

THE LONGITUDINAL EXAMINATION OF BODY MASS INDEX AND
INTERNALIZING SYMPTOMS AMONG CANADIAN ADOLESCENTS

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Abstract

Child and adolescent overweight and obesity issues are a rising concern. The mental health correlates of weight issues for youth are gaining recognition within the literature. However, the cross-sectional literature indicates that the relationship between weight and mental health problems is unclear. Further, few longitudinal studies have been completed to date. Thus, the overarching goal of the present dissertation was to examine longitudinally the relationship between body mass index (BMI) and internalizing symptoms among Canadian youth (ages 10-17, $N = 6,987$, 50.6% boys) using Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY), cycles 4 to 8. In order to achieve the abovementioned goal, the dissertation is presented as two distinct studies. Given differences in the availability of measures based on age group, developmental trajectories were mapped from ages 10 to 15 and follow-up measures were analyzed for ages 16 and 17.

The first study focused on the relationship between the developmental trajectories of BMI and internalizing symptoms. This objective was achieved through a parallel-process growth curve analysis, whereby the latent variables (i.e., intercept, slope, and quadratic) of the growth curves of BMI and internalizing symptoms were regressed on one another to examine the relationships over time. Results indicated that there were gender differences in trajectories and in the relationships among trajectories. More specifically, the shape of the BMI trajectory among girls (i.e., linear) and boys (i.e., quadratic) differed, possibly reflecting gender differences in pubertal timing. Regarding the parallel-process analysis, among boys, factors of the BMI trajectory predicted

changes in the trajectory of internalizing symptoms. Among girls, there was a bidirectional relationship between BMI and internalizing symptoms.

As heterogeneity in BMI development exists, there may be groups of youth that are most vulnerable to problems. As such, the second study used growth mixture modelling to identify different trajectory classes of BMI. Then, the trajectories of internalizing symptoms and physical activity were modelled and plotted to explore patterns across classes. Three classes were found for both boys and girls: ‘normative,’ ‘increasing,’ and ‘decreasing’ classes. Demographic attributes such as socioeconomic status, pubertal status, parent health, and community setting, were examined as predictors of class membership. Significant attributes differed between boys and girls. For both boys and girls, youth in the ‘increasing’ classes demonstrated higher levels of internalizing symptoms and lower levels of physical activity compared to other classes. Findings highlight that gender differences exist in the relationship between BMI and mental health. Implications for research and practice are discussed.

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Introduction

Obesity and weight-related issues are a growing concern for Canadian children and youth with 19.8% of children and youth ages 5 to 17 considered overweight and 11.7% considered obese, based on the World Health Organization (WHO) standards (Roberts, Shields, de Groh, Aziz, & Gilbert, 2012). Further, secular trends suggest increases in prevalence rates over time among Canadian youth (Willms, Tremblay, & Katzmarzyk, 2003). The short- and long-term health consequences of obesity are numerous and notably include cardiovascular risk for disease, disability, diabetes, and premature death (Birmingham, Muller, Palepu, Spinelli, & Anis, 1999; Must, 1996; Reilly et al., 2003). The economic costs of obesity are also substantial, with an estimated burden to Canadians of 1.6 billion dollars a year in direct health care costs and another 2.7 billion in indirect costs (i.e., lost productivity, disability insurance, mental health problems, etc; Healthy Weight for Healthy Kids, 2007). Furthermore, overweight and obese children and adolescents are at risk of continuing to be overweight and obese into adulthood (Whitaker, Pepe, Wright, Seidel, & Dietz, 1998; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Consequently, the prevalence of adults' physical health problems and the economic costs to Canadians will continue to grow.

More recently, the social and psychological correlates of childhood overweight and obesity have gained recognition within the literature (see Zeller & Modi, 2008, for review). Not only do young Canadians who are overweight and obese face compromised physical health, but these youth are also at risk of experiencing mental health problems such as depression, anxiety, lower levels of self-esteem and self-concept, and lower

quality of life (Adams & Bukowski, 2008; Cornette, 2008; Eisenberg, Neumark-Sztainer, Haines, & Wall, 2006; Reilly et al., 2003; The Health of Canada's Young People: A Mental Health Focus, 2011; Zeller & Modi, 2008). For example, Reilly and colleagues (2003) conducted a systematic review of the physical and mental health costs of childhood obesity and concluded that "obese children are more likely to experience psychological or psychiatric problems than non-obese children" (pp. 748-749). However, the research regarding the link between overweight and obesity and various mental health outcomes for child and early adolescent populations is inconsistent (Lamertz, Jacobi, Yassouridