). Therefore, it is important to examine Korean adolescents' PA based on a biocultural perspective (Cumming et al., 2008; Malina, 2008). This would offer a picture that not only accounts for biological and psychological aspects of adolescents, but cultural and environmental aspects unique to Korea as well.

Conclusion

This chapter reviewed the literature and demonstrated the need to examine the relationship between biological maturation and PA, and SB among Korean adolescents. In

addition, it demonstrated the need to examine potential mechanisms linking biological maturation and PA among adolescent girls in particular. Specifically, this review has demonstrated the need to test whether body fatness and psychosocial correlates of PA (i.e., sport competence, perceived barriers to PA, and self-efficacy) mediate and whether parental support moderate the relationship between biological maturation and PA among girls.

Research Aims and Objectives

This study seeks to understand the potential influence of biological maturation PA and SB among Korean adolescents, through the following aims: (1) to examine whether sex differences in PA disappear or attenuate when the indicator of biological maturation are controlled, (2) to examine whether body fatness and psychosocial correlates of PA mediate the relationship between biological maturation and PA among girls, and (3) to examine whether body fatness and psychological factors mediate the relationship between biological maturation and screen-time among adolescents.

To achieve these three aims, the following objectives were examined through three separate empirical studies (Chapters 3 to 5). Specifically, Study 1 examined the potential role of pubertal timing in PA and SB in a representative sample of Korean adolescents. Specific hypotheses include (1) sex will be a significant predictor in explaining the variances of PA and SB, and (2) sex differences in PA and SB will be eliminated or attenuated after controlling for individual differences in pubertal timing. Study 2 examined the potential pathways linking biological maturation and PA among adolescent girls. Proposed mediators included body fatness, sport competence, parental support, perceived barriers to PA, and self-efficacy. Study 3 longitudinally examined the potential pathways linking biological maturation and screen-time

among Korean adolescents. Proposed mediators include body mass index, self-esteem, and depression

Chapter 3: Study 1. The Role of Pubertal Timing in Sex Differences in Self-reported Physical Activity and Sedentary Behaviour among Korean Adolescents

Abstract

Objectives. This study examined whether pubertal timing mediates the relationship between sex and physical activity (PA), and sedentary behaviour (SB) respectively.

Methods. The analysis included 74,186 students in Grades 7-12 (Mean age=14.94 ± 1.75) who participated in the 2012 Korea Youth Risk Behavior Web-based Survey (48.5% girls). Mediation analysis was used to examine whether pubertal timing mediates the relationship between sex and PA, and sex and SB.

Results. Boys engaged in MVPA more frequently per week (3.29 ± 2.13 vs. 2.28 ± 1.66 day/week) and spent less time in SB (2.90 ± 1.14 vs. 3.09 ± 1.18 hr/day) than girls. Direct effects were found between sex and MVPA (β = - 0.58 ± 0.01; $p < 0.05$), and sex and SB (β = 0.17 ± 0.01; $p < 0.05$). Pubertal timing did not significantly mediate the relationship between sex and PA (β = 0.00; BC 95%CI = - 0.01, 0.01). Though pubertal timing significantly mediated the relationship between sex and SB, the effect was small (β = 0.01; BC 95%CI = 0.01, 0.02).

Conclusion. Sex is an important predictor of MVPA and SB, regardless of the variations in pubertal timing among Korean adolescents. Replicating this study with longitudinal design may help to understand these relationships.

Introduction

Sex is a well-recognized individual-level correlate of physical activity (PA) and sedentary behaviour (SB) among adolescents. Specifically, boys are more physically active than girls (Colley, Garriguet, Janssen, Craig, Clarke, Tremblay, 2011) and spend more time in media-based SB, while girls engage in more communication-based SB (Leatherdale, & Harvey, 2015). Given the health benefits of PA (Janssen, & LeBlanc, 2010) and the negative health implications of SB (Tremblay et al., 2011), health promotion strategies have focused on tailoring interventions by sex. However, emerging evidence suggests that the roots of the sex differences in PA and SB may be more complex, and that understanding sex dimorphism in biological maturation may help to better explain individual variations in PA and SB than sex (Eisenmann, & Wickel, 2009; Sherar, Cumming, Eisenmann, Baxter-Jones, & Malina, 2010).

In the Western context, this appears to be the case. Previous studies reported that controlling for biological maturity (i.e., individual variations in pubertal status) attenuates the relationship between sex and PA among adolescents (Cumming, Standage, Gillison, & Malina, 2008; Sherar, Esliger, Baxter-Jones, & Tremblay, 2007; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003). For instance, a longitudinal examination of 138 Canadian children found that sex differences in PA disappeared when maturity-related variation between sexes (i.e., girls experience puberty approximately 2 years earlier than boys) was controlled (Thompson et al., 2003). Similarly, sex differences in SB were attenuated when biological maturation was controlled Among 302 Portuguese adolescents (13-16 yr old), (Rodrigues et al., 2010). These findings suggest that biological maturation may be an important correlate of PA and SB.

Patterns of PA and SB observed among Korean adolescents are consistent with previous studies in the West. For instance, sex differences in PA were found among 1,033 Korean adolescents aged between 12-18 yrs. Specifically, the mean metabolic equivalent of task (MET) score for weekly vigorous PA (VPA) (i.e., MET value for VPA X time engaged in VPA per week) was 936.5 in boys and 484.5 in girls (Byun, Dowda, & Pate, 2012). In this sample, boys also spent more time playing computer/video games than girls during weekdays (1.7 hr/day vs 1.4hr/day) and weekend days (2.7 hr/day vs 2.1 hr/day) after controlling for age, sex, household income, and PA (Byun et al., 2012). Sex differences in PA and SB are evident among Korean adolescents, however it is unclear whether such differences would disappear or attenuate when the timing of biological maturation is controlled. Examining the potential influence of pubertal timing on PA and SB can offer important insights into the foundations of behaviour during these formative years. In addition, maturational influence on behaviour may vary by demographic characteristics (Patton, & Viner, 2007; World Health Organization [WHO], 2011). Thus, it is important to identify whether pubertal timing is associated with PA and SB in different cultural groups (Malina, 2008).

Therefore, this study examined whether sex differences in PA and SB decrease or disappear after controlling for pubertal timing in a representative sample of Korean adolescents. Based on the results of the previous literature (Cumming et al., 2008; Rodrigues et al., 2010; Sherar et al., 2007; Thompson et al., 2003), it is hypothesized that (i) sex will be a significant predictor in explaining the variances of PA and SB and boys will be more physically active and less sedentary than girls after controlling for age and covariates, and that (ii) sex differences in PA and SB will be eliminated or attenuated after controlling for individual differences in pubertal timing.

Methods

Participants

The eighth Korea Youth Risk Behavior Web-based Survey (KYRBS) (Korea Centers for Disease Control and Prevention [KCDC], 2012) was the source of data for this study. The KYRBS is an annual, cross-sectional, nationwide school-based web survey that monitors health risk behaviours among Korean adolescents in Grades 7 to 12, which is administered by the KCDC in collaboration with the Ministry of Education, Science, and Technology and the Ministry of Health and Welfare. It includes a 129-item questionnaire developed by a committee with expertise in the related fields. Core information includes background (e.g., age, sex), health behaviours (e.g., smoking, alcohol use, PA) and health outcomes (e.g., self-reported health, obesity).

Participating schools were selected based on geographical regions (n=16) and types of schools (n=3; i.e., middle schools, regular and specialized high schools). Teachers were assigned by principals in each school to administer the survey. On a registered date, students were led to a computer laboratory by the teacher in each school and were asked to read an information letter before beginning the online survey. Participation in the survey was anonymous and voluntary. Thus, written informed consent was not obtained. Each survey was administered during regular school hours for 40-50 minutes (KCDC, 2012).

Among 76,980 students from 400 middle and 400 high schools who participated in the eighth KYRBS (response rate: 96.4%), those with missing scores for height and weight (n=2,794) were excluded, leaving a total of 74,186 students (48.5% girls) included in the analyses. The age and sex distributions of participants were not significantly different between the sample included in the analyses and those excluded. The KYRBS received approval on the

study protocol from KCDC (approval number: 11758) (KCDC, 2012). Acceptable validity and reliability of the KYRBS survey has been reported previously (Bae, Joung, Kim, Kwon, Kim, & Park, 2010a; Bae, Joung, Kim, Kwon, Kim, & Park, 2010b).

Measures

Pubertal timing

The year of menarche (i.e., first menstruation) for girls and the year of semenarche (i.e., first ejaculation; also known as oiarche) for boys were used as indicators of pubertal timing. The KYBRS included one multiple-choice item related to pubertal timing. The question was "when did you experience your first menstruation (ejaculation)?" Response options were scaled from 1 (have not yet experienced) to 14 (Grade 12). For data analyses, pubertal timing was recoded so that lower scores indicated early maturation and higher scores indicated late maturation based on the average Grade/year of experiencing maturation (Grade 6/12 years for girls and Grade 7/13 years for boys). For example, students who have reached maturity (i.e., experienced menarche/semenarche) at Grade 12 was recoded to 13, and those who have not yet experienced maturity was recoded to 14.

Physical activity

Moderate-to-vigorous PA (MVPA) was assessed using an item from the short-version questionnaire of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). The question asked participants to answer the number of days that they engaged in leisure-time physical activity resulting in heart rate increase or shortness of breath for more than 60 minutes during the previous week of observation. Response options were no participation at all (1) to seven days a week (8).

Sedentary behaviour

Leisure-time SB was assessed with two items from the short-version of IPAQ (Craig et al., 2003). The questions asked, "Other than educational purposes, 1) how many hours a day did you spend your leisure time watching television, playing video games, internet surfing, or chatting with friends in a seated position during the last five weekdays?" and 2) how many hours a day did you spend in your leisure time watching television, playing video games, internet surfing, or chatting with friends in a seated position on the last two weekends?" Items were scaled from 1 (< 1 hr/day) to 5 (≥ 4 hrs/day). For analysis, responses from two questions were averaged.

Covariates

Chronological age, school type (i.e., middle school, regular high school, and specialized high school), economic status, parental education levels, and body mass index (BMI) were added in the analysis as covariates. Economic status was determined based on responses to the question, "What is your household's economic status?" The response options were low, low-to-middle, middle, middle-to-high, and high. Parental education levels were obtained by asking participants to describe their parents' educational attainment. The response options were elementary or less (≤ 6 years), middle school (7–9 years), high school (10–12 years), and college and above (≥ 13 years). For analysis, parental education levels were categorized into two groups: high school graduate or less and post-secondary graduate or more. Weight and height were self-reported by participants. BMI was computed by dividing weight in kilograms by height in meters squared (kg/m^2).

Statistical analysis

All analyses employed the sampling weights provided by KYRBS. Descriptive statistics summarized the characteristics of the sample, which were given in terms of means and standard

deviations (SD) or percentages. To examine whether pubertal timing mediated the relationship between (1) sex and MVPA, and (2) sex and SB, the recommendations suggested by Preacher and Hayes (2008) was followed (Figure 1). Age, school type, economic status, parental education levels, and BMI were included as covariates in all mediation models. Using a bootstrapping resampling approach, total, direct, and indirect effects were calculated. Specifically, the script version of the INDIRECT macro provided by Preacher and Hayes (2008) was used to calculate product-of-coefficients and bias-corrected 95% confidence intervals (BC 95% CI) based on 1000 resamples. There are four paths in explaining the relationship between sex, pubertal timing, and MVPA. Path c indicated the association between sex and MVPA whereas path c' indicated the association between sex and MVPA after pubertal timing has been introduced in the model. Path a indicated the association between sex and pubertal timing, and path b indicated the associations between pubertal timing and MVPA. This mediation model was repeated with SB as a criterion variable. Participants who have not experienced menarche/semenarche were removed from the mediation analysis due to possible bias towards younger adolescents (e.g., males in Grade 7 who have not experienced semenarche). All analyses were conducted using IBM SPSS 21.

Results

Table 1 shows the sample characteristics by sex. Compared to girls, boys were taller (169.35 ± 8.32 centimeters (cm) vs. 159.75 ±5.45 cm) and heavier (60.28 ± 12.01 kilograms (kg) vs. 51.82 ± 7.93 kg), and showed higher average BMI scores (20.90 ± 3.28 vs. 20.26 ± 2.66). A total of 74.5% of boys and 97.3% of girls had reached maturity at the time of observation. The average grade of menarche/semenarche was 8.13 ± 1.76 for boys and 7.27 ± 1.27 for girls. Nearly half of the participants (48.7% among boys and 49.4% among girls) were attending middle school. With respect to economic status, 66.7% of boys and 72.2% of girls reported their families as being in the middle or higher income

bracket. The percentages of participating in MVPA for more than five days per week were 17.3% among boys and 5% among girls. During weekdays, 45.4% of boys and 50.7% of girls spent time engaging in SB for more than 2 hours. The corresponding percentages during weekends were 67.7% among boys and 72.8% among girls. Combined time spent in SB was higher among girls than boys (2.90 ± 1.14 hours/day among boys vs. 3.09 ± 1.18 hours/day among girls).

The results from the mediating analyses are shown in Table 2. In the MVPA model, both total (c path) (β = - 0.58 ± 0.01; $p < 0.05$) and direct effect (c' path) (β = - 0.58 ± 0.01; $p < 0.05$) of sex on MVPA were significant. The path between sex and pubertal timing (path a) was significant (β = - 0.88 ± 0.01; $p < 0.05$), however, the path between pubertal timing to MVPA was not significant (β = 0.00; $p = 0.86$). The bootstrap analyses with 1000 samples demonstrated that the mediating effect of pubertal timing did not exist (β = 0.00 ± 0.00; BC 95% CI = - 0.01, 0.01). In the SB model, both total (c path) (β = 0.19 ± 0.01; $p < 0.05$) and direct effect (c' path) (β = 0.17 ± 0.01; $p < 0.05$) of sex on SB were significant. The paths between sex and pubertal timing (path a) (β = - 0.88 ± 0.01; $p < 0.05$), and between pubertal timing to SB were significant (path b) (β = - 0.02 ± 0.00; $p < 0.05$). The bootstrap analyses with 1000 samples demonstrated that the mediating effect of pubertal timing on the relationship between sex and SB existed (β = 0.01; BC 95% CI = 0.01, 0.02). To summarize, pubertal timing did not mediate the relationship between sex and MVPA. Though pubertal timing mediated the relationship between sex and SB, the effect was very small.

Discussion

This study examined whether pubertal timing mediates the relationship between 1) sex and MVPA and 2) sex and SB in a large representative sample of Korean adolescents. Pubertal timing did not mediate the relationship between sex and MVPA. Sex was significantly related to SB, and these associations remained significant when pubertal timing was entered as a predictor

simultaneously as sex. Pubertal timing partially mediated the relationship between sex and SB with a very small effect. Sex appears to be a more important predictor of MVPA and SB than pubertal timing among Korean youth.

These results do not align with those of previous studies (Cumming et al., 2008; Rodrigues et al., 2010; Sherar et al., 2007; Thompson et al., 2003). However, it is important to recognize that the inconsistency of findings between our study and other research is most likely due to the different measures used to assess biological maturation. The current study used a measure of relative pubertal timing (i.e., menarche, semenarche), while previous studies used a tool estimating pubertal status (i.e., age at peak height velocity, percentage of predicted mature height). Pubertal timing indicates the time at which distinct maturational landmarks are obtained, whereas pubertal status refers to the level of development reached by an individual in terms of physical changes at a given time (Coelho-e-Silva, Valente-dos-Santos, Figueiredo, Sherar, & Malina, 2013).

The relationship between sex and MVPA is largely consistent with previous findings (Colley et al., 2011), in that boys engage in MVPA more frequently than girls. Nevertheless, in general, the prevalence of engaging in a sufficient level of MVPA appears to be low among Korean adolescents regardless of sex. Our results indicated that only 7.2% of boys and 2% of girls are accumulating a recommended level of weekly MVPA as defined by the WHO (i.e., 60 minutes of MVPA each day) (WHO, 2010). Similarly, only 6% of Canadian adolescent boys and 2% of girls engaged in more than 60 minutes MVPA at least 6 days per week (Colley et al., 2011). Using a self-reported MVPA, corresponding percentages of boys and girls (i.e., those engaging in at least 60 minutes MVPA at least 6 days per week) in the current study were 9.8% and 3%. Given that self-reported PA is often over-estimate the actual PA levels compared to

objectively measured PA (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2008), the participation rate of recommended level of MVPA among Korean adolescents is a concern.

Malina (2008) argued that PA among adolescents is influenced by cultural and societal factors, which attached to differing values and meanings to various types of PA. The patriarchal culture of Korea may have an impact on girls' participation in PA. The emphasis on women's reproductive role in Korean culture may restrain their PA participation, particularly during pregnancy, postpartum periods, and menstrual periods (Im, & Choe, 2004). Accordingly, a number of studies suggested that gender inequality in a physical education setting is one of the barriers to PA among Korean girls (e.g., Kim, 2014; Won & Chung, 1999). Incorporating environmental factors as well as individual-level differences other than biological factors (e.g., psychological) is recommended for future studies examining sex differences in PA among Korean adolescents compared to adolescents in Western countries.

Girls spent more time in SB than boys. This is consistent with the findings of other studies that assessed SB using accelerometry among adolescents in Western countries (Colley et al, 2013; Matthews et al., 2008). Sex differences in the amount of time spent in SB vary by the type of sedentary activities. For instance, screen-based sedentary time is often higher in boys than in girls, except in the case of television watching and computer use, whereas girls appear to spend more time in communication-based SB (e.g., texting, talking on the phone) (Leatherdale, & Harvey, 2015). The KYRBS did not differentiate SB according to whether it is screen-based or communication-based. Nonetheless, it is a concern that over 60% of participants spent SB more than two hours per day.

The strengths of this study include a representative sampling design, a large sample size, and a contemporary mediation analytic method used in the study (i.e., bootstrapping approach). It has been indicated that bootstrapping is one of the more valid and powerful methods for testing

intervening variable effects (Hayes, 2009). However, several limitations should be acknowledged. First, data were collected through a self-administered questionnaire, which may have served as a threat to validity. Second, the items from the IPAQ we used to assess SB (e.g., watching TV, internet surfing) are not consistent with the currently accepted definition of SB which requires both a postural component (e.g., sitting) and low energy expenditure (Sedentary Behaviour Research Network, 2012).

The use of age at menarche/semenarche to indicate pubertal timing is another limitation of our study. Age at menarche has been widely used as a sign of pubertal timing among girls, while no comparative event is available for boys (WHO, 2011). One earlier study (Carlier, & Steeno, 1985) indicated that the onset of ejaculation is suggested as a measure of pubertal timing among boys in survey studies, and valid to use as an index of genital and sexual maturation of male puberty as first ejaculation occurs when testicular volume has reached a biologically mature state (≥ 10ml). Because both boys and girls experience puberty, and the timing and tempo of puberty differ across individuals, we hypothesized that pubertal timing and tempo affects health and behaviour of boys as much as it affects girls. Though one event, associated with the timing of biological maturation, may not be likely to determine a complex process of biological maturation accurately (WHO, 2011), the timing of semenarche is an important psychological event among boys (WHO, 2011) and therefore, likely to influence puberty-associated psychological and behavioural changes among boys. It is suggested that the KYRBS questionnaire should adopt a more valid parameter to measure biological maturation (e.g., Pubertal Development Scale) (Petersen, Crockett, Richards, & Boxer, 1988) to better capture biological maturation in Korean adolescent populations.

In conclusion, sex appears to be a more important predictor PA and SB than pubertal timing among Korean adolescents. However, it is most likely that a combination of cultural, environmental, and individual factors (e.g., psychological, and biological) contribute to adolescents' behaviour. Therefore, such factors should be taken into considerations when developing sex-tailored programs to promote PA and reduce SB among Korean youth. Replicating this study with a longitudinal design will shed further insight on these relationships.

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Table 1. Sample characteristics by sex— Korea Youth Risk Behavior Web-based Survey, 2008 (Estimated N = 3,745,735).

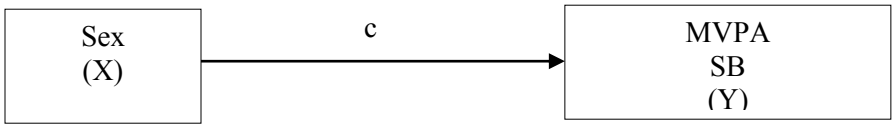
	Boys (n = 1,966,019)	Girls (n = 1,779,716)
Age (M ± SD)	14.96 ± 1.75	14.92 ± 1.74*
Height (M ± SD)	169.35 ± 8.32	159.75 ±5.45*
Weight (M ± SD)	60.28 ± 12.01	51.82 ± 7.93*
BMI status[1]		
Overweight (85 - 95%)	9.7	2.5
Obese (≥ 95%)	4.9	4.9
BMI (kg/m^2) (M ± SD)	20.90 ± 3.28	20.26 ± 2.66*
Menarche/semenarche obtained (%)	74.5	97.3
Average grade of pubertal timing[2]	8.13 ± 1.76	7.27 ± 1.27*
School type (%)[3]		
Middle school	48.7	49.4
Regular high school	39.3	39.2
Specialized high school	12.0	11.4
Economic status (%)		
Low	8.3	5.0
Low to middle	25.1	22.7
Middle	44.7	48.9
Middle to high	16.6	18.6
High	5.4	4.7
Parental education (%)		
Father ≥ Post-secondary graduate	55.6	53.9
Mother ≥ Post-secondary graduate	52.8	47.2
MVPA/week (%)[4]		
None	27.9	46.8
1 day	15.4	19.1
2 days	16.4	14.4
3 days	13.8	9.6
4 days	8.3	4.0
5 days	7.5	3.0
6 days	2.6	1.0
7 days	7.2	2.0
MVPA/week (M ± SD)	3.29 ± 2.13	2.28 ± 1.66
SB (%)[4]		
Weekdays		
< 1 hour	22.9	20.9
1-2 hours	31.7	28.4
2-3 hours	23.3	22.7
3-4 hours	10.2	12.0
≥ 4 hours	11.9	16.0

Weekend days		
< 1 hour	11.3	9.4
1-2 hours	20.9	17.8
2-3 hours	25.8	23.5
3-4 hours	17.1	18.9
≥ 4 hours	24.8	30.4
Total (weekdays + weekends) (M ± SD)	2.90 ± 1.14	3.09 ± 1.18*

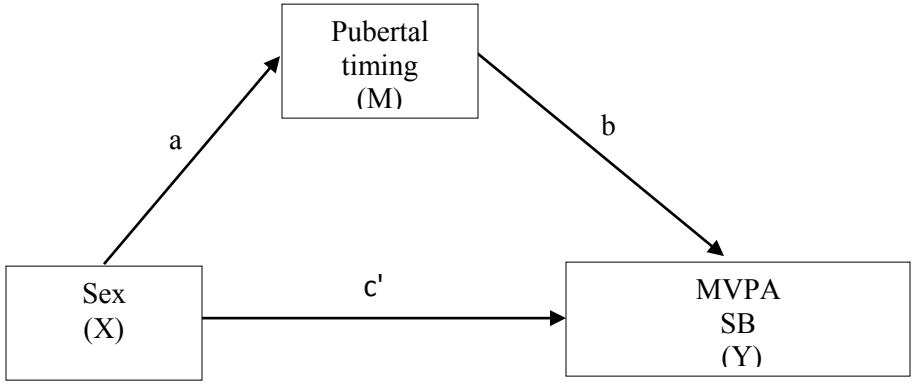
Data are represented as mean ± standard deviation (M ± SD) or percentage (%).
* $p < 0.05$.
[1] BMI: Body Mass Index; Calculated based on the 2007 BMI-for-Age in Korean children and adolescents: Obese ≥ 95%; 85% ≤ Overweight < 95% (Moon et al., 2007).
[2] Excluding those who have not yet experienced menarche/semenarche.
[3] Regular high schools include regular public/private, science, foreign language, art, sports schools; specialized high schools include schools with enhanced coverage of certain that constitute the specialization of the school.
[4] MVPA: Moderate-to-vigorous physical activity; SB: Sedentary behaviour.

Figure 1. Model of the total, direct, and mediated effect of sex moderate-to-vigorous physical activity (MVPA) or sedentary behaviour (SB).

a) Total effect (path c)



b) Direct (path c') and indirect effect / mediation model (path a and b)



Complete mediation occurs in which variable X no longer affects Y after M has been introduced and so path c' is zero.
Partial mediation occurs when the path from X to Y is reduced in absolute size but remains different from zero when the mediator is introduced.

Table 2. Total, direct, and indirect effects of the relationships between (1) sex, pubertal timing, and moderate-to-vigorous physical activity (MVPA), and (2) sex, pubertal timing, and sedentary behaviour (SB)—Korea Youth Risk Behavior Web-based Survey, 2008 (Estimated N=2,686,256).

Criterion variable	Sex to pubertal timing (a path)	Pubertal timing to MVPA/SB (b path)	Total effect of sex on MVPA/SB (c path)	Direct effect of sex on MVPA/SB (c' path)	Bootstrap results for indirect effect[1]
	Coefficient (SE)[3]	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)	$\alpha\beta^2$ (SE) (95% CI)
MVPA	- 0.88 (0.01)*	0.00 (0.00)	- 0.58 (0.01)*	- 0.58 (0.01)*	- 0.00 (0.00) (- 0.01, 0.01)
SB[4]	- 0.88 (0.01)*	- 0.02 (0.00)*	0.19 (0.01)*	0.17 (0.01)*	0.01 (0.00) (0.01, 0.02)

All analyses excluded students who have not experienced menarche/semenarche and were controlled for age, school type, economic status, parental education levels, and body mass index (kg/m^2).

* $p < 0.05$.

[1] Bootstrap results based on 1000 resamples.

[2] Product-of-coefficient estimate.

[3] Unstandardized regression coefficient; SE = standard error.

[4] Sedentary behaviour included watching television, playing video games, surfing the net, and chatting with friends.

Chapter 4: Study 2. Pubertal Status and Physical Activity in Korean Adolescents: The Role of Self-efficacy and Perceived Barriers

Abstract

Objectives. To examine whether body fatness (i.e., body mass index and % body fat) and psychosocial correlates of physical activity (PA) mediate the relationships between pubertal status and PA and sedentary behaviour (SB) among Korean adolescent girls.

Methods. Pubertal status, body fatness, sport competence, perceived barriers to PA, self-efficacy, parental support for PA, PA, and SB were assessed among 236 Korean adolescent girls (mean age = 13.56 ± .08 years).

Results. A direct association was identified between pubertal status and PA in all models; more advanced pubertal status predicted lower PA among Korean adolescents (b = -.51 ~ -.57; $p < .001$). Indirect effects on the pubertal status-PA relationship were also found. Body fatness, perceived barriers to PA, and self-efficacy mediated the relationship between pubertal status and PA. Parental support for PA did not moderate the relationship between maturation and PA. SB does not appear to be associated with pubertal status.

Conclusion. This study found mediated effects of body fatness, and psychosocial correlates (i.e., perceived barriers to PA, and self-efficacy) on the relationship between pubertal status and PA among Korean adolescent girls. Efforts to promote PA among Korean adolescent girls should focus on reducing perceived barriers to PA, and increasing self-efficacy by providing more opportunities to have positive, and enjoyable experience in PA among early-maturing girls.

Introduction

Young people tend to engage in progressively less physical activity (PA) over their adolescent years (Barnett, Gauvin, Carig, & Katzmarzyk, 2007; Caspersen, Pereira, & Curran, 2000; Gordon-Larsen, Nelson, & Popkin, 2004; Hallal, Anderson, Bull, Guthold, Haskell, & Ekelund, 2012). This is a concern because physical inactivity has a negative impact on physical and mental health among adolescents (Haskell, Blair, & Hill, 2009), and may track into adulthood (Anderson et al., 2006). Biological maturation may contribute to PA decline among adolescents, particularly among early maturing girls (Baxter-Jones, Eisenmann, & Sherar, 2005; Eisenmann & Wickel, 2009; Sherar, Cumming, Eisenmann, Baxter-Jones & Malina, 2010). For example, advanced puberty in girls has been shown to be associated with low levels of PA in both cross-sectional (Cumming, Standage, Gillison, & Malina, 2008; Rodrigues, Silva, Mota, Cumming, Sherar, & Malina, 2010; Sherar, Eslinger, Baxter-Jones, & Tremblay, 2007) and longitudinal studies (Baker, Birch, Trost, & Davison, 2007; Knowles, Niven, Fawkner, & Henretty, 2009; Thompson, Baxter-Jones, Mirwald, & Bailey, 2003). Such maturation-related variances in PA have been partially explained interactions among biological, psychosocial, and environmental (e.g., social, cultural) factors (Cumming et al., 2012; Eisenmann & Wickel, 2009; Malina, 2008; Rowland, 1998). Even less is understood on how biological maturation influences sedentary behaviour (SB) which is considered independent to PA (Sedentary Behaviour Research Network, 2012).

A biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012), which includes antecedent biological factors and psycho-behavioural outcomes, suggests that maturation influences PA in both direct and indirect ways (i.e., via mediated & moderated

effects). In this model, physical self-concept, self-esteem, self-efficacy, body image satisfaction, and attitude and feelings towards growth or adulthood are suggested as potential mediators. Some of these variables were found to mediate the relationship between maturation and PA in previous studies (e.g., Davison, Werder, Trost, Baker, & Birch, 2007; Hunter Smart, Cumming, Sherar, Standage, Neville, & Malina, 2012; Jackson, Cumming, Drenowatz, Standage, Sherar, & Malina, 2013). The model also suggests potential moderators on the maturation-PA relationship: suggested moderators of societal and cultural factors such as social support and acceptance (Pindus, Cumming, Sherar, Gammon, Silva, & Malina, 2011), cultural ideals, and opportunities for PA.

To better understand PA decline among girls, more investigation is needed to determine which factors (i.e., mediators/moderators) play a role in the relationship between maturation and PA. It is also important to note that the relevance of such factors may vary across cultures (Cumming et al., 2012; Malina, 2008). Among girls in Western countries, for example, advanced pubertal timing was associated with a low level of PA in connection with weight-related maturity fears (Davison et al., 2007), low physical self-worth (Davison et al., 2007; Niven, Fawkner, Knowles, & Stephenson, 2007), body attractiveness (Cumming et al., 2010; Niven et al., 2007), and sport competence (Craft, Pfeiffer, & Pivarnik, 2003; Cumming et al., 2010): The pattern of such associations may be different for girls in Asian countries. Recently, Lee and Spence (2012) reported sex differences in PA regardless of biological maturity among Korean adolescents, and argued that cultural factors may outweigh the potential influence of maturation on the PA of youth in Asian countries.

This study proposes to address these gaps by examining the relationship between maturation and PA among Korean girls. Given the limited research examining the role of

maturation in SB, it was included as a second dependent variable. In accordance with the extant literature pertaining to the biological and psychosocial correlates of growth and maturation (e.g., Cumming et al., 2010; Davison et al., 2007; Jackson et al., 2013; Malina, Bouchard, & Bar-Or, 2004; Niven et al., 2007; Sherar et al., 2009), an adapted version of the biocultural model (Cumming et al., 2012) was proposed to test (refer to Figure 1). Specifically, the aim of the study was to examine whether body fatness, sport competence, perceived barriers to PA, and self-efficacy for PA mediated the relationships between maturation and PA/SB among Korean adolescent females. Because positive experiences in sport can serve as a potential source of power, and may reduce the influence of other confounders to participate in PA among girls (Summers-Effler, 2004), it is hypothesized that self-efficacy may play a critical role on the relationship between maturity, other psychosocial correlates of PA, and PA. Body fatness was also included, as it may have bidirectional relationships with biological maturation, SB, and PA among girls. For example, increase in body fat and breast development during pubertal changes may also influence psychosocial factors (e.g., self-perceptions, self-esteem) in a physical setting (Monsma et al., 2006; Davison et al., 2007). In addition, as the biocultural model (Cumming et al., 2012) suggested, perceptions of parental support for PA was tested as a moderator on the relationship between maturation and PA. It was predicted that parents play an important role in this sample as it has been found that parent-child relationships in collectivistic societies such as Korea, are often characterized by hierarchical power relations based on obedience to the parents (Trommsdorff, & Korndadt, 2003).

Methods

Participants and procedures

Using a convenience sampling method, five schools were invited to participate in the study, however, only three agreed. Female children and adolescents aged between 11 and 15 years were recruited from one elementary school (grades 5 and 6), and two middle schools (all grades) near Seoul, South Korea (N = 269) (Mean age = 13.56, SD = 0.08). Written consent was obtained from the parents of each participant and verbal assent was obtained from the participants. During the months of September and October 2014, two researchers visited each school and collected data from the students under the agreement with the school and physical education (PE) teachers during PE class. A researcher provided brief instruction on the protocol of data collection. Accordingly, one researcher distributed questionnaires while the other researcher measured anthropometric profiles in another room. The questionnaires were screened for missing or invalid responses before students were allowed to leave. Completing the questionnaire by participants took approximately 20-25 minutes, and physical assessments took approximately 8-12 minutes. After completing the questionnaires and physical measures, pedometers and log sheets were distributed to participants and researcher provided brief instruction on how to wear a pedometer and to complete the log sheet.

After excluding the data from students who did not wish to be weighed or assessed or who did not provide at least five days of pedometer data, a total of 236 students (87.7%) was included in the final analysis. This study was approved by a human research ethics committee at the University of Alberta (approval number: Pro00039992).

Measures

Anthropometric profiles and body fatness

Height and weight were directly measured using a Prospective Enterprises stadiometer and Detecto balance beam scale following a standard protocol (Gordon, Chumlea, & Rocke, 1988). A final score was calculated by averaging the first two measurements, or the median value was used when a third measure took place. Body Mass Index (BMI) (kg/m^2) was calculated using directly measured height and weight. Body fat percentage (%BF) was measured using Inbody 4.0 body composition analyzer (Biospace). Studies seeking to validate the bioelectrical impedance analysis (BIA) method with Dual-energy X-ray absorptiometry (DXA) among Korean children and adolescents aged 6 to 18 years showed that, although BIA and DXA technique are not interchangeable in %BF, the two methods provided similar estimates of fat free mass (i.e., muscle mass), fat mass, and %BF, and were recommended for use in screening and population studies (Lim et al., 2009).

Pubertal status

The Pubertal Development Scale (PDS) was adopted to obtain pubertal status among participants. The PDS consists of four items assessing growth or change in height, the presence of body hair (including underarm and pubic hair), skin changes (especially the presence of pimples), and breast development for girls. Response options were: not started (1 point); barely started (2 points); definitely started (3 points); seems complete (4 points); and I don't know (excluded from calculation). Additionally, all participants were asked to answer if they experienced menarche (first menstruation in female) ("Yes"; 4 points) or not ("No"; 1 point). All items were aggregated and then averaged which a score of 5 indicating post-pubertal status.

Previous research supports the reliability and validity of this scale (Peterson, Crockett, Richards, & Boxer, 1988).

Physical activity

Participants were asked to wear a pedometer (XC-StepX, Piezo) during their waking hours (except for during water activities, showers, and martial arts training) and to record the number of steps daily before bed time for seven consecutive days. On the seventh day of testing, researchers visited schools to collect the devices. Based on the pedometer log sheets recorded by the participants, those who successfully wore a pedometer and recorded their steps for at least five full days including three weekdays and two weekend days, were included in the analysis.

Self-reported PA was also measured using the Korean version of the Physical Activity Questionnaire for Older children (PAQ-C; Crocker et al., 1997). The Korean version of PAQ-C (Lee et al., 2009) includes Taekwondo and Judo on the list of physical activities as those are most common for Korean children. The PAQ-C has been validated as a reliable measure of PA levels among children (e.g., Crocker et al., 1997) in diverse population groups including Korean children (Lee et al., 2009). In the current sample the PAQ-C demonstrated an excellent level of internal consistency (Cronbach's alpha= .92).

Sedentary behaviour

The Adolescent Sedentary Activity Questionnaire (ASAQ: Hardy, Booth, & Okely, 2007) was used to measure SB among participants. The ASAQ includes small screen recreation (SSR), education, travel, cultural activities, and social activities (Hardy et al., 2007). Participants were asked to state the amount of time they usually engage in five different SBs during weekdays and weekend days. Time spent in each category was calculated and also aggregated across categories to obtain the total amount of time spent in SB per week.

Psychosocial correlates of PA

An in-class questionnaire was designed to measure the psychosocial correlates of PA among adolescents. The questionnaire included measures of sport competence, parental support, perceived barriers, and self-efficacy which have been validated in previous studies (Motl et al., 2000; Saunders et al., 2004; Allison, Dwyer, & Makin, 1999; Rodgers, Wilson, Hall, Fraser, & Murray, 2008; Whitehead, 1995). The translation of each question into Korean followed the protocol described by Lee and colleagues (2009) and internal consistency for each measure was noted.

Mediators

Sport competence was assessed using the sport competence subscale of the Children and Youths' Physical Self-Perception Profile (CY-PSPP; Whitehead, 1995). The sport competence scale has six items, each of which is divided into two contrasting statements. Each item was scored from 1 (low perceived competence) to 4 (high perceived competence). Total scores were summed and manipulated so that high scores reflect greater sport competence and small scores reflect less sport competence (Cronbach's alpha = .85).

Perceived barriers to PA were measured using the Barriers to Being Active scale (US Centers for Disease Control and Prevention, 1999). It contains 21 items asking about time-related barriers, social influential barriers, physical barriers, motivation barriers, barrier from fear of injury, lack of skill, and lack of resources and each sub-category contains 3 items. Questions on the barrier from fear of injury were excluded for the current study since it describes barriers to PA for older people. A total of 16 items were used; responses were rated on a 4-point scale from 1(very unlikely) to 4 (very likely). The responses were recoded so that lower scores indicated

higher barriers to PA and higher scores indicated lower barriers to PA, all items were summed to obtain an average score (Cronbach's alpha = .90).

Self-efficacy of physical activity was measured by adopting three dimensions of self-efficacy: Coping, task, and scheduling self-efficacy (Rodgers et al., 2008). A total of nine items were assessed a 10-point-Likert-type scales ranging from 1 (no confidence) to 10 (complete confidence). The responses were summed and calculated by averaging across the nine questions (Cronbach's alpha = .93).

Moderator

Parental support was measured using five items asking the frequency of support on PA from parents on a weekly basis (Saunders et al., 2004). The items were rated based on the extent to which male adult(s) and female adult(s) provided support during a typical week on a 5-point scale with anchors of 1(none) and 5(daily). The responses for each adult were summed and calculated by averaging across the five questions (Cronbach's alpha = .81).

Statistical Analysis

Mean values for height, weight, body fat percentage, and measured variables by chronological age group were initially calculated using descriptive statistics. Spearman's rank correlation coefficients (one-tailed) were calculated to examine relations among biological maturity, BMI, %BF, sport competence, parental support, perceived barriers, self-efficacy, PA, and SB.

Structural equation modeling (SEM), utilizing maximum likelihood estimation and bootstrapping procedures, was employed to test the hypothesized model concerning direct and indirect relations among variables with AMOS 20.0. Models including each of the two psychosocial correlates of PA (i.e., sport competence, and perceived barriers) were tested

separately. The root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis Index (TLI) were used to determine the approximate fit of the model, the improvement in fit over the null model, and the fit adjusted for parsimony with independence of sample size, respectively (Kline, 2005). RMSEA values close to .05 (or lower), and CFI and TLI values of close to .95 reflect good fit between the model and data, respectively (Kline, 2005). To address the study objectives, direct and indirect effects were estimated. Mediated effects were explored by examining the 90% upper and lower limits of bootstrap-generated bias-corrected confidence intervals of indirect effects (MacKinnon, Lockwood, & Williams, 2004).

The main and interactive effects of biological maturation and parental support for PA, separately by paternal and maternal support, on PA and SB were examined through hierarchical regression analysis. In two-step forced-entry models, chronological age was entered as a predictor in step one, and pubertal status and parental support were entered as predictors in step two (Malina et al., 2004). Values for pubertal status and parental support were centred prior to the analysis to avoid problems associated with correlated independent variables and interpret significant interactions (if any) more easily (Cohen, & Cohen, 1983). Significant interaction effects on step three of the analyses would indicate that parental support moderated the relationship between maturation and PA, and maturation and SB.

Results

Descriptive statistics are presented in Table 1. A mean value for pubertal status was 3.09 ± 0.05, indicating that girls in our sample, on average, reached 75% of maturation. The PDS scores varied from 1.67 ± 0.10 (11 yr olds) to 3.46 ± 0.05 (15 yr olds). Higher %BF was observed in older age groups than in younger ones. Mean steps were 11,404 ± 227.18 during

weekdays and 9,494.42 ± 341.48 on weekends. The total amount of time spent in SB in minutes per week was 1,677.84 ± 63.24 during weekdays and 882.97 ± 34.97 on weekends.

Relationships among variables are summarized in Table 2. Chronological age was negatively correlated with self-reported (r = - .29) and step-determined PA (r = - .39) and positively associated with pubertal status (r = .50) and SB (r = .27). Pubertal status was positively associated with BMI (r = .22), %BF (r = .42), and negatively associated with paternal support (r = - .16), maternal support (r = - .15), barriers to PA (r = - .23), self-efficacy (r = - .20), and self-reported (r = - .25) and step-determined PA (r = - .17). BMI was also positively correlated with %BF (r = .71), and negatively associated with SB during weekend days (r = - .17). %BF was positively correlated with sport competence (r = .18). All psychosocial correlates of PA (i.e., sport competence, parental support, perceived barriers, and self-efficacy) were strongly correlated to each other (r = - .50 to .66), and with self-reported and step-determined PA. A moderate-sized correlation was observed between self-reported and step-determined PA (r = .30).

SEM utilizing maximum likelihood estimation to obtain model fit revealed that the data violated the assumption of multivariate normality. Therefore, bootstrapping procedure with 5000 bootstrap samples were used to test the hypothesized model (Byrne, 2001) (Figure 2). The model fit indices suggested a good fit between the data and the proposed models for sport competence (RMSEA = 0.04, CFI = 0.99; TLI = 0.99), and perceived barriers to PA (RMSEA = .07, CFI = 0.98; TLI = 0.96). A direct association between biological maturity and PA was identified in all models; more advanced pubertal status predicted lower PA among Korean adolescents (β = - 0.51 ~ - 0.57; $p < 0.001$). Body fatness, perceived barriers to PA, and self-efficacy mediated the relationship between biological maturity and PA. Specifically, biological maturity positively

predicted body fatness (β = 1.00, BBC 90% CI = 1.00, 1.00), body fatness negatively predicted less perceived barriers to PA (β = - 0.22, BBC 90% CI = - 0.33, - 0.10), perceived barriers to PA positively predicted self-efficacy β = 0.49, BBC 90% CI = 0.38, 0.59; β = 0.38, BBC 90% CI = 0.27, 0.48; and β = 0.37, BBC 90% CI = 0.26, 0.47 respectively), and, in turn, self-efficacy predicted PA (β = 0.76 ~ 0.82). No associations between pubertal status, mediators (i.e., %BF, sport competence, perceived barriers to PA), and SB were found in the sample. Therefore, SB was excluded from the mediation analysis.

The results of hierarchical regression analyses examining self-reported and pedometer-determined PA among adolescent girls are presented in Table 3. Chronological age, and paternal and maternal support were significant predictors of PA in the final models. Age explained 12-15% of the variance in PA and paternal and maternal support for PA explained an additional 1-18% of the variance after accounting for age. There was no significant interaction effect in any of the models. No associations were found with respect to SB (results not shown).

Discussion

This study examined an adapted version of the biocultural model (Cumming et al., 2012) among Korean girls. Both direct and indirect associations between maturation and PA were observed. Specifically, advanced pubertal status was directly related to lower PA. Furthermore, small to large indirect relationships existed for body fatness, perceived barriers to PA and self-efficacy on the relationship between maturation and PA among Korean girls. Parental support for PA did not moderate the maturation-PA relationship. The results partially support the biocultural model (Cumming et al., 2012) in that both direct and indirect effects existed between maturity and PA among girls.

In our sample, sport competence did not mediate the relationship between biological maturity and PA. Conflicting results exist in the literature mainly due to the lack of relevant studies (Cumming et al., 2010; Davison et al., 2007; Hunter Smart et al., 2012; Jackson et al., 2012). In the current study, though sport competence was negatively associated with both self-reported and pedometer-determined PA, no association existed with maturation or body fatness (i.e., %BF, BMI). This may be explained partly in cultural terms. Korean girls may have more negative feelings towards PA than their Western counterparts; therefore, participation in PA is not as important. In a study examining barriers to PA among 670 Korean girls (Lee, Nam, & Yeo, 2013), negative feelings towards PA (e.g., not important, don't want to move, tiresome) ranked the highest followed by physical appearance (e.g., don't want to sweat, don't want to get tanned). Thus, doing well at all kinds of sports or doing well at athletics may not be an important factor influencing Korean girls to participate in habitual PA, regardless of their pubertal status and body fatness.

Perceived barriers to PA, on the other hand, did appear to play an important role in the relationship between maturation and PA. These results support the biocultural model (Cumming et al., 2012), suggesting that perceived barriers to PA are one of the mediator of the maturity-PA relationship. In contrast, no significant differences in perceived barriers to PA were found among Canadian girls at varying maturity status (Sherar et al., 2009). Our findings may again suggest cultural influence on girls' PA. In Korea, PA is not prioritized, rather, it is considered as something in which girls would not want to engage (Lee et al., 2013). Indeed, 70% of girls reported they either have neutral or negative perceptions of PA, while the corresponding score for boys was 25% (Lee, 2009). Similarly, a qualitative study noted that PE classes, coed in particular, prevent adolescent girls from developing their active identity. Instead, socially

acceptable heterosexual female identity is developed under the influence of peers or a social group (e.g., 'being one of the crowd') (Knowles, Niven, & Fawkner, 2013). Given that almost all daily PA is occurred in PE class for Korean girls (Kim, & Cho, 2013), low quality PE is a potential barrier to PA.

Another possible explanation of the mediating role of perceived barriers to PA is the inclusion of self-efficacy in the model. Self-efficacy refers to one's confidence in the ability to execute behaviours regardless of their own motivation or social environment (Bandura, 1986). Accordingly, we hypothesized that self-efficacy would have more influence over one's behaviour than other psychosocial correlates (e.g., sport competence and perceived barriers to PA) and would serve as a mediator on the maturity-PA relationship among girls. Indeed, strong associations between perceived barriers to PA and self-efficacy, and self-efficacy and PA were observed in our model, indicating that self-efficacy may play an important role in explaining the mechanisms linking biological maturation and PA among Korean girls. For instance, early-maturing girls with higher body fatness may perceive/experience more barriers to PA and, in turn, feel less efficacious in PA, and thus show lower PA than their peers in other stages of maturation. This is consistent with the argument that self-efficacy is more important for girls than boys in explaining PA (Spence, Blanchard, Clark, Plotnikoff, Stroey, & McCargar, 2010). Increasing self-efficacy may help early-maturing girls to engage in more PA. This should be incorporated with providing more opportunities for girls to have positive experience in PA (e.g., increasing mastery experience though enjoyable and easy PA programs, focusing less on developing specific motor skills, reducing competitive environment).

Parental support for PA appears to be important for PA participation among Korean girls, regardless of their pubertal status. Girls' participation in PA is greatly influenced by their parents

(Davison, Cutting, & Birch, 2003), and it appears true in our sample. However, neither paternal nor maternal support moderate the relationship between maturation and self-reported and pedometer-determined PA in our study. Given that these results are consistent with the findings of two earlier studies (Bradley, McRitchie, Houts, Nader, & O'Brien, 2011; Jackson, Cumming, Drenowatz, Standage, Sherar, & Malina, 2013), perhaps parental support for PA is not as important as it appears in explaining the relationship between maturation and PA among girls. Jackson and colleagues (2013) have speculated that parental reactions (e.g., support, acceptance) towards physical growth and maturation are more important than parental support for PA among pubertal girls. In particular, there is evidence that early timing of puberty is associated with greater conflict and less closeness in parent-child relationships (Collins, & Laursen, 2004).

The strengths of the study include the use of two indicators to predict PA and body fatness in the SEM model. The use of single indicator (i.e., path analysis) is more susceptible to measurement error (Kline, 2005). Another strength is that we included multiple mediators in our model. Multiple-mediator models are likely to provide more accurate assessment of mediation effects (MacKinnon, Fairchild, & Fritz, 2007). However, the use of BIA, which has been noted as an inferior measure of fatness among adolescents (Meyer, Friend, Hennan, Himes, Demerath, & Neumark-Sztainer, 2011), to estimate %BF is a potential limitation. Though the validity and reliability of BIA have not been extensively tested among Korean adolescent girls, several studies examining metabolic syndrome risk factors and health among Korean adolescents (e.g., Jekal et al., 2009; Park, Kim, Jekal, & Jeon, 2010) calculated body composition using BIA as well as BMI, waist circumference, and hip circumference as indicators of fatness and showed similar distribution across different measures. SB includes any activities that require ≤ 1.5 METs in a seated or reclined position during waking hours (SBRN, 2012). Because the ASAQ does not specifically assess sitting time and/or energy expenditure, but instead asks about time spent in certain types of

behaviours (e.g., small screen recreation), it is inconsistent with the currently accepted definition of SB (SBRN, 2012). Furthermore, the amount of time spent in SB likely under represents the actual sedentary time of the participants because the ASAQ does not consider other frequently used screen-based devices such as tablets. The cross-sectional design is a further limitation. However, in using a theory, we were able to test for mediators because we could articulate a temporal sequence for the variables (MacKinnon et al., 2007).

In conclusion, this study found mediated effects of body fatness, and psychosocial correlates (i.e., perceived barriers to PA, and self-efficacy) on the relationship between maturity and PA among Korean adolescent girls. Efforts to promote PA among Korean adolescent girls should focus on reducing perceived barriers to PA, and increasing self-efficacy by providing more opportunities to have positive, and enjoyable experience in PA among early-maturing girls. Our findings build on the current existing literature pertaining to the possible pathways between maturation and PA among adolescents.

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Table 1. Descriptive statistics for chronological age, biological maturity status, psychosocial correlates of physical activity (PA), and PA of Korean adolescent females by age group.

	Total Mean (SE)	11 years (n = 23) Mean (SE)	12 years (n = 24) Mean (SE)	13 years (n = 45) Mean (SE)	14 years (n = 87) Mean (SE)	15 years (n = 57) Mean (SE)
Mean age	13.56 (.08)	11.78 (.30)	12.52 (.20)	13.49 (.30)	14.50 (.30)	15.38 (.20)
PDS score[a] (88.5% achieved menarche) (1-4)	3.09 (.05)	1.67 (.10)	2.83 (.15)	3.10 (.09)	3.29 (.05)	3.46 (.05)
Height (cm)	158.00 (.39)	151.39 (1.17)	156.52 (1.17)	157.98 (.97)	158.90 (.54)	159.95 (.71)
Weight (kg)	51.70 (.65)	45.01 (1.82)	51.00 (2.34)	52.51 (1.67)	51.47 (.99)	54.39 (1.19)
Body Mass Index (kg/m^2)	20.62 (.23)	19.53 (.62)	20.02 (.69)	21.14 (.59)	20.27 (.38)	21.21 (.41)
Body fat mass (kg)	19.28 (.72)	17.67 (.55)	18.09 (.98)	22.12 (3.63)	18.68 (.37)	19.09 (.47)
Body fat mass (%)	28.44 (.45)	19.53 (.62)	24.33 (1.32)	29.53 (.91)	29.41 (.70)	30.98 (.81)
Sport competence (1-4)	2.36 (.04)	2.25 (.20)	2.65 (.53)	2.83 (.09)	2.62 (.05)	2.56 (.08)
Parental support (maternal) (1-4)	1.92 (.05)	2.40 (.22)	1.73 (.14)	2.01 (.12)	1.89 (.08)	1.83 (.12)
Parental support (paternal) (1-4)	1.82 (.05)	2.30 (.21)	1.73 (.14)	1.81 (.11)	1.86 (.08)	1.70 (.11)
Perceived barriers (1-4)	2.66 (.04)	2.99 (.12)	2.59 (.10)	2.71 (.07)	2.59 (.05)	2.65 (.08)
Self-efficacy (1-10)	5.49 (.13)	6.86 (1.67)	5.22 (.42)	5.86 (.30)	5.26 (.21)	5.11 (.28)
PAQ-C score[d] (1-5)	2.34 (.05)	3.24 (.19)	2.30 (.10)	2.34 (.09)	2.29 (.06)	2.10 (.09)
Steps taken during weekdays (steps/day)	11404 (227.18)	13684.17 (681.29)	11659.00 (680.11)	11971.75 (603.50)	11112.73 (332.18)	10352.42 (438.05)
Steps taken during weekend days (steps/day)	9494.42 (341.48)	15490.67 (1777.04)	10273.58 (848.59)	10517.99 (682.07)	8488.01 (456.43)	7420.78 (477.26)
Average steps taken (steps/day)	10449.58 (254.63)	14587.42 (1082.52)	10966.29 (705.32)	11244.87 (596.49)	9800.37 (339.02)	8886.60 (411.32)
Sedentary behaviour during weekdays	1,677.83 (63.24)	1,615.91 (213.80)	1,369.52 (148.41)	1,208.75 (189.62)	1,868.99 (112.00)	1,893.78 (115.94)

(min/weekdays)						
Sedentary behaviour during weekend days (min/weekend days)	882.97 (34.97)	640.43 (85.14)	657.92 (79.83)	725.68 (76.30)	988.83 (55.76)	1041.00 (79.25)

[a] PDS: Pubertal Development Scale.
[b] PAQ-C: Physical Activity Questionnaire for Children.

Table 2. Spearman rank correlations (one-tailed) between measures of estimated biological maturity status, body fat percentage, psychosocial correlates of physical activity, physical activity, and sedentary behavior in Korean adolescent females.

	1	2	3	4	5	6	7	8	9	10	11
1. Age											
2. PDS score[a]	.50***										
3. Body Mass Index (kg/m^2)	.12	.22**									
4. Body fat (%)	.40***	.42***	.71***								
5. Sport competence	.11	.12	.00	.13*							
6. Parental support (maternal)	-.15*	-.15*	.07	-.04	-.29***						
7. Parental support (paternal)	-.15*	-.16*	-.04	-.11	-.28***	.66***					
8. Perceived barriers	-.12	-.23***	.04	-.11	-.41***	.32***	.28***				
9. Self-efficacy	-.20**	-.20**	-.03	-.20**	-.50***	.36***	.31***	.49***			
10. PAQ-C score[b]	-.29***	-.25***	-.05	-.21**	-.47***	.39***	.33***	.49***	.50***		
11. Average daily steps taken	-.39***	-.17***	.08	-.22**	-.16*	.20**	.15*	.16*	.30***	.30***	
12. Sedentary behaviour (min/week)	.27***	.11	-.10	.00	.10	.02	.04	-.11	-.01	-.04	-.10

[a] PDS: Pubertal Development Scale.
[b] PAQ-C: Physical Activity Questionnaire for Children.
*$p < .05$; **$p < .01$; ***$p < .001$.

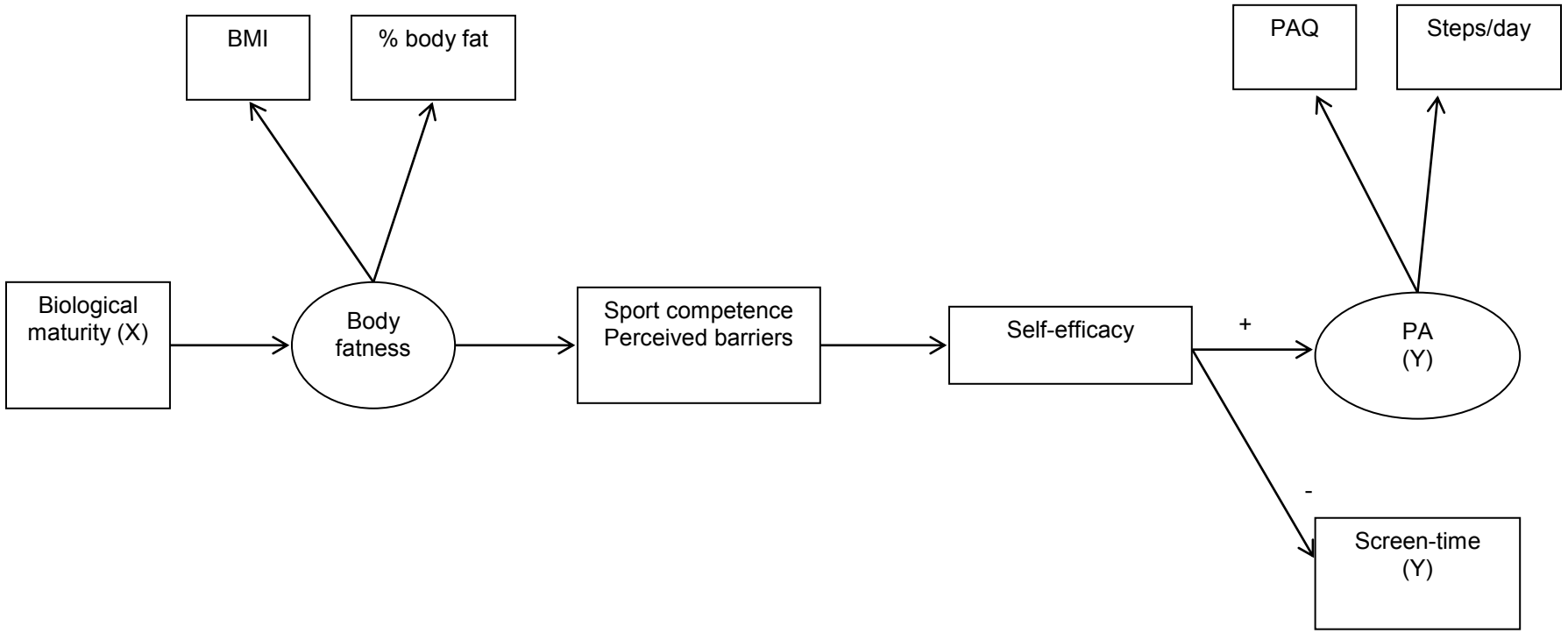
Table 3. Results of hierarchical regression analyses explaining self-reported and pedometer-determined physical activity (PA) among Korean adolescent girls.

Variable	Step 1	Step 2	Step 3
	ß (SE)	ß (SE)	ß (SE)
Self-reported PA			
Age	-.35 (.04)***	-.23 (.04)**	-.22 (.04)**
Pubertal status		-.12 (.07)	-.12 (.07)
Maternal support		.42 (.05)***	.41 (.05) ***
Pubertal status X maternal support			-.05 (.06)
F	32.93***	34.71***	26.15***
Adjusted R^2	.12	.30	.30
Age	-.35 (.035)***	-.22 (.04)**	-.22 (.04)**
Pubertal status		-.12 (.07)	-.12 (.07)
Paternal support		.43 (.05)***	.43 (.05)***
Pubertal status X paternal support			-.02 (.06)
F	32.93***	36.43***	27.27***
Adjusted R^2	.12	.31	.31
Pedometer-determined PA			
Age	-.39 (190.81)***	-.40 (245.28)***	-.40 (247.59)***
Pubertal status		.05 (429.13)	.05 (430.97)
Maternal support		.16 (285.04)**	.17 (288.56)**
Pubertal status X maternal support			.02 (341.92)
F	40.76***	16.35***	12.25***
Adjusted R^2	.15	.17	.16
Age	-.39 (190.81)***	-.40 (245.557)***	-.40 (246.68)***
Pubertal status		.05 (429.46)	.05 (431.54)
Paternal support		.16 (290.76)**	.16 (294.68)**
Pubertal status X paternal support			.03 (336.96)
F	40.76***	16.22***	12.18***
Adjusted R^2	.15	.16	.16

*$p < .05$; **$p < .01$; ***$p < .001$.

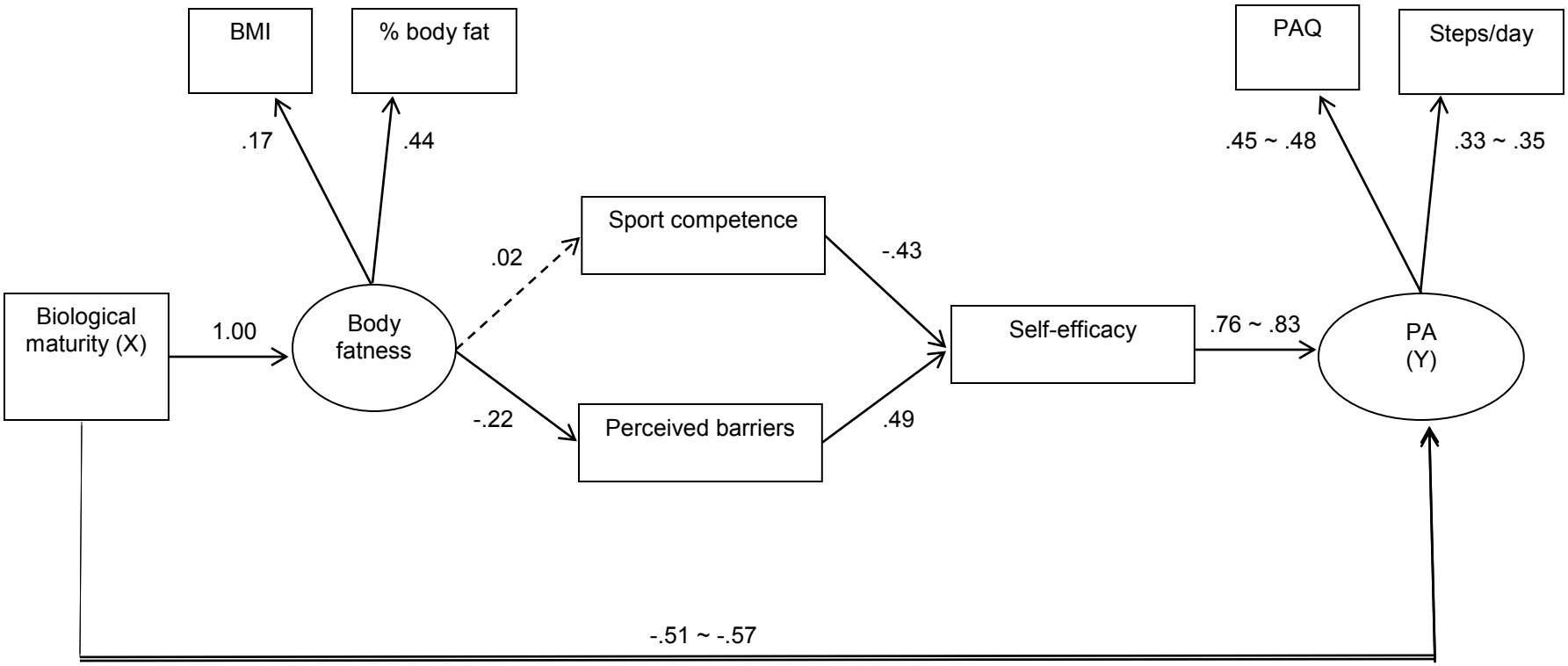
[a] Standardized Beta-coefficients and standard errors from the various steps of the regression model.

Figure 1. A hypothesized mediated effects model describing the role of psychosocial correlates of physical activity explaining the relationships between biological maturity and behaviours among Korean adolescent girls.



Rectangles indicate measured variables and ovals indicate latent variables.

Figure 2. Direct and indirect effects (β) of biological maturity on physical activity among Korean adolescent girls (All solid line parameters are significant ($p < .05$) and dashed line parameters are non-significant).



Chapter 5: Study 3. A Longitudinal Examination of the Influence of Pubertal Timing on Screen-time among Korean Adolescents

Abstract

Purpose. To test links between pubertal timing and screen-time among Korean adolescent boys and girls.

Method. Secondary analysis was conducted on data from the Korean Children and Youth Panel Study (KCYPS) involving 2,071 Korean adolescents. Body mass index (BMI) at Grade 8, self-esteem and depression at Grade 9 were examined as mediators of the relationship between pubertal timing and screen-time after controlling for household income and academic performance. Structural equation modeling was used to assess direct and indirect pathways between pubertal timing at Grade 8 and screen-time at Grade 9.

Results. No direct effect of pubertal timing on screen-time was found. An indirect effect of pubertal timing on screen-time through BMI existed among boys. Earlier pubertal timing predicted higher BMI, and in turn, higher BMI predicted more time spent in screen-time. Among girls, pubertal timing negatively predicted BMI; however, no mediation effect of BMI between pubertal timing and screen-time was observed. No mediation effect of self-esteem or depression was found among boys and girls.

Conclusion. Pubertal timing appears to have an indirect influence on screen-time through BMI for Korean boys. More studies examining potential pathways between pubertal timing and sedentary behaviour are needed to build on these findings.

Introduction

Accumulating evidence suggests that sedentary behaviour (SB) is an important determinant of the current and future health of adolescents, regardless of their physical activity level (Salmon, Tremblay, Marshall, & Hume, 2011; Spence, & Dinh, 2015). Therefore, identifying predictors of SB should be a key public health priority. Notable individual-level correlates of SB include age, sex, and weight status (Pate, Mitchell, Byun, & Dowda, 2011; Salmon et al., 2011). Though biological factors such as maturation (e.g., pubertal timing) are thought to influence physical activity among youth (Cumming, Sherar, Pindus, Coelho-e-Silva, Malina, & Jardin, 2012), only a few studies have examined the role of such factors on SB. For instance, more advanced puberty positively predicted SB in a large sample of British adolescents aged between 12 and 13 years (Brodersen, Steptoe, Boniface, & Wardle, 2007). In addition, percentage of predicted mature stature (i.e., the child's current height relative to their expected height at maturity) was a significant predictor of SB among 13-16 year-old Portuguese boys (Rodrigues et al., 2010).

The mechanisms by which pubertal timing influences SB are even less understood. Because pubertal timing is associated with weight status, particularly among girls (Davison, Susman, & Birch, 2003; Kaplowitz, 2008), and weight status is one of the correlates of SB such as screen-time (Salmon et al., 2011), it is possible that pubertal timing may influence screen-time mediated by weight status. Likewise, puberty accompanies psychological changes (Patton, & Viner, 2007), and psychological factors are known to be associated with SB among adolescents (Tremblay et al., 2011). For instance, prolonged time spent in SB was associated with higher depressive symptoms (Maras et al., 2015), lower self-esteem (Russ, Larson, Franke, & Halfon, 2009), and less pro-social behaviour (Mistry, Minkovitz, Strobino, & Borzekowski, 2007) among

children. Two longitudinal studies (Epstein et al., 2008; Neumark-Sztainer, Goeden, Story, & Wall, 2004) reported negative associations between screen-time and self-esteem among boys, and a positive association between screen-time and aggression among girls. Thus, psychological well-being may be another potential mediator of the relationship between pubertal timing and SB.

The aim of this study, therefore, was to examine whether pubertal timing, BMI, and psychological well-being influence screen-time among adolescents in the Korea Children and Youth Panel Study (KCYPS). Data from boys and girls were analyzed separately, as patterns may differ between the sexes (Byun et al., 2012). Specific hypotheses included: (i) differences will exist in pubertal timing, BMI, psychological well-being, and screen-time by sex and over time; (ii) pubertal timing will predict BMI, psychological well-being, and screen-time; and (iii) pubertal timing will predict screen-time mediated by BMI and psychological well-being. Understanding the mechanisms linking pubertal timing and screen-time may positively contribute to the development of well informed, effective, and evidence-based interventions aimed at promoting cardio-metabolic and psychological health among adolescents.

Methods

Participants

This study involved a secondary analysis of data from the KCYPS, which is a seven-year prospective panel study of a representative sample of students in Grade 1, 4, and 7 in Korea (National Youth Policy Institute [NYPI], 2014). Each panel aimed to recruit at least 2,200 students using a stratified multi-stage cluster sampling method in 2009; the sample population was geographically representative of Korea. KCYPS was developed based on Bronfenbrenner's ecological framework (Bronfenbrenner, 1979); the survey questions are divided into two categories (i.e., personal development and environment) with 10 sub-categories (physical,

intellectual, socio-emotional development, delinquency behavior, and lifestyle patterns). Data were available and accessible to any registered member of the NYPI data archives website (http://archive.nypi.re.kr/).

At baseline, four trained research staff visited participating schools during regular school hours. Self-report questionnaires were administered to the students who were encouraged to complete all items. Demographic information was collected from the caregivers of each student. For the Grade 7 panel, baseline measures were collected from October to November in 2009. Subsequent measures were made from October to December in every year since 2010. Students who participated in the survey at baseline, and who agreed to continue in the study were contacted via telephone at follow-up. After obtaining a verbal consent, research staff then had a face-to-face meeting with each student followed by an interview with caregivers to collect demographic information. According to the NYPI data user manual, incentives were provided to students who participated in each panel (NYPI, 2014).

At the first wave in 2010, data were collected from a total of 2,351 students (49% of females). Follow-up rates for the second and third waves were 97.0% (N = 2,346) and 96.1% (N = 2,337) respectively. For the current study, the second and third waves (2011-2012) were downloaded and analyzed because they were the only ones to include measures of pubertal timing and psychological well-being along with the other necessary variables. A total eligible number of students included in the analyses were 2,071 (49% of females) after excluding samples with missing data. The details of the goals, design, and sampling of this panel were published on the data archives webpage of NYPI (http://archive.nypi.re.kr/) (Kim, Baek, Im, & Lee, 2010). Ethics approval was obtained by Statistics Korea for baseline data collection and for the follow-up data collection (approval number: 40202). Informed written consent was obtained

from the parent/main guardian of each student who participated in data collection (Kim et al., 2010); KCYPS is de-identified data (NYPI, 2014).

Measures

Pubertal timing

Participants were asked in which grade they experienced first ejaculation (i.e., semenarche, spermarche, oiarche)/menstruation. Responses options were as follows: 1 (have not yet experienced), 2 (Grades 1-3), 3 (Grade 4), 4 (Grade 5), 5 (Grade 6), 6 (Grade 7), and 7 (Grade 8). For analyses, the scores were recoded so that the lowest score (0) represented no menarche/semenarche and the highest score (7) represented early pubertal timing (Grade 1-3). Menarche and semenarche have been recognized as landmark pubertal events in each sex; they are a key part of childhood and adolescence in all biological, psychological, social, and cultural realms (Ponton, & Judice, 2004).

Body Mass Index (BMI)

Weight and height were self-reported by participants. BMI was computed by dividing weight in kilograms by height in meters squared (kg/m^2).

Psychological well-being

Depression in Grade 8 and 9 and self-esteem in Grade 9 were used to indicate psychological well-being among participants. Korean versions of the Beck Depression Inventory (Beck, Steer, & Carbin, 1988) and the Rogenberg Self-esteem Scale (Rosenberg, 1979), translated and validated by the Korea University Behavioral Science Research Institute (Korea University Behavioural Science Research Institute, 2000), were used. The scales consisted of 10 items each and the responses were scaled from 1 (very much) to 4 (not at all). Self-esteem scores were recoded so that lower scores indicated negative psychological well-being. In the current

sample, the internal consistency coefficients for depression at Grades 8 and 9, were α = .90, and .91 respectively. The corresponding Cronbach's alpha for self-esteem at Grade 9 was .60; thus, exploratory factor analysis was performed to improve the internal consistency of the self-esteem measure and determine the most appropriate item structure for the sample.

Screen-time

Screen-time was measured by four questions asking students to report the amount of time spent (hour and minute) in playing computer/video games, and watching television during weekdays (two items), and on weekends (two items) in each year. For the analysis, total time in each category was calculated by converting hours to minutes and then adding any additional minutes.

Covariates

Monthly household income reported by the parents/guardians of all participating students in Grade 9 was categorized into quartiles (1,000 Korean Won): Quartile 1 = lowest –2,999.99; quartile 2 = 3,000– 4,199.99; quartile 3 = 4,200–5,999.99; and quartile 4 = 6,000– highest. Academic performance was obtained by asking participants to rate their achievement at school; response options scaled from 1 (very satisfied) to 5 (not satisfied at all).

Statistical Analysis

All data were screened and checked for inconsistencies by KYCPS before the data were released. An exploratory factor analysis was performed on the self-esteem measures. The principal components method with an oblique rotation was used to allow for a correlated factor structure. A number of factor extractions were attempted to achieve an acceptable internal consistency (α = .802); four out of ten items were removed from the self-esteem measure.

To examine the patterns of BMI, psychological well-being, and screen-time (hypothesis one), descriptive statistics were tabulated; sex-differences within the same grade and grade-differences within the same sex were also calculated through paired sample t-tests. To test hypotheses two and three, bivariate associations between pubertal timing in Grade 8, BMI, psychological well-being, and screen-time in Grades 8 and 9, self-esteem in Grade 9, household income, and academic performance were assessed using Spearman rank correlation analysis.

Consequently, structural equation modeling (SEM) was conducted using maximum likelihood to fit the model. Because the data violated a multivariate normality assumption, SEM analysis was conducted using bootstrapping procedures with 5000 resampling separately by sex, and separately for depression and self-esteem with IBM SPSS AMOS software. The model potentially explaining the relationship between pubertal timing and screen-time included the following pathways: (i) an association between pubertal timing and BMI at Grade 8 after controlling for screen-time at Grade 8; (ii) an association between BMI at Grade 8 and screen-time at Grade 9; (iii) an association between BMI at Grade 8 and psychological well-being at Grade 9 after controlling for corresponding psychological well-being at Grade 8; (iv) an association between psychological well-being and screen-time after controlling for screen-time at Grade 8. All analyses were also controlled for parental-reported household income and self-reported academic performance at Grade 9. The SEM approach uses latent variables that represent a hypothetical construct with multiple measurable variables. It allows for inclusion of multiple variables of the same construct without problems of collinearity and accounts for measurement error of each indicator (MacKinnon, Fairchild, & Fritz, 2007). The root mean square error of approximation (RMSEA) and comparative fit index (CFI) were used to determine the approximate fit of the model, the improvement in fit over the null model and the fit adjusted

for parsimony with independence of sample size, respectively (Keith, 2014). RMSEA values close to .05 (or lower), and CFI values of close to .95 reflect good fit between the model and data (Keith, 2014). In accordance with recent recommendations (MacKinnon, Lockwoo, & Williams, 2004), mediated effects were explored by examining the 90% upper and lower limits of bootstrap-generated bias-corrected confidence intervals (BBC 90% CI) of indirect effects.

Results

Table 1 shows various characteristics of the study sample including physical attributes and screen-time. Boys were generally taller and heavier than girls both at Grade 8 and 9. As for pubertal timing, 21.6% of boys and 6.1% of girls had not experienced semenarche/menarche at baseline. Depressed mood increased with age, and girls scored higher than boys at Grade 8 (3.15 ± 0.61 in boys vs. 3.11 ± 0.61 in girls) and 9 (2.99 ± 0.61 in boys vs. 2.93 ± 0.63 in girls). Self-esteem was higher among boys (2.84 ± 0.45) than girls (2.80 ± 0.01). Time spent in screen-time decreased over time for both boys and girls. Boys spent more time in screen-time than girls at Grades 8 and 9 (123.05 ± 55.77 min and 114.62 ± 55.21 min in boys vs. 121.66 ± 54.48 min and 109.38 ± 60.79 min in girls).

Bivariate correlations between predictor and outcome variables and covariates are shown in Table 2 separately by sex. Among boys, pubertal timing at Grade 8 showed weak correlations with BMI in Grade 8 (r = .10) and 9 (r = .11); pubertal timing was not correlated with either well-being indicators or screen-time. Among girls, pubertal timing at Grade 8 was correlated with BMI at Grade 8 (r = .33) and 9 (r = 32). In both sexes, psychological well-being indicators at Grades 8 and 9 were fairly to moderately correlated with each other (r = .38 ~ .43 among boys and r = .45 ~ .54 among girls). Marginally significant correlations were observed between screen-time, and psychological well-being indicators.

The results of mediation analyses are shown in Figure 1, separately by sex. Latent variables were created for depression and self-esteem measures to limit the number of estimated parameters using item parceling (Hall, Snell, & Foust, 1999). One of the advantages of parceling items are that the composite-level indicators tend to be more reliable and normally distributed, and to have values that are more continuously distributed. In addition, the number of indicators in mediation models directly affects the sample size requirements (Hall et al., 1999).

The 10 items of the depression measure were parceled into five indicators of a latent variable representing depression. Item-to-construct loadings were used to pair items (e.g., the highest and the lowest loadings, the second highest and the second lowest loadings…the fifth and sixth loadings). The same strategy was employed for the self-esteem measures, producing three indicators. Figure 1 shows the model fit and standardized Beta coefficients associated with the model separately by sex. The mediated models for boys and girls showed adequate fit between the proposed model and the data (RMSEA = .018, CFI = .991 among boys; RMSEA = .992, CFI = .992 among girls).

For the models assessing the pathways between pubertal timing and screen-time, an indirect relationship existed between pubertal timing and screen-time through BMI among boys. Specifically, early timing of puberty among boys was associated with higher BMI (β = .09; BBC 90% CI= .04, .14), and in turn, predicted a greater amount of time spent in screen-time (β = .07, BBC 90% CI= .02, .12), independent of the specified covariates. Among girls, pubertal timing positively predicted BMI (β = .28, BBC 90% CI= .23, .34) but no mediation effect between pubertal timing and screen-time was observed.

Discussion

This study examined mediation models depicting the longitudinal relationships between pubertal timing, BMI, psychological well-being (i.e., depression, self-esteem), and screen-time separately by sex among Korean adolescents. Though the amount of screen-time decreased over time among both boys and girls, sex differences existed. In addition, we found sex differences in the relationship between pubertal timing and screen-time. Notably, boys spent significantly more time in screen-time than girls at Grade 9, but not at Grade 8. Among boys, an indirect influence of pubertal timing on screen-time through BMI was observed. Neither depression nor self-esteem mediated the relationship between pubertal timing and screen-time.

The key finding of this study is the role that BMI appears to play for boys. Though no direct effect of pubertal timing on screen-time was found, pubertal timing positively predicted BMI at Grade 8, and BMI positively predicted screen-time (e.g., watching television, playing computer or video games) at Grade 9 after controlling for other specified covariates. According to Hayes (Hayes, 2009), it is possible for a mediator (M) to be causally linked between a predictor (X) and a criterion (Y) variable even when no association exists between X and Y; in such cases, it is suggested to use the term *indirect effect* instead of *mediator* to describe the relationship (Mathieu, & Taylor, 2006). These results suggest that the relationship between BMI and SB may differ by the type of behaviour, and that higher BMI may be also a marker for, not just a result of (Epstein et al., 2008; Mitchell, Pate, Betts, & Nader, 2013), extended screen-time.

No direct relationship was observed between pubertal timing and screen-time in our study. Similarly, Bradley and colleagues (2000) reported that pubertal status was not a significant indicator of SB among middle school boys. In contrast, longitudinal examination of maturation and video game playing using accelerometry (Janz, & Mahoney, 1997) reported that late and

post-pubertal boys were more sedentary than boys in mid-puberty (mean age = 15 years). Also, pubertal maturation was a significant predictor of SB among Portuguese boys (Rodrigues et al., 2010) and British boys (Brodersen et al., 2007). Thus, future research should test for both direct and indirect effects of pubertal timing on SB. Furthermore, it is possible that cultural factors (e.g., emphasis on school and home work in Korea) may moderate the role or impact of biological processes (e.g., pubertal timing) on engagement in SB such as excessive consumption of screen-time (Cumming et al., 2012).

One of the possible explanations as to why neither depression nor self-esteem mediated the relationship between pubertal timing and screen-time in our study may be due to *suppression* (MacKinnon et al., 2007). For example, the beta coefficients between pubertal timing and BMI, between BMI and self-esteem, and between self-esteem and screen-time among girls were positive, negative, and positive thus, opposing mediational processes may exist. It has been reported that such inconsistent mediation is more common in models with multiple mediators (MacKinnon et al., 2007). Another surprising finding that applied to both boys and girls in our study was that screen-time decreased between Grades 8 and 9. Previous research suggests that, regardless of sex, older adolescents spend more time spent in SB than younger adolescents (Brodersen et al., 2007, Kim, 2010, Pate et al., 2011). A longitudinal investigation also confirmed age-related increases in screen-time across adolescence (Mitchell et al., 2013). Our study results were the opposite of previous findings. We only observed a-one-year period; the results may have been clearer if we included longitudinal data beyond one year.

A key strength of this study was the use of a longitudinal design with a geographically representative sample of Korean adolescents. In addition, this is the first study examining the relationship between pubertal timing and screen-time longitudinally among adolescents with

multiple mediators. Regardless, some limitations should be acknowledged as well. The survey did not measure the actual sitting-time among participants which is a criterion of the current definition of SB (Sedentary Behaviour Research Network, 2012). Instead, self-reported screen-time is used as a proxy for SB. Thus, our findings provide limited insight on the determinants of SB but make important contributions to our understanding of screen-time consumption among adolescents. The data were collected using self-reports from students and their parents, and inaccurate recall and intra personal bias may have occurred. In particular, self-reports of puberty related events are likely sensitive topics for adolescents to report. The development of more robust, yet convenient biomarkers to measure pubertal timing, or where possible, using objective or direct measures of pubertal timing and adiposity, will help to elucidate this relationship in future investigation. Finally, self-esteem was measured at Grade 9 only; thus, we were not able to control for self-esteem at Grade 8.

In summary, pubertal timing appears to have an indirect influence on screen-time through BMI for Korean boys. This study contributes to the current literature, as only a few have examined such relationships among boys in particular. More studies examining potential pathways between pubertal timing and SB are needed to build on these findings.

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Table 1. Descriptive statistics for physical characteristics, pubertal timing, screen-time, and depression at Grades 8 and 9— Korea Children and Youth Panel Study, 2011-2012.

	Scale	Grade 8 (n=2,276)		Grade 9 (n=2,226)	
		Boys	Girls	Boys	Girls
N (%)		1,150 (50.5)	1,126 (49.5)	1,128 (50.7)	1,098 (49.3)
Household income (1,000 Korean won) (%)					
Q1 (lowest-2,999.99)		-	-	21.0	20.4
Q2 (3,000-4,199.99)		-	-	30.9	27.8
Q3 (4,200-5,999.99)		-	-	21.3	25.5
Q4 (6,000-highest)		-	-	26.8	26.3
Academic performance (M±SD)	1-5	-	-	2.75 ± 0.82	2.76 ± 0.78
Height (M±SD)		167.58 ± 7.09	159.41 ± 5.35*	**171.26 ± 6.31**	**160.42 ± 5.3***
Weight (M±SD)		57.88 ± 11.62)	50.18 ± 7.7)*	**61.25 ± 11.24**	**51.59 ± 7.15***
BMI (M±SD)		20.53 ± 3.49)	19.73 ± 2.74*	**20.85 ± 3.39**	**20.02 ± 2.51***
Pubertal timing (M±SD)	0-6	1.27 ± 1.32	2.63 ± 1.12*	-	-
Depression (M±SD)	1-5	3.15 (.61)	3.11 (.61)	**2.99 (0.61)**	**2.93 (0.63)**
Self-esteem (M±SD)	1-5	-	-	2.84 (0.45)	2.80 (0.01)*
Screen-time during weekdays (minute)[1] (M±SD)					
Computer/video games		86.16 (65.88)	84.35 (66.63)	88.57 (67.11)	**69.83 (67.29)**
TV watching		89.59 (66.87)	96.78 (73.13)*	**84.06 (63.43)**	94.73 (75.38)*
Screen-time on weekends (min)[1] (M±SD)					
Computer/video games		162.48 (104.59)	135.15 (93.91)	**157.88 (102.58)**	**114.87 (93.35)***
TV watching		153.97 (95.95)	170.37 (104.97)	**137.06 (89.12)**	168.91 (107.17)*
Screen-time total (min)[1] (M±SD)		123.05 (55.77)	121.66 (54.48)	**114.62 (55.21)**	**109.38 (60.79)***

Data were presented as means and standard deviations (M±SD) or percentages (%).
[1]Screen-time: Computer/video games, watching television.
*$p < 0.05$, significant sex differences within the same grade.
***p* < 0.05**, significant differences over time within sex.

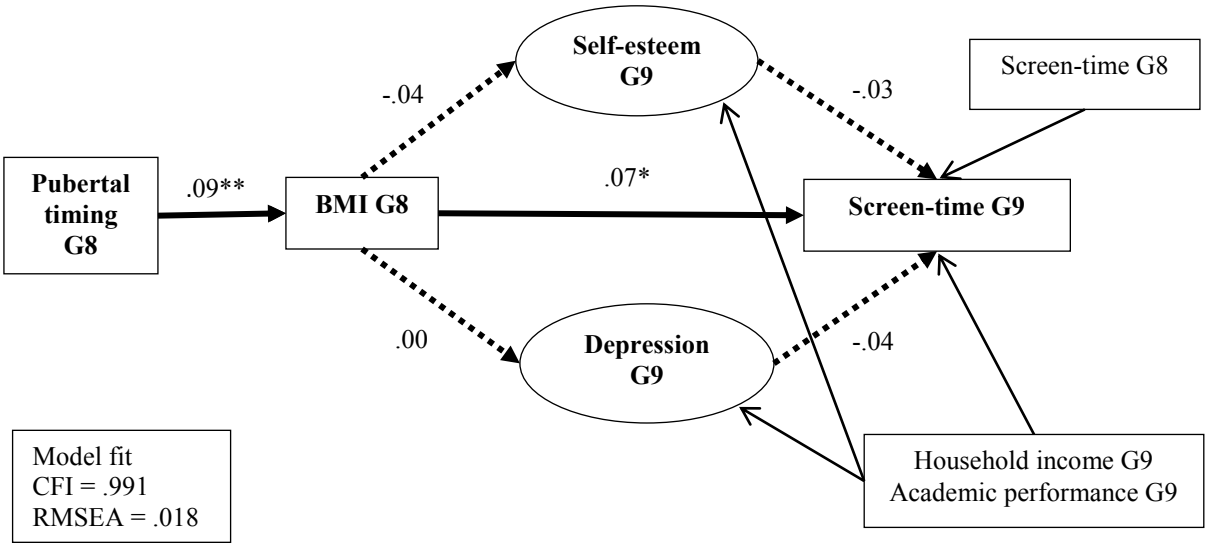
Table 2. Correlation coefficients for pubertal timing (Grade 8), Body Mass Index (BMI), psychological well-being, and screen-time among boys (n=1,056) (shaded) and girls (n=1,015)—Korea Children and Youth Panel Study, 2011-2012 (N=2,071).

	1	2	3	4	5	6	7	8	9	10
1. Pubertal timing (8)	–	.33***	-.06*	.06	.32***	-.04	-.05	.05	-.01	-.01
2. Body Mass Index (8)	.10**	–	-.02	.07*	.81***	-.05	-.05	.07*	-.04	.02
3. Depression (8)	-.04	-.06	–	-.06	-.03	.54***	.41***	-.06	.08**	-.13***
4. Screen-time (8)[1]	.003	.004	-.05	–	.05	-.08*	-.07*	.38***	-.19***	.09**
5. Body Mass Index (9)	.11**	.83***	-.05	-.03	–	-.03	-.05	.08*	-.05	.04
6. Depression (9)	-.04	.007	.43***	-.04	.03	–	.56***	-.02	.10**	-.14***
7. Self-esteem (9)	.04	-.04	.36***	-.10**	-.02	.48***	–	-.07*	.15***	-.21***
8. Screen-time (9)[1]	-.002	.03	-.08*	.43**	-.01	-.05	-.03	–	-.19***	.03
9. Household income (9)	.02	.01	.07*	-.21***	.04	.03	.06	-.18***	–	-.04
10. Academic performance (9)	-.02	.03	-.05	.08**	.002	-.11***	-.21***	.04	-.06	–

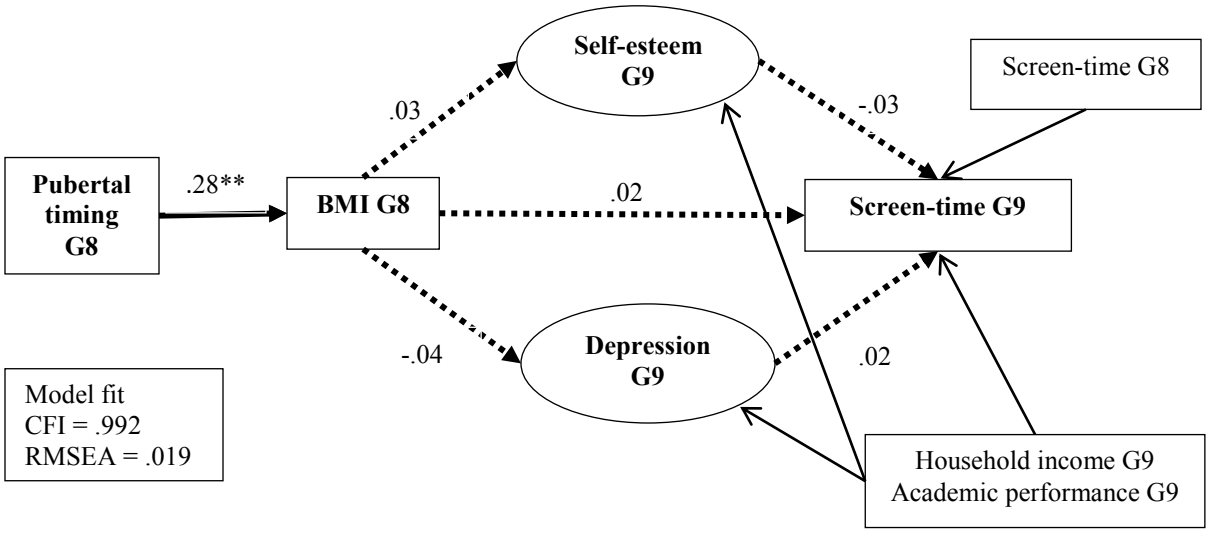
[1]Screen-time: Computer/video games, television viewing.
***$p < .001$, **$p < .01$, *$p < .05$.

Figure 1. Associations between pubertal timing, Body Mass Index (BMI), psychological well-being and screen-time—Korea Children and Youth Panel Study, 2011-2012 (N=2,071).

C. Mediated effects (β) model describing the associations between pubertal timing, Body Mass Index (BMI), psychological well-being and screen-time among boys (n=1,056).



D. Mediated effects (β) model describing the associations between pubertal timing, Body Mass Index (BMI), psychological well-being and screen-time among girls (n=1,015).



The primary variables of interest are shown in bolded texts; covariates are shown in non-bolded texts.
Bolded lines indicate significant effect; dashed lines indicate non-significant effect; non-bolded lines indicate covariates.
A rectangle represents a measured variable and an oval represents a latent variable.
CFI = Comparative Fit Index; RMSEA = Root Mean Squared Error of Approximation.
***$p < .001$, **$p < .01$.

Chapter 6: General Discussion and Conclusions

This chapter summarizes and discusses the results of three studies. After briefly reviewing the key findings of each study, it reflects on the strength and limitations of the research. It also highlights the implications of those findings and their relevance to research, practice, education, policy, and suggests recommendations for future research.

Overview of the Study

Guided by the biocultural model of maturity-associated variance in adolescent physical activity (PA), this thesis aimed to identify and test the mechanisms between biological maturation and PA and sedentary behaviour (SB) among Korean adolescents. The key objectives were: (1) to test the role of pubertal timing in sex differences in PA and SB, (2) to investigate the potential mechanisms linking pubertal status, body fatness, and the psychosocial correlates of PA with PA and SB, and (3) to examine the influence of pubertal timing, body fatness, and psychological well-being on SB.

Summary of Key Findings

In addressing the key objectives, the three studies yielded somewhat inconsistent findings on the relationship between maturation and behaviour among adolescents. Regardless, this research partially supports the biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012). The findings are discussed more specifically in the following sections.

Study 1: The role of pubertal timing in sex differences in self-reported physical activity and sedentary behaviour among Korean adolescents

This study tested the potential role of pubertal timing in relation to sex differences in PA and SB in a representative sample of Korean adolescents in the 2012 Korea Youth Risk

Behaviour Web-based Survey (KYRBS) (estimated N = 3,745,735). In general, as hypothesized, boys engaged in moderate-to-vigorous PA (MVPA) more frequently and engaged in SB less than girls after controlling for chronological age, school type, economic status, parental education levels, and body mass index (BMI). The effect of sex on MVPA remained same magnitude when pubertal timing was introduced as a mediator in the model. Though the effect was small, pubertal timing significantly mediated the relationship between sex and SB. Previous studies have found that sex differences in PA and/or SB were eliminated or attenuated after adjusting for biological maturity among British adolescents (Cumming et al., 2008), Portuguese adolescents (Rodrigues et al., 2010), and Canadian youth (Sherar et al., 2007; Thompson et al., 2002). Though pubertal timing significantly predicted SB among the sample, it did not sufficiently explain the relationship between (1) sex and PA, or (2) sex and SB.

Study 2: Pubertal status and physical activity in Korean adolescents: The role of self-efficacy and perceived barriers

This study identified the potential mechanisms between pubertal status, body fatness, psychosocial correlates of PA, and PA among female adolescents recruited from three schools near Seoul, Korea (N = 236). A direct association between maturation and PA was observed. Advanced pubertal status was directly related to lower PA. Furthermore, small to large indirect relationships existed for body fatness, perceived barriers to PA and self-efficacy on the relationship between pubertal status and PA among Korean girls. These findings made an important contribution to the current literature because no previous study has examined the mediated effects of the variables mentioned above even though they have been suggested as potential mediators in the biocultural model (Cumming et al., 2012). However, in contrast to the majority of previous findings (Cumming et al., 2010; Hunter Smart et al., 2012), sport competence did not mediate the

relationship between pubertal status and PA in our sample. Furthermore, though the biocultural model (Cumming et al., 2012) suggests parental support for PA as a moderator on the pubertal status-PA relationship, neither paternal nor maternal support for PA appear to moderate the relationship (cf. Bradley et al., 2011; Jackson et al., 2013).

Study 3: Longitudinal associations between pubertal timing and screen-time

The third study examined mediation models depicting the longitudinal relationships between pubertal timing, BMI, psychological well-being (i.e., depression, self-esteem), and screen-time separately by sex among Korean adolescents in the Korea Children and Youth Panel Study (KCYPS) (N = 2,071). Though no direct effect of pubertal timing on screen-time was found, pubertal timing positively predicted BMI at Grade 8, and BMI positively predicted screen-time (e.g., watching television, playing computer or video games) at Grade 9 after controlling for other specified covariates among boys. No direct or indirect effect existed among girls. Furthermore, screen-time decreased over time among the adolescents. Previous studies have reported that, regardless of sex, older adolescents spend more time spent in SB than younger adolescents cross-sectionally (Brodersen et al., 2007; Kim, 2010; Pate et al., 2011) and longitudinally (Mitchell et al., 2013).

Overall summary of key findings

The findings to be drawn from the three studies are as follows:

1. Regardless of pubertal timing, girls were less physically active and more sedentary than boys after controlling for chronological age, school type, economic status, parental education levels, and body mass index (BMI). Though pubertal timing mediated the relationship between sex and SB, sex remains a strong determinant of PA and SB among Korean adolescents.

2. As the biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012) suggested, perceived barriers to PA and self-efficacy appear to play roles in explaining the relationship between pubertal status and PA among adolescent girls. Parental support for PA did not moderate the maturation-PA relationship.
3. No direct association between pubertal timing and SB was found among Korean adolescents across the Studies 1 to 3. However, an indirect association was observed between pubertal timing and screen-time through BMI among boys. Thus, BMI appears to play a role in the relationship between these factors among Korean boys.

These findings shed light on an area that has received little empirical attention and suggest future implications for adolescents, parents, educators, researchers, health professionals, and policy makers in promoting the health and well-being of adolescents. The following sections discuss the overall strengths and limitations of this thesis.

Strengths of the Thesis

Studies 1 and 3 used a nationally representative sample of Korean adolescents. Therefore, it is assumed that the patterns and trends observed among these studies are generalizable to the entire Korean adolescent population. Study 2 did not include a representative sample of Korean girls, therefore, its generalizability is limited. However, this study was one of the first that has attempted to test body fatness, perceived barriers to PA, and self-efficacy as mediators and paternal and maternal support as moderators on the relationship between pubertal status and PA. Another key strength of this thesis is the use of a longitudinal design in Study 3. The inclusion of both sexes in examining the relationship between biological maturation and behaviours cross-sectionally and longitudinally is also a strength. Previous studies have observed maturity-related variances in body fatness and PA primarily among adolescent girls. It has been

indicated that the associations between pubertal timing, BMI, and PA are inconclusive among boys mainly due to the lack of relevant research. Study 3 included measures of pubertal timing, BMI, and behaviours among males and females, which likely to fill an important gap in the literature.

Employing contemporary mediation analytic methods (Preacher, & Hayes, 2008; Hayes, 2009; Mackinnon et al., 2007) also strengthened this thesis. Mediation analysis enabled us to identify and explicate the mechanisms linking biological maturation and PA and SB. In particular, structural equation modeling (SEM), using bootstrap resampling methods was employed in studies 2 and 3 to test mediation effects. There are several advantages associated with using SEM instead of using standard regression methods. Specifically, SEM is a powerful multivariate technique that is a specialized version of other analysis methods. It enables researchers in measurement of direct and indirect effects, it tests models with multiple dependent variables, and uses several regression equations simultaneously (Kline, 2005). SEM also allows researchers to handle difficult data (e.g., non-normal data, incomplete data). In addition, latent variables (versus observed variables) reduce vulnerability of the research to measurement error. In Study 2, for example, the use of more than a single measure to predict body fatness (i.e., %BF and BMI) and PA (i.e., pedometer and PAQ-C) likely reduced the effect of measurement error.

Limitations of the Thesis

Regardless of the several strengths of this thesis, which may have reduced some of the threats to internal and external validity (e.g., large, representative sample, longitudinal design), several limitations should be acknowledged. Studies 1 and 2 used a cross-sectional design; therefore, causal inference cannot be determined. Despite this nature of cross-sectional research,

we were able to test for mediations because we could articulate a temporal sequence for the variables (MacKinnon et al., 2007).

Another concern in this thesis was the measure of pubertal timing among boys. The onset of ejaculation was used to indicate pubertal timing for Studies 1 and 3. Though some earlier studies suggested semenarche as an alternative measure of pubertal timing to a direct measure (e.g., physical examination) (e.g., Carlier, & Steeno, 1985) and a significant psychological event associated with puberty (WHO, 2011) among boys, reliability and validity have not been established in recent years. The standard five-stage visual Tanner scale of sexual maturation classifies boys according to genital (i.e., testicular, penile) size and shape and pubic hair, which can be self-administered by adolescents who compare their bodies with drawings illustrating each stage. However, self-reported Tanner scale was not available in the KYRBS and KCYPS surveys.

The data were collected using self-reports except for the use of pedometer to measure PA in Study 2. Inaccurate recall and intra personal bias may have occurred. In particular, self-reports of puberty related events are likely sensitive topics for adolescents to report. Accordingly, the lack of validity and reliability testing for the single-item surveys on PA, SB, and pubertal timing are another limitation of Studies 1 and 3. In addition, the KYRBS and KCYPS surveys did not measure the actual sitting-time among participants. Instead, self-reported screen-time is used as a proxy for SB. Thus, our findings provide limited insight on the determinants of SB. Similarly, the questionnaire used to measure SB in Study 2 (ASAQ) does not correspond with the currently accepted definition of SB (SBRN, 2012). In addition, the amount of time spent in SB is likely under represents the actual sedentary time of the participants because the ASAQ does not consider other frequently used screen-based devices such as tablets.

The individual constructs of the psychosocial correlates of PA (i.e., sport competence, perceived barriers to PA, parental support, self-efficacy) in Study 2 and psychological well-being in Study 3 showed acceptable internal consistency except for the self-esteem measure in Study 3, thus, factor analysis and extraction of items were performed to improve its internal consistency to an acceptable level (as described in Chapter 6). Therefore, we can conclude that any error in statistical conclusions drawn is likely not due to this measure.

Relevance and Implications for Intervention and Policy

Before discussing the relevance of the three studies, it is important to mention that the results of Study 2 support the empirical evidence showing that PA and SB are two independent behaviours (Marshall, & Ramirez, 2011; Salmon et al., 2011). For example, the findings of Study 2 found no correlation between PA and SB among Korean girls. Physically active girls can also be sedentary, and physically inactive girls can also be less sedentary, therefore, increasing PA will not necessarily decrease the time spent in SB. Thus, interventions and programs to promote health among adolescents should treat PA and SB as two separate constructs.

Though biological maturation appears to have direct and/or indirect influence on PA, sex seems to play a critical role in PA participation among Korean adolescents. Studies 1 and 3 found that girls were significantly less active and more sedentary than boys. Sex differences in PA and SB among Korean children and adolescents have been observed in the majority of studies (e.g., Byun et al., 2012; Kang et al., 2005; Lee, 2011; Lee, & Spence, 2012). Providing more opportunities to participate in PA may increase girls' self-efficacy. The importance of promoting self-efficacy for PA among girls was emphasized in previous studies (e.g., Dishman et al., 2004; Dishman et al., 2010; Spence et al., 2010). In particular, Spence and colleagues (2010) suggested that the lack of opportunities to participate in PA, to have positive

experience through PA (e.g., mastery experience), and the tendency to experience injuries as a result of biological maturation may lead girls to report lower self-efficacy than boys. Though self-efficacy can change based on one's experience at any time of their life (Bandura, 1997), efforts to increase this attribute among girls may be the most effective when implemented before puberty. In addition, the findings from Study 2 suggest a negative direct relationship exists between pubertal status and PA among girls. Intervention strategies to promote PA should, therefore, take approaches that are based on biological maturation (e.g., timing, status) among Korean adolescent girls.

An indirect relationship between pubertal timing and screen-time through BMI was identified in Study 3 among boys. Overweight or obesity in male adolescents, combined with a relatively early pubertal timing, appears to make them likely to consume more screen-time. Perhaps preventive strategies to reduce obesity among male adolescents in Korea should be applied separately by pubertal timing. In addition, BMI and screen-time may have a reciprocal influence on each other. For example, reducing screen-time may positively contribute to BMI, and higher BMI may contribute to excessive screen-time. Therefore, these two physical and behaivoural factors should be considered complementary when developing health interventions among Korean boys.

Implications for educators, researchers, and health professionals

Findings from the three studies within this thesis have implications for educators, researchers, and health professionals. In the university setting, it is important to teach students who are majoring in physical education (PE) to be aware of the factors identified in this thesis when planning PE class particularly among girls. It is also important for graduate students and researchers in the field to recognize the influencing factors and pathways linking biological

maturation and behaviour when they develop local/provincial/national level school-based interventions. Health professionals can use the knowledge to prevent childhood obesity and the early onset of chronic diseases. Currently, preventive interventions or programs focus on increasing PA, however, most initiatives do not account for individual variances in psychosocial factors (e.g., self-efficacy, barriers to PA). Targeting the improvement of these factors may be important for further efforts aimed at increasing PA among Korean adolescent girls. For Korean boys, variances in body fatness should be taken into consideration when developing interventions to decrease screen-time.

Implications for education and public health policy

One of the mandates of the Korean government is to tackle deteriorating health among adolescents by increasing opportunities to participate in PA (Ministry of Culture, Sports, and Tourism, 2013). Such effort has been made by creating more opportunities to participate in PA/sports mainly in collaboration with schools (e.g., after-school organized team sports). Some of the potential individual- and family-level approaches to increase girls' PA were identified in Studies 2 and 3. For instance, perceived barriers to PA and self-efficacy, identified in Study 2, may be important to consider for future interventions and initiative among girls. However, it is important to note that changes in individual-level factors (e.g., body image, body dissatisfaction, feelings toward PA, enjoyment of PA) through interventions may not be the most effective in promoting long-term PA participation (Dishman, & Buckworth, 1996; Spence, & Dinh, 2015). In patriarchal societies such as Korea, there are clearly defined gender roles (Kim, 2014; Seo, & Lee, 2010; Won & Chung, 1999). For example, behavioural expectation towards girls in transition between childhood and adolescence (e.g., being modest, quiet, or docile) may prevent girls from becoming physically active regardless of their pubertal status or pubertal timing.

Gender inequality in coed PE classes has been consistently reported in Korean studies (Lee, Yoon, Jeon, & Spence, in press). In particular, psychosocial correlates of PA were higher among girls in girls-only class compared to those in coed class (Park, & Lee, 2011; Seo, Choi, & Kim., 2004). Therefore, interventions to promote PA among girls should incorporate the changes of higher level determinants of PA (Sallis, & Owen, 1997; Spence, & Lee, 2003). For Korean girls, providing more opportunities to PA in a supportive environment and reducing stereotypical gender roles in societal and cultural levels may further help to increase their participation in PA.

Though the Korean national curriculum has been revised seven times over the past 60 years, PE class is still considered as a minor subject within the competitive education system in Korea (Lee, & Cho, 2014). The deteriorating health among Korean youth may suggest the ineffectiveness of the PE curriculum (Lee, & Cho, 2014). The current government is attempting to tackle health problems among Korean youth through PE. However, this effort should be accompanied with overcoming fundamental issues associated with PE: limited availability of space and facilities in schools, in metropolitan cities in particular, and the continued implementation of the traditional PE curriculum (e.g., learning athletic activities such as soccer or basketball before the acquisition of basic physical literacy) (Lee et al., in press). The findings from Study 2 indicated that sport competence did not predict PA levels among Korean adolescent girls. This suggests that the current PE curriculum is not aligned with girls' own expectations towards PA and should be revised.

Information gained from this thesis may also inform public health policy in developing nation-wide interventions or programs aimed at increasing PA and reducing SB among Korean adolescents. In particular, the findings of three studies can provide important information in developing PA and SB guidelines for Koreans. Knowledge through research has to be translated

into practice and should be disseminated by knowledge users in various possible ways. However, the scarcity of scientific evidence associated with PA and SB specific to Korean context makes it difficult to develop an evidence-based policy. Therefore, directions for future research that could build on the current literature are outlined in the following section.

Recommendations for Future Research

This section outlines recommendations for future research to strengthen our understanding of the role of biological maturation on PA and SB and potential mediators and moderators in these relationships.

1. Little attention has been paid to examining the maturation-PA or the maturation-SB relationship among boys, mainly due to the lack of less invasive, reliable, and convenient measure of biological maturation. Though our study fills a gap, more research is needed to confirm the relationship between biological maturation and behaviour. It is recommended that national surveys including the KYRBS and KCYPS should adopt the self-reported Tanner scale to more accurately estimate pubertal status among Korean adolescents. This may also solve problems associated with the use of a single-item measure: (i.e., multiple items may reduce the measurement error from the lack of information gathered). Though this is a possibility, it is important to note that the self-reported Tanner scale is not the measure that "solves it all." The proportion of predicted adult stature at the time of study (Roche, Tyleshevski, & Rogers, 1983), and predicted maturity offset/PHV (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002), are the most common, and noninvasive maturation measures used in studies of PA and sport in recent years (Malina, 2014). Perhaps the percentage of predicted mature height attained at a given

age can also be used for the KYRBS and KCYPS surveys. However, validation of age at PHV among Korean children and adolescents should be done first.

2. The biocultural model of maturity-associated variance in adolescent PA (Cumming et al., 2012) outlines the potential mediators and moderators of the relationship between biological maturation and PA among adolescents. The majority of previous studies have focused on examining the role of physical self-concept. The studies within this thesis examined other potentially important factors (i.e., body fatness, perceived barriers to PA, parental support, self-efficacy) and identified their mediating roles on the relationship between biological maturation and PA. Replication of this study may help to confirm these relationships. As well as using the biocultural model (Cumming et al., 2012), ecological models could be incorporated (e.g., Spence & Lee, 2003) to specify interventions at individual-, family-, school-, environmental-, social-, and cultural levels.
3. Studies examining patterns, correlates, and determinants of SB among Korean adolescents are lacking, which makes it difficult to compare with adolescents in different countries or cultural groups. In a recent review of SB research among Korean youth (Lee, Spence, Hwang, Yi, & Jeon, 2015), only 15 papers were identified. These studies, which primarily focused on screen-time, have reported that screen-time is associated with factors such as age, sex, weight status, cardiometabolic and mental health, sleep time, dietary habits, PA, and delinquency behaviours. Additional research on adolescents' SB within representative samples of Korean adolescents are warranted to yield inferences specific to this population group. Intervention studies to decrease SB among Korean adolescents should be conducted

according to the best available evidence. A significant but small intervention effect to reduce SB in young people found in a meta-analysis also suggests that more evidence is needed to optimize intervention effects (Biddle, O'Connell, & Braithwaite, 2011). BMI acted as a mediator on the relationship between pubertal timing and screen-time among Korean boys in our study; however, one study cannot provide sufficient evidence for interventions.

4. Given that sex is more important predictor of the low level of PA than pubertal timing among Korean adolescents, in contrast to the previous findings from samples in Western countries (Cumming et al., 2008; Rodrigues et al., 2010; Sherar et al., 2007; Thompson et al., 2003), cultural factors preventing Korean girls from being physically active should be elucidated in future studies. For example, girls may have positive or negative experiences in PE class/PA depending on whether it is offered in co-education or single-sex education school. Therefore, future studies should examine potential higher level influences on PA. Perhaps girls' perception of teaching style of PE teachers, or the content of PE class, may act as a moderator of the relationship between maturation and PA.
5. With technological advances in Korea, Internet and smartphone addiction have been indicated as major public health concern (Kim, & Kim, 2014). The displacement hypothesis posits that the amount of time spent in screen-based activities compete with or be a substitute for social and physical activities (Ha et al., 2007; Heo et al., 2014; Jang et al., 2008; Park, 2014; Park et al., 2013). Though this hypothesis remains controversial, addictive Internet use consistently showed inverse associations with PA among Korean adolescents (Heo et al., 2014; Park, 2014). Given that the

amount time spent in screen-based activities increases and PA decreases during adolescence (Nadar et al., 2008), it may be possible that additive Internet or smartphone use may explain the relationship between maturation and PA in this particular cultural group.

Conclusions

Emerging evidence suggests that biological maturation may help researchers to better understand individual variations in PA and SB among children and adolescents. The three studies undertaken for this thesis make important contributions to the field. More specifically, the findings provide further evidence for the potential influence of biological maturation on adolescents' behaviour through mediators including body fatness, perceived barriers to PA, and self-efficacy. The mediating effect of BMI on the relationship between pubertal timing and screen-time among Korean boys found in this thesis also provided important empirical evidence to a relatively new area of research. This thesis also makes important contributions to the field in that Korean adolescents are an under-researched population. In summary, the findings highlight the importance of approaching adolescent behaviour from a biocultural perspective. Future studies should replicate this work using more valid measures of biological maturation, PA, and SB among Korean youth.

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Appendices

Appendix 1: Korea Youth Risk Behavior Web-based Survey (KYRBS) Study Design

Background

The Korea Children and Youth Panel Survey (KYRBS) is an annual, cross-sectional, nationwide school-based web survey that monitors health and health behaviours among Korean adolescents in Grades 7 to 12. The survey is administered by the KCDC in collaboration with the Ministry of Education, Science, and Technology and the Ministry of Health and Welfare. The first survey was conducted in 2005. The primary goal of KYRBS is to provide cross-sectional estimates of health and health behaviours of Korean adolescents for policy development and evaluation; a more comprehensive list of goals is available in the survey website (http://yhs.cdc.go.kr/). The public access data is located on the KYRBS website, and organized by year that survey occurred (e.g., 2011, 2012). All files are SPSS Xport Transport files and are specific to the year of measurement (e.g., the "_2012" in the file name list in the previous sentence indicates that this file is from the 2012 of KYRBS). Data files, along with corresponding documentation, can be downloaded from the website. Study 1 used data from the 2012 KYRBS survey.

Study Design

Sampling. KYRBS uses a two-stage probability sampling procedure to select a representative sample of the Korean adolescent population (KCDC, 2012). Korea contains seven self-governing cities (e.g., Seoul, Busan, Daegu, Incheon, Kwangju, Daejeon, Ulsan) and six provinces (e.g., Kyounggi, Kangwon, Choongcheong, Jeolla, Kyoungsang, Jeju), these 15 cities and provinces were categorized into 129 strata according to their metropolitan statistical area status (e.g., geographical accessibility, a number of schools, a number of people, smoking rate, drinking rate). Samples were selected to represent distributions of schools by size, type (e.g., basic sciences, specialized), and location. Specifically, a sample of students in Grades 7-12 who

attend general sciences and specialized school was produced and 400 middle schools and 400 high schools were proportionally allocated based on the geographical accessibility, number of schools and population in the area, living environment, smoking rate, and alcohol consumption rate. The classes of each school were randomly selected, if the selected class contained less than 60 students however, it was replaced with a class of a school that was geographically close and similar in type and size in the same stratum. As a result, a total 74,186 adolescents completed the online KYRBS questionnaire in 2012, representing 96.4% of eligible students invited to participate. Overall, the distribution of the 2012 KYRBS reflects the population (KCDC, 2012).

Data collection. Survey procedures were designed to protect students' privacy by allowing for anonymous and voluntary participation. Before survey administration, consent was obtained from the participating school boards, individual schools, and teachers, and local parental permission procedures were followed. Students completed the self-administered, web-based questionnaire during one class period (40-50 minutes). All surveys include a core set of questions that were supplemented with additional focus questions to gain further information on specific issues. The core information includes socio-demographic background (e.g., age, sex, socio-economic status), health behaviours (e.g., smoking, alcohol use, physical activity) and health outcomes (e.g., self-reported health, obesity). The KYRBS questionnaire is available at http://yhs.cdc.go.kr/ under permission from the website administrator. The KYRBS is de-identified data, thus ethics approval for secondary analysis of the KYRBS dataset was not necessary (KCDC, 2012).

The important health and health behaviours are divided into 18 categories:

1. Tobacco use;
2. Alcohol use;

3. Obesity and weight control;
4. Physical activity;
5. Dietary behaviours;
6. Injury prevention;
7. Violence;
8. Sexual behaviours;
9. Mental health;
10. Oral health;
11. Personal hygiene;
12. Athma (added in 2007);
13. Allergic Rhinitis (added in 2007);
14. Atopic dermatitis (added in 2007);
15. Internet use (added since 2008);
16. Drug use; and
17. Health equity (added since 2006).

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Appendix 2: Korea Youth and Children Panel Study (KYCPS) Study Design

Background

The Korea Children and Youth Panel Survey (KCYPS) is a panel study based at Korean National Youth Policy Institute (2010). The project was started in the year of 2010 and has conducted five waves of surveys in three age groups since then. The original respondents of this project include 7,017 students (2, 342 in the Grade 1 panel; 2,378 in the Grade 4 panel; 2,351 in the Grade 7 panel) as well as one of their parents. The goal of the comprehensive research design is to examine various aspects of interplay among family, school, community, which shape adolescents' growth and development based on an ecological framework (Bronfenbrenner, 1979).

The public access data is located on the NYPI data archives website, and organized by waves. Files are distributed in SAS, SPSS, and STATA formats. User's guides, data files, surveys, and coding books representing each wave can be downloaded from their website (https://archive.nypi.re.kr). Study 3 within this thesis used the Grade 7 panel of the KCYPS.

Study Design

Sampling. KCYPS used the multistage-stratified cluster method to select a representative sample of the Korean adolescent population. Using different criteria of the urbanization level, 16 cities and provinces were classified into 27 strata, and schools from 27 strata were selected based on probability proportional sampling. Classes and participants were then randomly selected from schools accepted to participate in the study. Schools rejected to participate were replaced to schools near by. For the fourth wave of the Grade 7 panel, 89.7% of participants at baseline (N= 2,108) participated in the survey (NYPI, 2014).

Data collection. The data has been collected from October to December each year.

Survey procedures were designed to protect students' privacy by allowing for anonymous and voluntary participation. Before survey administration, consent was obtained from the

participating school boards, individual schools, and teachers, and local parental permission procedures were followed. Students who participated in the survey at baseline, and who agreed to continue in the study were contacted via telephone at follow-up. After obtaining a verbal consent, research staff then had a face-to-face meeting with each student followed by an interview with caregivers to collect demographic information. According to the NYPI data user manual, incentives were provided to students who participated in each panel (NYPI, 2014).

All surveys include a core set of questions that were supplemented with additional focus questions to gain further information on specific issues. The areas of research are primarily divided into two categories: individual development and developmental environment. Individual development includes questions on physical development, cognitive development, psychosocial development, delinquency, and time use. Developmental environment includes questions on family environment, peer relations, educational environment, community, mass media, and extra-curricular activities. The KYRBS is de-identified data, thus ethics approval for secondary analysis of the KYRBS dataset was not necessary (NYPI, 2014).

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Appendix 3: Korea Youth Risk Behavior Web-based Survey (KYRBS) Relevant Questionnaire Items

Gender:

Are you male or female?

□ Male
□ Female

Age:

Which grade are you in?

□ Middle School Grade 1
□ Middle School Grade 2
□ Middle School Grade 3
□ High School Grade 1
□ High School Grade 2
□ High School Grade 3

Family economic status:

What is your household's economic status:
□ High
□ Middle-high
□ Middle
□ Middle-low
□ Low

Pubertal timing:

Which grade have you experienced semenarche (boys only)/menarche (girls only)?

□ Have not yet experienced
□ Before elementary school
□ Elementary School Grade 1
□ Elementary School Grade 2
□ Elementary School Grade 3
□ Elementary School Grade 4
□ Elementary School Grade 5
□ Elementary School Grade 6
□ Middle School Grade 1
□ Middle School Grade 2
□ Middle School Grade 3
□ High School Grade 1

□ High School Grade 2
□ High School Grade 3

Moderate-to-vigorous physical activity:

For the past seven days, how many days have you engaged in physical activity resulted in increases in heart rate or the shortness of breath for more than 60 minutes per day?

□ None
□ One day per week
□ Two days per week
□ Three days per week
□ Four days per week
□ Five days per week
□ Six days per week
□ Seven days per week

Sedentary behaviour:

For the past week (during weekdays; Monday to Friday), how many hours did you spent sitting while watching TV, playing game, Internet surfing, and chatting with friends per day (except for the amount of time spent in sitting for education purposes)?

□ Less than 1 hour per day
□ 1 – less than 2 hours per day
□ 2 – less than 3 hours per day
□ 3 – less than 4 hours per day
□ More than 4 hours per day

For the past week (on weekends; Saturday and Sunday), how many hours did you spent sitting while watching TV, playing game, Internet surfing, and chatting with friends per day (except for the amount of time spent in sitting for education purposes)?

□ Less than 1 hour per day
□ 1 – less than 2 hours per day
□ 2 – less than 3 hours per day
□ 3 – less than 4 hours per day
□ More than 4 hours per day

Appendix 4: Korea Youth and Children Panel Study (KYCPS) Relevant Questionnaire Items

Wave 2 (2011) – Students' report

Gender:

Are you male or female?

□ Male
□ Female

Age:

Which grade are you in?

□ Middle School Grade 1
□ Middle School Grade 2
□ Middle School Grade 3
□ High School Grade 1
□ High School Grade 2
□ High School Grade 3

Pubertal timing:

Which grade have you experienced semenarche (boys only)/menarche (girls only)?

□ Have not yet experienced
□ Between grades 1 and 3 in elementary school
□ Grade 4 in elementary school
□ Grade 5 in elementary school
□ Grade 6 in elementary school
□ Grade 1 in middle school (Grade 7)
□ Grade 2 in middle school (Grade 8)

Height and weight:

What is your current height in centimeters and weight in kilograms?

Height: ( ) centimeters.
Weight: ( ) kilograms.

Depression:

	Strongly agree	Agree	Disagree	Strongly disagree
1. I don't have much energy	□	□	□	□
2. I feel sad	□	□	□	□
3. I have a lot to worry	□	□	□	□
4. I want to kill myself	□	□	□	□
5. I cry often	□	□	□	□
6. I blame myself for everything bad that happens	□	□	□	□
7. I feel lonely	□	□	□	□
8. I have lost all of my interest in things	□	□	□	□
9. I feel the future is hopeless and that things cannot improve	□	□	□	□
10. I feel that everything is hard	□	□	□	□

Screen-time:

During this term (second term of 2011),

Q 1. How many hours have you spent in watching TV, videos, or dvds per day during leisure time?

During weekdays: ( ) hour and ( ) minutes
On weekends: ( ) hour and ( ) minutes

Q 2. How many hours have you spent in surfing the Internet or playing video games per day?

During weekdays: ( ) hour and ( ) minutes
On weekends: ( ) hour and ( ) minutes

Wave 2 (2011) – Parental report

Monthly household income:

In the last 12 months, can you tell me the total amount of monthly income of your house hold? (This includes income from all sources such as wages, salaries, Social Security or retirement benefits, help from relatives and so forth).

Korean Won (₩) ( )

Wave 3 (2012) – Students' report

Height and weight:

What is your current height in centimeters and weight in kilograms?

Height: ( ) centimeters.
Weight: ( ) kilograms.

Academic performance:

How satisfied with your academic performance?
□ Very satisfied
□ Satisfied
□ Dissatisfied
□ Very dissatisfied

Depression:

	Strongly agree	Agree	Disagree	Strongly disagree
1. I don't have much energy	□	□	□	□
2. I feel sad	□	□	□	□
3. I have a lot to worry	□	□	□	□
4. I want to kill myself	□	□	□	□
5. I cry often	□	□	□	□
6. I blame myself for everything bad that happens	□	□	□	□
7. I feel lonely	□	□	□	□
8. I have lost all of my interest in things	□	□	□	□
9. I feel the future is hopeless and that things cannot improve	□	□	□	□
10. I feel that everything is hard	□	□	□	□

Self-esteem:

	Strongly agree	Agree	Disagree	Strongly disagree
1. On the whole, I am satisfied with myself	□	□	□	□
2. At times, I think I am no good at all	□	□	□	□
3. I feel that I have a number of good qualities	□	□	□	□
4. I am able to do things as well as most other people	□	□	□	□
5. I feel I do not have much to be proud of	□	□	□	□
6. I certainly feel useless at times	□	□	□	□
7. I feel that I am a person of worth, at least on an equal plane with others	□	□	□	□
8. I wish I could have more respect for myself	□	□	□	□
9. All in all, I am inclined to feel that I am a failure	□	□	□	□
10. I take a positive attitude toward myself	□	□	□	□

Screen-time:

During this term (second term of 2011),

Q 1. How many hours have you spent in watching TV, videos, or dvds per day during leisure time?

During weekdays: ( ) hour and ( ) minutes
On weekends: ( ) hour and ( ) minutes

Q 2. How many hours have you spent in surfing the Internet or playing video games per day?

During weekdays: ( ) hour and ( ) minutes
On weekends: ( ) hour and ( ) minutes

Appendix 5: Ethics approval for Study 2

Notification of Approval

Date:	October 16, 2013
Study ID:	Pro00039992
Principal Investigator:	Eun Young Lee
Study Supervisor:	John Spence
Study Title:	Psychosocial correlates of the relationship between biological maturation and physical activity among adolescents
Approval Expiry Date:	October 15, 2014

Approved Consent Form:	Approval Date	Approved Document
	16/10/2013	3.2 Parent consent form (Korean)
	16/10/2013	3.2 Parent consent form

Sponsor/Funding Agency:	John Spence, University of Alberta

Thank you for submitting the above study to the Research Ethics Board 2. Your application has been reviewed and approved on behalf of the committee.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Approval by the Research Ethics Board does not encompass authorization to access the staff, students, facilities or resources of local institutions for the purposes of the research.

Sincerely,

Dr. Stanley Varnhagen

Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix 6-1: Participant assent form for Study 2 (English)

UNIVERSITY OF ALBERTA

Faculty of Physical Education and Recreation

P417 Van Vliet Centre
Edmonton, Alberta, Canada T6G 2H9

Title: Psychosocial correlates of the relationship between biological maturation and physical activity among adolescents

Investigators: Eun-Young Lee, MA, John C. Spence, PhD
P4-17 Van Vliet Centre, Faculty of Physical Education & Recreation,
University of Alberta, Edmonton, Alberta, T6G 2H9, (780) 492-2004

You are invited to participate in the study titled, "**Biological maturation and physical activity**". We want to learn what makes adolescent girls physically inactive. This is not part of your regular class work and is an optional activity.

The testing will take approximately 30 minutes and will take place at school. You will be asked your age and grade at school. You will also have your height, weight, and percent body fat measured.

Physical activity monitor

After the testing session some of you will be loaned an activity monitor. The activity monitor tells the number of minutes spent in light, moderate, or strenuous exercise. The activity monitor is to be worn each day for 7 days following the testing session. You will also be given a log to record the time each day that the monitor was attached and removed for the purpose of calculating activity time and sleeping time. You can return the monitor to us at school after the 7 days.

Questionnaires

You will be asked to fill out a questionnaire that assess factors affecting physical activity, if you have had your period, and if you have you will be asked to recall when it happened.

Risks and Benefits

There are no risks to participating in this study. You have the right to refuse to answer any question. You will have corrent information on your height, weight, and body fat percent. Also, we will provide a lecture on future academic career from the current university/graduate students of Yonsei University as a thank you for taking part in the research.

Keeping it Secret

Your test results will be kept secret and will not be shown to other people, unless you say so. The numbers for the entire group will be used in reports but your name will not be used. The data may also be published and presented at conferences; however, your identity will be kept confidential.

Right to Ask Questions and to Quit the Study

You can decide if you want to be in this study and you are free to get out of the study at any time and we will not be upset. Before you sign this form, do you have questions?

Consent

By signing this paper: I understand the study and the consent form I agree to be in the study.

Your signature	Date
Signature of person obtaining Assent	Date

Appendix 6-2: Participant assent form for Study 2 (Korean)

UNIVERSITY OF ALBERTA
Faculty of Physical Education and Recreation
P417 Van Vliet Centre
Edmonton, Alberta, Canada T6G 2H9

연구참여자 동의서

연구 제목: 성 성숙도와 사회심리적 요인, 신체활동과의 관계 조사

연구자: 이은영, MA, John C. Spence, PhD
P4-17 Van Vliet Centre, Faculty of Physical Education & Recreation,
University of Alberta, Edmonton, Alberta, T6G 2H9, (780) 492-2004
국내 연락처: 010-8873-1392

당신은 '성 성숙도와 사회심리적 요인, 신체활동과의 관계 조사' 연구의 참여자로 선정되었습니다.
본 연구는 왜 국내 여자청소년들의 신체활동량이 점점 감소하는지에 대해 알아보는 것이 목적입니다. 본 연구과정은 정규수업이 아니며, 본 연구에의 참여는 의무가 아닙니다.
본 연구의 자료 수집은 총 30 분 정도 소요될 것이며, 체육수업 시간을 이용하여 진행될 것입니다. 당신의 신장, 체중, 체지방량이 수집될 것이며, 언제 월경이 시작되었는지, 당신의 현재 신체활동량은 얼마나 되는지, 신체활동 관련 사회심리적 요인이 어떻게 되는지에 대한 질문에 답하게 될 것입니다. 또한, 신체활동 측정기를 앞으로 7 일 간 착용하도록 요구되어질 것입니다. 신체활동 측정기를 착용하는 기간 동안에는 매일 신체활동 기록지에 활동시간, 내용 등을 기록해야 하며, 측정기는 당신이 얼마만큼의 시간을 약한 강도, 중강도, 고강도 운동에 투자하는지 알려줄 것입니다. 측정기는 7 일 이후에 수집될 것입니다.

<u>예상되는 위험성과 이점</u>
본 연구진행 시, 예상되는 신체적, 심리적 피해는 없습니다. 본 연구를 통해 본인의 정확한 신장, 체중, 체지방량에 대한 정보를 얻을 수 있으며, 신체활동이 본인의 건강에 얼마나 중요한지 알게 될 것입니다.
<u>비밀 보장</u>
본 연구에서 수집된 자료는 연구자 이외에 다른 사람들은 볼 수 없을 것이며, 연구 결과는 국제학회 등에서 발표될 것이지만, 당신의 본명은 사용되지 않을 것입니다.
<u>연구에 대해 질문할 권리와 연구동의를 취소할 권리</u>
연구참여자는 언제라도 연구의 목적, 내용, 성격 등에 대해 질문할 권리가 있으며, 더이상 참여를 원하지 않을 경우 연구참여에의 동의를 취소할 권리가 있습니다.
<u>동의</u>
밑에 제공된 빈 칸에 서명함으로서, 본 연구에의 참여에 동의합니다.

Your signature	Date
Signature of person obtaining Assent	Date

Appendix 7-1: Parent and guardian consent form for Study 2 (English)

UNIVERSITY OF ALBERTA

Faculty of Physical Education and Recreation

P417 Van Vliet Centre
Edmonton, Alberta, Canada T6G 2H9

Title: Psychosocial correlates of the relationship between biological maturation and physical activity among adolescents

Investigators: Eun-Young Lee, MA, John C. Spence, PhD
P4-17 Van Vliet Centre, Faculty of Physical Education & Recreation,
University of Alberta, Edmonton, Alberta, T6G 2H9, (780) 492-2004

This Parent/Guardian Authorization form is being sent to you to obtain your permission in allowing your child to participate in the research study titled as above. This is an optional activity and is not part of the school curriculum. Please read this form carefully and feel free to ask any questions. The testing will be overseen by Dr. John Spence. For more information contact 000 at 0000/ Your participation in this project is greatly appreciated.

Purpose of the study

The participation in physical activity significantly decreases across adolescence particularly in girls. This study aims to explore some of the factors may influence girl's participation in physical activity.

Procedures

The testing will take approximately 30 minutes and will take place at a time convenient to the girls and will not disrupt school. Students will be asked their age and grade at school Height, weight, and percent body fat will be measured. The girls will be asked if they have had their menstrual period. If they have they will be asked to recall when, to the month and year, their first period occurred.

Physical activity monitor

After the testing session, some of the students will be loaned an activity monitor. The activity monitor tells the number of minutes spent in light, moderate, or strenuous exercise. Your child (if selected) is asked to wear the activity monitor each day for 7 days following the testing session. Your child will also be given a log to record the time each day that the monitor was attached and removed for the purpose of calculating activity time and sleeping time. Your child can return the monitor to us at school after the 7 days.

Questionnaires

Your child will be asked to fill out a questionnaire that assess factors affecting physical activity.

Potential Risks

Your child will not be subjected to any physical or psychological risk. You or your child may withdraw from the study for any reason, at any time, without penalty of any sort.

Potential Benefits

Participation of your child in this study may help researchers to better understand why girls become less active across adolescence. Information from this study has the potential to tailor physical activity interventions in the future. Lecture on future academic career from the current university/graduate students of Yonsei University will be given to students as a thank you for taking part in the research.

Storage of Data

All research material will be securely stored in the office of Dr. John Spence, at the University of Alberta, for a minimum five years post publication of the findings.

Confidentiality

The data from this study will be written as a Doctoral thesis. The data may also be published and presented at conferences; however, your child's identity will be kept confidential.

Right to Withdraw

Your child's participation is voluntary and she may withdraw from the study for any reason, at any time, without penalty of any sort. Should you decide to withdraw from the project, your child's information will be automatically deleted from the study and destroyed permanently.

Questions

If you have any questions concerning the study, please feel free to ask the research assistants at any time; you are also free to contact the researcher at 010-8873-1392 if you have questions at a later date. This study has been approved by the school's administration. This study has been also been approved on ethical grounds by the University of Alberta Research Ethics board on (date). If you have any questions or concerns regarding your rights as a participant, or how this study is being conducted, you may contact the University of Alberta's Research Ethics Office at 780-492-2615. This office has no affiliation with the study investigators. You may contact the researcher to find out the results of the study and a copy of the published manuscript can also be requested.

Consent form

My signature on this sheet indicates that I have received information regarding the nature of the study, its purpose, and procedures.

I will allow my child _____ , to participate in the study entitled Pubertal development and physical activity. My signature indicates that I understand the following:

1. I received information regarding the nature of the study, its purpose, and procedures. This research project was reviewed and approved on ethical grounds by the University of Alberta Advisory Committee on Ethics in Behavioural Science Research
2. Participation is totally voluntary; the participant (my child) has the right not to answer any or all of the questions, refuse any or all of the measurements and can withdraw from the study at any time without any fear of penalty.
3. If my child withdraws from the study then his/her data will be deleted.
4. There are no risks of psychological or physiological harm.
5. All individual data that is provided will remain confidential from sources outside of the study.
6. I will receive a summary of the project, upon request, following completion of the project.
7. I have read and understood the information provided in the cover letter, and have received a copy of that letter and the consent form for my records.

I _____ have read the above statements regarding the study and understand the conditions of _____(my child's) participation in this study.

Parent/Guardian's Signature _____ Date _____

Researcher's signature _____ Date _____

Appendix 7-2: Parent and guardian consent form for Study 2 (Korean)

UNIVERSITY OF ALBERTA

Faculty of Physical Education and Recreation

P417 Van Vliet Centre
Edmonton, Alberta, Canada T6G 2H9

부모 동의서

연구 제목: 성 성숙도와 사회심리적 요인, 신체활동과의 관계 조사

연구자: 이은영, MA, John C. Spence, PhD
P4-17 Van Vliet Centre, Faculty of Physical Education & Recreation,
University of Alberta, Edmonton, Alberta, T6G 2H9, (780) 492-2004
국내 연락처: 010-8873-1392

안녕하십니까,

'국내 여자 청소년의 성 성숙도와 사회심리적 요인, 신체활동과의 관계 조사' 연구의 진행을 위해 당신의 자녀를 본 연구에 초대하고자 합니다. 본 연구의 참여에 강제성은 없으며, 본인 혹은 부모님이 원하지 않으실 경우 참여하지 않으셔도 됩니다. 다음의 글을 읽고 연구의 윤리와 비밀 보장에 대한 사항을 확인해 주시기 바랍니다. 본 연구는 캐나다 University of Alberta 의 Dr. John Spence 의 지도 하에 진행될 것입니다.

<u>연구의 목적</u>

신체활동은 건강의 유지와 증진, 자기효능감과 자아존중감 증진에 큰 도움이 되는 것으로 알려져있습니다. 하지만, 국내 여자 청소년들의 신체활동량은 캐나다의 여자 청소년, 한국 남자 청소년에 비해 매우 낮습니다. 따라서, 본 연구는 어떠한 요인들이 국내 여자 청소년들의 신체활동 감소에 영향을 미치는지에 대해 밝혀내는 것을 목표로 하고 있습니다.

<u>연구과정</u>

본 연구는 총 30 분 정도 소여될 것이며, 최대한 학생들의 학업에 방해가 되지 않도록 체육시간에 연구를 진행하도록 할 것입니다. 모든 연구참여자들은 신장, 체중, 체지방량을 측정하게 될 것이며, 신체활동 관련 질문지에 답을 기입하도록 요구되어 질 것입니다. 또한, 연구시작과 동시에 7 일 간, 신체활동 측정기를 착용하게 될 것입니다.

<u>예상되어지는 위험성</u>

본 연구과정에서 당신의 자녀에게 미칠 수 있는 신체적, 정신적 위험은 없습니다. 하지만, 본인 혹은 부모님이 원하시면 언제라도 연구참여에서 제외될 수 있습니다.

<u>예상되어지는 이점</u>

본 연구를 통해 예상되어지는 이점은 다음과 같습니다.
- 본인의 정확한 신장, 체중, 체지방량에 대한 지식 습득
- 신체활동에 대한 올바른 정의와 신체활동의 중요성에 대한 정보 습득
- 후속연구에 중요한 기초자료 제공
- 국내 여자청소년들의 건강 증진을 위한 기초자료 마련

연구자료 보관

본 연구를 통해 수집된 자료는 캐나다 Dr. John Spence 의 연구실 향후 5 년 간 보관될 것입니다.

비밀 유지

본 연구를 통해 수집된 자료는 박사논문을 위해 활용될 것이며, 각 국제논문지와 국제학회에서 발표될 것입니다. 그러나 당신 자녀의 신분은 비밀로 유지될 것입니다.

연구참여 동의를 취소할 권리

모든 연구참여자는 이유에 상관없이 본 연구참여를 취소할 권리가 있습니다. 만약, 본 연구에 동의를 한 후, 참여를 취소하고 싶을 경우에는 언제라도 연구담당자에게 의사를 표해 주시기 바랍니다. 당신 자녀의 정보는 모두 영구 삭제될 것입니다.

질문

본 연구에 대해 궁금한 점이 있을 경우에는 연구자 이은영 (010-8873-1392)에게 주저말고 연락해 주시기 바랍니다. 본 연구는 캐나다 University of Alberta 와 연세대학교로부터 허가를 받았으며, University of Alberta 연구윤리위원회에서 연구윤리 허가를 받았음을 알려드립니다.
연구결과를 알고싶으실 경우에는 연구보조자에게 주저말고 연락을 주시기 바랍니다.

연구참여 동의서

연구의 목적, 성격, 과정을 이해하신 분들은 아래의 내용을 읽어보신 후, 연구에의 참여에 동의할 경우, 마련된 빈 칸에 서명하여 주시기 바랍니다.

나는 내 자녀 _____가(이) 본 연구에 참여하는 것을 동의하며, 아래의 내용을 이해합니다.

1. 나는 연구의 목적, 성격, 과정에 대한 정보를 받았으며, 이가 University of Alberta 연구윤리위원회에서 승인을 받았음을 이해합니다.

2. 본 연구에의 참여는 철저히 본인과 연구참여자 본인의 의사결정에 의한 것이며, 강제성이 없음을 이해합니다. 또한, 언제라도 원하지 않을 경우, 본 연구에의 참여를 취소할 수 있음을 이해합니다.
3. 만약 나의 자녀가 본 연구에의 참여를 원하지 않을 경우, 그 당시 수집된 모든 자료는 삭제될 것을 이해합니다.
4. 본 연구에서 예상되는 신체적, 정신적 피해는 없습니다.
5. 모든 연구참여자 각각의 자료는 비밀로 유지될 것입니다.
6. 요청에 한하여, 본 연구의 결과를 받아볼 수 있을 것입니다.
7. 위의 내용을 모두 이해하며, 기록용 연구참여 동의서 복사본을 받았음을 증명합니다.

나, _____, 는(은) 본 연구의 내용을 이해하며, 내 자녀, _____의 연구참여에 동의합니다.

부모/보호자 서명 _____ 날짜 _____

연구자 서명 _____ 날짜 _____

Appendix 8-1: Questionnaire for Parents for Study 2 (English)

Questionnaire for Parent(s)

As you consented to participate in the study on behalf of your child, I would like to obtain your sociodemographic information. This questionnaire will be kept confidential and will be destroyed after connecting the data of your child.

Please read the questions below, and answer correctly.

Your child's name

_____

Your relationship with your child

① Mom ② Dad

1. Please indicate the level of education of you and your spouse.

Your level of education	Your spouse's level of education
① Elementary school graduate or less	① Elementary school graduate or less
② Middle school graduate	② Middle school graduate
③ High school graduate	③ High school graduate
④ College or University graduate	④ College or University graduate
⑤ Graduate school and above	⑤ Graduate school and above

2. Please indicate your household income per year

_____ Won

3. Please indicate you and your spouse's height and weight.

You	Your spouse
Height (Cm)	Height (Cm)
Weight (Kg)	Weight (Kg)

Appendix 8-2: Questionnaire for parents for Study 2 (Korean)

학부모 설문지

연구참여 동의서에 동의하신 부모님에 한하여 다음의 질문을 읽고 답변해주시기 바랍니다.

연구참여 자녀 이름

_____

연구참여 자녀와의 관계

① 모 ② 부

1. 본인과 동반자의 학력은 어떻게 됩니까? (동반자 부재의 경우, 동반자의 학력은 답하지 않으셔도 됩니다)

본인	배우자
① 초등학교 졸업 혹은 이하	① 초등학교 졸업 혹은 이하
② 중학교 졸업	② 중학교 졸업
③ 고등학교 졸업	③ 고등학교 졸업
④ 전문대 혹은 4 년제 대학 졸업	④ 전문대 혹은 4 년제 대학 졸업
⑤ 대학원 졸업 이상	⑤ 대학원 졸업 이상

2. 가정의 일년 수입은 어떻게 됩니까?

_____ Won

3. 본인과 동반자의 체중과 신장을 기입하여 주시기 바랍니다.

본인	배우자
키 (Cm)	키 (Cm)
몸무게 (Kg)	몸무게 (Kg)

Appendix 9-1: Pedometer log sheet for Study 2 (English)

Physical Activity Monitor Information

Please:

- Wear the activity monitor for 7 full days
- Remove the monitor when you go to bed and put it back on when you get up
- During the 7 days you are asked to record when you put the monitor on in the morning and when you take it off in the evening
- (If you take the monitor off for any reason during the day) record the length of time it was off and the activity you were doing while it was off.
- Do not alter your normal physical activity behaviour while wearing the activity monitor – we are interested in your normal level of activity
- Remove the monitor for all water activities (e.g., showering, swimming)
- Keep the monitor fastened on the belt to reduce the chance of losing it, as these are expensive pieces of research equipment
- We will return to school in 7 days to collect the activity monitors. Please wear the monitor until we meet with you.
- If you have questions about the monitor please call Eun-Young at 010-8873-1392.

ID [ ] 학년과 반 [학년 반] 이름 [ ]

Date	Steps taken	Time worn	Time taken off	Time taken off	
				Time	Reason
EXAMPLE	8,552	7:15 am	10:55 pm	2:00 – 2:50 pm	Swimming
				6:00 – 7:00 pm	Bicycle
				9:00 – 9:30 pm	Shower
DAY 1					
DAY 2					
DAY 3					
DAY 4					
DAY 5					
DAY 6					
DAY 7					

Appendix 9-2: Pedometer log sheet for Study 2 (Korean)

신체활동 기록하는 방법

- 신체활동 측정기를 7 일 동안 연속으로 착용하여 주시기 바랍니다.
- 신체활동 측정기는 아침에 일어나자마자 착용하여 주시고, 잠자리에 들기 직전 빼주시기 바랍니다.
- 앞으로 7 일 동안 신체활동 측정기를 뺀 시간, 탈착 시간 등을 상세하게 기록해 주시기 바랍니다.
- 신체활동 측정기를 미착용할 시, 미착용한 시간, 장소 등을 상세하게 기록해 주시기 바랍니다.
- 저희가 알고싶은 것은 일상 생활 신체활동량이므로, 평상 시 신체활동량을 유지해 주시기 바랍니다.
- 수영, 샤워, 목욕 등에는 신체활동 측정기를 빼주시기 바랍니다.
- 당신이 사용하는 신체활동 측정기는 매우 비싼 기계입니다. 사용 시, 주의해 주시기 바랍니다.
- 7 일 후, 신체활동 측정기를 수집할 것입니다. 당일에도 신체활동 측정기를 착용하여 주시기 바랍니다.
-
- 질문이 있으시면 010-8873-1392 (담당자: 이은영) 로 연락하여 주시기 바랍니다.

ID [ ] 학년과 반 [학년 반] 이름 [ ]

날짜	스텝 수	착용한 시각 (기상 후)	뺀 시각 (취침 전)	미착용 시각과 그 이유	
				시각	이유
EXAMPLE	8,552	7:15 am	10:55 pm	2:00 – 2:50 pm	수영 (물놀이)
작성 예시				6:00 – 7:00 pm	자전거
				9:00 – 9:30 pm	샤워 혹은 설것이
DAY 1					
첫번째 날					
DAY 2					
두번째 날					
DAY 3					
세번째 날					
DAY 4					
네번째 날					
DAY 5					
다섯번째 날					
DAY 6					
여섯번째 날					
DAY 7					
일곱번째 날					

Appendix 10-1: Questionnaire for Study 2 (English)

Demographic Information

Name:_____ Age:_____

Grade:_____ Date of Birth:_____

Teacher:_____

Physical Activity Questionnaire for Children (PAQ-C)

We are trying to find out about your level of physical activity from ***the last 7 days*** (in the last week). This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing, and others.

Remember:
1.There are no right and wrong answers — this is not a test.
2. Please answer all the questions as honestly and accurately as you can — this is very important.

---

1. Physical activity in your spare time: Have you done any of the following activities in the past 7 days (last week)? If yes, how many times? (Mark only one circle per row.)

	No	1-2	3-4	5-6	7 times or more
Skipping ……	O	O	O	O	O
Rowing/canoeing ……	O	O	O	O	O
In-line skating ……	O	O	O	O	O
Tag ……	O	O	O	O	O
Walking for exercise ……	O	O	O	O	O
Bicycling ……	O	O	O	O	O
Jogging or running ……	O	O	O	O	O
Aerobics ……	O	O	O	O	O
Swimming ……	O	O	O	O	O
Baseball, softball ……	O	O	O	O	O
Dance ……	O	O	O	O	O
Football ……	O	O	O	O	O
Badminton ……	O	O	O	O	O
Skateboarding ……	O	O	O	O	O
Soccer ……	O	O	O	O	O
Street hockey ……	O	O	O	O	O
Volleyball ……	O	O	O	O	O

Floor hockey	……	O	O	O	O	O
Basketball	……	O	O	O	O	O
Ice skating	……	O	O	O	O	O
Cross-country skiing	……	O	O	O	O	O
Ice hockey/ringette	……	O	O	O	O	O
Other:						
( )	……	O	O	O	O	O
( )	……	O	O	O	O	O

2. In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)? (Check one only)

I don't do PE	.....	O
Hardly ever	.....	O
Sometimes	.....	O
Quite often	.....	O
Always	.....	O

3. In the last 7 days, what did you do most of the time *at recess*? (Check one only)

Sat down (talking, reading, doing schoolwork)	.....	O
Stood around or walked around	.....	O
Ran or played a little bit	.....	O
Ran around and played quite a bit	.....	O
Ran and played hard most of the time	.....	O

4. In the last 7 days, what did you normally do *at lunch* (besides eating lunch)? (Check one only)

Sat down (talking, reading, doing schoolwork)	.....	O
Stood around or walked around	.....	O
Ran or played a little bit	.....	O
Ran around and played quite a bit	.....	O
Ran and played hard most of the time	.....	O

5. In the last 7 days, on how many days *right after school*, did you do sports, dance, or play games in which you were very active? (Check one only)

None	.....	O
1 time last week	.....	O
2 or 3 times last week	.....	O
4 times last week	.....	O
5 times last week	.....	O

6. In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... O
1 time last week ..... O
2 or 3 times last week ..... O
4 or 5 times last week ..... O
6 or 7 times last week ..... O

7. *On the last weekend*, how many times did you do sports, dance, or play games in which you were very active? (Check one only.)

None ..... O
1 time ..... O
2 – 3 times ..... O
4 – 5 times ..... O
6 – 7 times ..... O

8. Which *one* of the following describes you best for the last 7 days? Read *all five* statements before deciding on the *one* answer that describes you.

A. All or most of my free time was spent doing things that involve little physical effort ..... O

B. I sometimes (1—2timeslastweek) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics) ..... O

C. I often (3—4times last week) did physical things in my free time ..... O

D. I quite often (5 — 6 times last week) did physical things in my free time..... O

E. I very often (7 or more times last week) did physical things in my free time .. O

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

	None	Little bit	Medium	Often	Very often
Monday	O	O	O	O	O
Tuesday	O	O	O	O	O
Wednesday	O	O	O	O	O
Thursday	O	O	O	O	O
Friday	O	O	O	O	O
Saturday	O	O	O	O	O
Sunday	O	O	O	O	O

10. Were you sick last week, or did anything prevent you from doing your normal physical activities? (Check one.)

Yes ..... O
No ..... O

If Yes, what prevented you? _____

The Adolescent Sedentary Activity Questionnaire

1. Think about a normal school week, and write down how long you spend doing the following activities before and after school each day. You can write fractions like 1⁄2 hour or 30 mins.

	Monday	Tuesday	Wednesday	Thursday	Friday
Watching TV?					
Watching videos/DVDs?					
Using the computer for fun?					
Using the computer for doing homework?					
Doing homework not on the computer?					
Reading for fun? Being tutored?					
Travel (car/bus/train)? Doing crafts or hobbies?					
Sitting around (chatting with friends/on the phone/chilling)?					
Playing/practicing a musical instrument?					

2. Think about a normal weekend, write down how long you spend doing the following activities on the weekend. You can write fractions like 1⁄2 hour or 30 mins.

	Saturday	Sunday
Watching TV?		
Watching videos/DVDs?		
Using the computer for fun?		
Using the computer for doing homework?		
Doing homework not on the computer?		
Reading for fun?		
Being tutored?		
Travel (car/bus/train)?		
Doing crafts or hobbies?		
Sitting around (chatting with friends/on the phone/chilling)?		

Playing/practicing a musical instrument?		
Going to church or Saturday school?		

A self-Administered Rating Scale for Pubertal Development

Introduction: The next questions are about changes that may be happening to your body. These changes normally happen to different young people at different ages. Since they may have something to do with your sleep patterns, do your best to answer carefully. If you do not understand a question or do not know the answer, just mark "I don't know."

Question	Response option	Point value
1. Would you say that your growth in height:	Has not yet begun to spurt	1
	Has barely started	2
	Is definitely underway	3
	Seems completed	4
	I don't know	
2. And how about the growth of your body hair? ("Body hair" means hair any place other than your head, such as under your arms.)		
Would you say that your body hair growth:	Has not yet begun to grow	1
	Has barely started to grow	2
	Is definitely underway	3
	Seems completed	4
	I don't know	
3. Have you noticed any skin changes, especially pimples?		
	Skin has not yet started changing	1
	Skin has barely started changing	2
	Skin changes are definitely underway	3
	Skin changes seem complete	4
	I don't know	
4. Have you noticed that your breasts have begun to grow?		
	Have not yet started growing	1
	Have barely started growing	2
	Breast growth is definitely underway	3
	Breast growth seems complete	4
	I don't know	

5a. Have you begun to menstruate (started to have your period)?

Yes	4
No	1

5b. If yes, how old were you when you started to menstruate?

_____ Year _____ Month

6. Please indicate the height of your parents.
Dad: _____ cm Mom: _____ cm

Physical Competence Scale

Below are several pairs of statements. Choose the statement that describes you the best, and then check whether it is really true for you or sort of true.

How I See Myself

1. Some kids do very well at all kinds of sports

   Really true for me □ Sort of true for me □

   BUT

   Other kids *don't* feel that they are very good when it comes to sports

   Sort of true for me □ Really true for me □

2. Some kids feel that doing well at athletics is important.

   Really true for me □ Sort of true for me □

   BUT

   Other kids *don't* think doing well at athletics is that important to how they feel about themselves as a person

   Sort of true for me □ Not true for me □

3. Some kids feel c*onfident* when it comes to doing vigorous physical exercise

   Really true for me □ Sort of true for me □

   BUT

   Other kids feel *uneasy* when it comes to doing vigorous physical exercise

   Sort of true for me □ Not true for me □

4. Some kids feel that having the ability to do a lot of running and exercising is *very* important to how they feel about themselves as a person

   Really true for Sort of true for

   BUT

   Other kids *don't* feel that it's all that important to have the ability to do a lot of running and exercising

   Sort of true for Not true for me

	me	me	me	
	□	□	□	□

5.	Some kids feel that they are good enough at sports		BUT	Other kids wish they could be a lot better at sports	
	Really true for me	Sort of true for me		Sort of true for me	Not true for me
	□	□		□	□

6.	Some kids think it's important to be good at sports		BUT	Other kids don't think how good you are at sports is that important	
	Really true for me	Sort of true for me		Sort of true for me	Not true for me
	□	□		□	□

Parental Support Scale

From mom per week	None	1-2	3-4	5-6	Daily
1. How often your parents encouraged you to do physical activity or sports?	□	□	□	□	□
2. How often have your parents done a physical activity or played sports with you?	□	□	□	□	□
3. How often your parents provided transportation to a place where you can do physical activities of sports?	□	□	□	□	□
4. How often your parents watched you participate in physical activities or sports?	□	□	□	□	□
5. How often have your parents told you that physical activity is good for your health?	□	□	□	□	□

From dad per week	None	1-2	3-4	5-6	Daily
1. How often your parents encouraged you to do physical activity or sports?	□	□	□	□	□
2. How often have your parents done a physical activity or played sports with you?	□	□	□	□	□
3. How often your parents provided transportation to a place where you can do physical activities of sports?	□	□	□	□	□
4. How often your parents watched you participate in physical activities or sports?	□	□	□	□	□
5. How often have your parents told you that physical activity is good for your health?	□	□	□	□	□

Perceived Barriers to Being Active

How likely are you to say?	Very likely	Somewhat likely	Somewhat unlikely	Very unlikely
1. My day is so busy now, I just don't think I can make the time to include physical activity in my regular schedule	□	□	□	□
2. None of my family members or friends like to do anything active, so I don't have a chance to exercise.	□	□	□	□
3. I'm just too tired after school to get any exercise.	□	□	□	□
4. I've been thinking about getting more exercise, but I just can't seem to get started	□	□	□	□
5. I don't get enough exercise because I have never learned the skills for any sport	□	□	□	□
6. I don't have access to jogging trails, swimming pools, bike paths, etc.	□	□	□	□
7. Physical activity takes too much time away from other commitments—work, family, etc.	□	□	□	□
8. I'm embarrassed about how I will look when I exercise with others.	□	□	□	□
9. I don't get enough sleep as it is. I just couldn't get up early or stay up late to get some exercise.	□	□	□	□
10. It's easier for me to find excuses not to exercise than to go out to do something	□	□	□	□
11. It's just too expensive. You have to take a class or join a club or buy the right equipment	□	□	□	□
12. My free times during the day are too short to include exercise	□	□	□	□
13. My usual social activities with family or friends to not include physical activity	□	□	□	□
14. I'm too tired during the week and I need the weekend to catch up on my rest	□	□	□	□
15. I want to get more exercise, but I just can't seem to make myself stick to anything	□	□	□	□
16. I'm not good enough at any physical activity to make it fun	□	□	□	□

Multidimensional Self-efficacy for Exercise Scale

How confident are you that you can…	0	10	20	30	40	50	60	70	80	90	100

…complete exercise using proper technique	□	□	□	□	□	□	□	□	□	□	□
…follow directions to complete exercise	□	□	□	□	□	□	□	□	□	□	□
…perform all of the required movements	□	□	□	□	□	□	□	□	□	□	□
…exercise when you feel discomfort	□	□	□	□	□	□	□	□	□	□	□
…exercise when you lack energy	□	□	□	□	□	□	□	□	□	□	□
…exercise when you don't feel well	□	□	□	□	□	□	□	□	□	□	□
…include exercise in my daily routine	□	□	□	□	□	□	□	□	□	□	□
…consistently exercise three times per week	□	□	□	□	□	□	□	□	□	□	□
…arrange schedule to include regular exercise	□	□	□	□	□	□	□	□	□	□	□

0% indicates "not confident at all" and 100% indicates "completely confident"

Appendix 10-2: Questionnaire for Study 2 (Korean)

ID [ ]

작성일 [월 일] | 소속학년과 학급 [학년 반] | 이름 [ ]

안녕하세요 여러분:

캐나다의 University of Alberta 와 연세대학교에서는 한국 여학생들을 대상으로 성 성숙도와 사회심리적 요소가 신체활동에 미치는 영향을 조사하고자 합니다. 여러분의 도움은 국제 및 국내 학계에 유용한 정보를 제공해 줄 것이며, 한국 여학생들의 삶의 질 향상 관련 정책에 기초자련을 마련해 줄 것입니다. 참여에 감사드리며, 다음의 설문에 답해 주시기 바랍니다.

설문지 기입 시, 다음의 사항을 기억해주세요.

- 첫째, 본 설문지의 질문들에는 정답이 없습니다. 본인이 생각하시는 그대로를 반영해주시면 됩니다.
- 둘째, 본 설문지 작성은 시험이 아닙니다. 하지만, 최대한 정직하고 정확하게 모든 질문에 답해주시기 바랍니다.
- 셋째, 질문이 있으실 경우에는, 주저 말고 연구관련 담당자들에게 질문하여 주시기 바랍니다.

답 작성 예) 모든 질문들에서 본인이 해당되는 사항의 □에 V 혹은 ■ 로 체크하여 주시기 바랍니다.

UNIVERSITY OF ALBERTA

YONSEI UNIVERSITY

I. Physical Activity (신체 활동) – 10 문항

본 설문은 당신의 지난 7 일 간의 신체활동 수준에 대해 알아보고자 합니다. 신체활동은 스포츠참여와 춤 등의 활동을 통해 땀을 흘리거나, 피로를 느끼는 것, 그리고 잡기놀이, 줄넘기, 달리기, 걷기, 등산과 같이 당신을 숨차게 만드는 모든 활동들을 포함합니다.

1. 쉬는 시간 신체활동: 지난 7 일 (지난주) 동안 당신은 아래의 활동 중 어떤 활동에 몇 번 정도 참여하셨나요?					
	안했음	1-2 번	3-4 번	5-6 번	7 번 이상
줄넘기	☐	☐	☐	☐	☐
인라인스케이트	☐	☐	☐	☐	☐
잡기놀이	☐	☐	☐	☐	☐
걷기	☐	☐	☐	☐	☐
자전거타기	☐	☐	☐	☐	☐
조깅/달리기	☐	☐	☐	☐	☐
산책	☐	☐	☐	☐	☐
에어로빅 운동	☐	☐	☐	☐	☐
수영	☐	☐	☐	☐	☐
야구/소프트볼	☐	☐	☐	☐	☐
축구	☐	☐	☐	☐	☐
농구	☐	☐	☐	☐	☐
배구	☐	☐	☐	☐	☐
춤	☐	☐	☐	☐	☐
배드민턴	☐	☐	☐	☐	☐
태권도/유도 등의 무도	☐	☐	☐	☐	☐
그 외 1. [ ]	☐	☐	☐	☐	☐
그 외 2. [ ]	☐	☐	☐	☐	☐

다음 장 계속…

2. 지난 7 일 동안, 체육 시간에 당신은 얼마나 활동적이었습니까?	
☐	**전혀 활동적이지 않았음**
☐	**거의 활동적이지 않았음**
☐	**때때로 활동적이었음**
☐	**자주 활동적이었음**
☐	**항상 활동적이었음**

3 – 4. 지난 7 일 동안, 당신은 학교에서 다음의 시간에 무엇을 하였습니까?			
3. 쉬는 시간		4. 점심 시간	
☐	**앉아 있었음 (수다, 독서, 숙제, 음악 감상 등)**	☐	**앉아 있었음 (수다, 독서, 숙제, 음악 감상 등)**
☐	**주위에 서 있거나, 걸어다님**	☐	**주위에 서 있거나, 걸어다님**
☐	**뛰어다니거나, 약간 활동적으로 놀았음**	☐	**뛰어다니거나, 약간 활동적으로 놀았음**
☐	**주위를 뛰어다니면서 활동적으로 놀았음**	☐	**주위를 뛰어다니면서 활동적으로 놀았음**
☐	**뛰어다니면서, 매우 활동적으로 놀았음**	☐	**뛰어다니면서, 매우 활동적으로 놀았음**

5 – 7. 지난 7 일 동안, 당신은 학교 밖에서 다음의 시간에 얼마나 많은 날 동안 매우 활동적인 스포츠나, 춤 또는 게임에 참여하였습니까?					
5. 방과 직후		6. 저녁 시간		7. 주말 중	
☐	없음	☐	없음	☐	없음
☐	한 번	☐	한 번	☐	한 번
☐	2-3 번	☐	2-3 번	☐	2-3 번
☐	4 번	☐	4 번	☐	4 번
☐	5 번 이상	☐	5 번 이상	☐	5 번 이상

8. 다음의 항목 중, 지난 7 일 동안의 당신의 신체활동(스포츠, 달리기, 수영, 걷기, 자전거타기 등) 을 가장 잘 묘사하는 것을 고르시오. 모든 다섯 문장을 읽은 후에, 자신을 가장 잘 묘사하는 문장 하나를 선택하여 주세요	
☐	**모든 또는 대부분의 자유 시간에 나는 신체활동을 거의 하지 않았다**
☐	**나의 자유 시간에 나는 때때로 (지난 7 일 중 1-2 번) 신체활동에 참여했다**
☐	**나의 자유 시간에 나는 자주 (지난 7 일 중 3-4 번) 신체활동에 참여했다**
☐	**나의 자유 시간에 나는 꽤 자주 (지난 7 일 중 5-6 번) 신체활동에 참여했다**
☐	**나의 자유 시간에 나는 매우 자주 (지난 7 일 중 7 번 혹은 그 이상) 신체활동에 참여했다**

9. 당신이 얼마나 자주 신체활동에 참여했는지 요일별로 표기하여 주세요.					
	없음	**매우 약간**	**중간**	**자주**	**매우 자주**
월요일	☐	☐	☐	☐	☐
화요일	☐	☐	☐	☐	☐

수요일	☐	☐	☐	☐	☐
목요일	☐	☐	☐	☐	☐
금요일	☐	☐	☐	☐	☐
토요일	☐	☐	☐	☐	☐
일요일	☐	☐	☐	☐	☐

10. 지난 주, 당신은 아팠습니까? 또는 당신이 평상시 신체활동을 못하도록 만든 어떠한 이유가 있었습니까?	
☐	네
	→ 이유:
☐	아니오

다음 장 계속…

II. Sedentary Behaviour (좌식 행동) – 10 문항

본 설문은 당신의 지난 7 일 간의 좌식행동 수준에 대해 알아보고자 합니다. 좌식행동은 신체의 큰 움직임을 요구하지 않는 활동으로, 주로 앉아서 하는 활동들을 의미합니다.

주중, 학교 이외의 시간, 즉 등교 전과 하교 후, 그리고 주말 앉아서 하는 활동에 소비한 시간이 어느 정도 되는지 적어주시기 바랍니다 (예시. ½ 시간 또는 30 분 등의 시간 단위로 작성)							
	월요일	화요일	수요일	목요일	금요일	토요일	일요일
텔레비전 시청							
영화/다큐멘터리 등 감상							
컴퓨터-인터넷 서핑							
컴퓨터-숙제							
숙제							
독서 혹은 과외							
산책							
자동차, 버스, 지하철 등을 이용한 장소 이동 혹은 취미생활							
앉아서 수다떨기/문자 질/전화통화							
악기 연주 및 연습							

다음 장 계속…

III. Pubertal Development (성 성숙도) – 5 문항

본 설문은 당신의 성 성숙 정도에 대한 조사입니다. 최대한 정확하게 자신의 상태를 반영해 주시기 바랍니다.

아래의 성장 및 성숙 관련 요인들 (키, 체모, 피부, 가슴) 에 대한 본인의 성숙 정도를 표기하여 주시기 바랍니다					
	아직 시작되지 않음	이제 막 시작됨	한참 진행 중	거의 다 끝나감	잘 모름
1. 신장 (키)	☐	☐	☐	☐	☐
2. 체모	☐	☐	☐	☐	☐
3. 피부	☐	☐	☐	☐	☐
4. 가슴	☐	☐	☐	☐	☐

당신은 초경 (첫 생리)을 경험하셨나요?	
☐	네
	‘네’ 라면, 언제 초경을 경험하셨나요? [년 월]
☐	아니오

다음 장 계속…

IV. Sport Competence (스포츠 유능감) – 6 문항

다음은 당신의 스포츠 유능감에 대한 질문들입니다. 1 번 부터 6 번까지 두 쌍의 글 들 중 본인을 가장 잘 묘사하는 쪽을 선택한 후, 매우 그런 편이다 혹은 그런 편이다 중 하나에 체크하여 주시기 바랍니다.

나를 가장 잘 묘사하는 쪽의 사항에 체크하여 주세요.				
1	모든 운동을 골고루 잘한다		모든 운동을 골고루 잘하지 못한다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다
2	운동을 잘 하는 것은 중요하다		운동을 잘하는 것은 그다지 중요하지 않다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다
3	격렬한 운동에 자신이 있다		격렬한 운동은 쉽지 않다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다
4	달리기와 격렬한 운동을 오래 그리고 많이 할 수 잇는 능력을 갖추는 것은 중요하며, 이는 자기 자신을 어떻게 생각하는 지에 반영된다		달리기와 격렬한 운동을 오래 그리고 많이 할 수 잇는 능력을 갖추는 것은 별로 중요하지 않다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다
5	운동은 충분히 잘한다고 생각한다		운동을 더 잘했으면 좋겠다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다
6	기술을 필요로 하는 개인 혹은 팀 스포츠를 잘 하는것은 중요하다		기술을 필요로 하는 개인 혹은 팀 스포츠를 잘 하는것은 그리 중요하다지 않다	
	☐ 매우 그런 편이다	☐ 그런 편이다	☐ 그런 편이다	☐ 매우 그런 편이다

V. Parental Support (지각된 부모지지) – 10 문항

다음의 문항은 신체활동과 관련하여 지난 일주일 간, 당신이 당신의 부모님으로부터 받는 지지 (support) 에 대한 질문입니다. 혹 아버님 혹은/그리고 어머님이 안계신 경우에는 작성하시지 않으셔도 됩니다.

1. 당신의 어머니는 지난 일주일 간 얼마나 자주…					
	없다	1-2 일	3-4 일	5-6 일	매일
신체활동 혹은 스포츠활동에의 참여를 얼마나 자주 권장합니까?	☐	☐	☐	☐	☐
당신과 신체활동 혹은 스포츠활동에 참여하였나요?	☐	☐	☐	☐	☐
당신을 신체활동 혹은 스포츠활동 참여장소로 데려다 주었나요?	☐	☐	☐	☐	☐
당신이 신체활동 혹은 스포츠활동에 참여하는 것을 지켜보았나요?	☐	☐	☐	☐	☐
신체활동이 건강에 좋다고 당신에게 말했나요?	☐	☐	☐	☐	☐
2. 당신의 아버지는 지난 일주일 간 얼마나 자주…					
	없다	1-2 일	3-4 일	5-6 일	매일
신체활동 혹은 스포츠활동에의 참여를 얼마나 자주 권장합니까?	☐	☐	☐	☐	☐
당신과 신체활동 혹은 스포츠활동에 참여하였나요?	☐	☐	☐	☐	☐
당신을 신체활동 혹은 스포츠활동 참여장소로 데려다 주었나요?	☐	☐	☐	☐	☐
당신이 신체활동 혹은 스포츠활동에 참여하는 것을 지켜보았나요?	☐	☐	☐	☐	☐
신체활동이 건강에 좋다고 당신에게 말했나요?	☐	☐	☐	☐	☐

다음 장 계속…

VI. Perceived Barriers to Being Active (신체활동 참여에의 장애요인) – 16 문항

다음의 문항은 당신이 신체활동에 참여하는 데에 방해가 되는 사항들에 대한 질문입니다. 왼쪽의 질문들을 읽고, 오른쪽의 선택사항 중 하나만 체크해주세요.

Perceived Barriers to Being Active				
	매우 그렇다	그렇다	그렇지 않다	매우 그렇지 않다
나는 너무 바빠서 일상스케쥴에 신체활동을 포함시키기 힘들다				
나의 가족 혹은 친구들 중 아무도 신체활동에 관심이 없고, 그래서 나는 운동할 기회가 별로 없다				
방과 후 너무 피곤해서 운동할 생각이 잘 들지 않는다				
운동을 더 하고 싶은데, 시작하기기 힘들다				
스포츠에 참여하기 위한 기술을 배운 적이 없기 때문에 충분한 운동을 하기 힘들다				
나는 조깅트랙, 수영장, 자전거 도로와 같은 곳과는 멀리 떨어져 살고 있다				
신체활동에의 참여는 가족, 친구, 혹은 학업에 투자할 수 있는 시간을 너무 많이 앗아간다				
다른 사람들과 신체활동을 할 때 내가 어떻게 보일지를 생각하면 창피하다				
나는 수면 시간 조차도 부족하다. 운동을 위한 시간을 내기 위해, 아침 일찍 일어나거나, 저녁 늦게 자는 것은 너무 힘들다				
운동을 하지 못하는 이유는 굳이 생각하지 않아도 많이 있다				
헬스클럽 등록이나 운동기구를 사는 것은 너무 비싸다				
하루 중 나의 자유 시간에 운동을 포함시키기에는 자유 시간이 너무 짧다				
가족, 친구들과 보통 즐기는 활동에 신체활동은 없다				
주중에는 너무 바쁘기 때문에 주말에는 그저 푹 쉬고 싶다				
운동을 더 하고 싶지만 꾸준히 실행하는 것은 너무 힘들다				
나는 운동에 재미를 붙일만큼의 소질이 없다				

VI. Exercise Self-efficacy (운동 자기효능감) – 9 문항

다음은 신체활동에의 참여를 방해하는 요인들의 목록입니다. 아래의 항목 중, 당신의 일상생활에서 신체활동에 참여할 수 있는 자신감 정도를 표시해주시기 바랍니다.

Physical Activity Self-efficacy										
나는 운동에(을)…	1	2	3	4	5	6	7	8	9	10
…요구되는 기술을 이용하여 완료할 수 있다.										
…정해진 방향에 따라 완료할 수 있다.										
…요구되는 움직임을 모두 수행할 수 있다.										
…조금 불편함을 느껴도 할 수 있다.										
…기력 (에너지)가 없어도 할 수 있다.										
…상태가 좋지 않아도 할 수 있다.										
…매일의 일상에 포함할 수 있다.										
…일주일에 세 번 실행할 수 있다.										
…포함하여 하루 일과를 계획할 수 있다.										

끝입니다. 설문에 응해주셔서 감사드립니다!
본 연구에 대해 궁금하신 점이 있을 경우에는 이은영 (elee2@ualberta.ca) 에게 연락주시기 바랍니다.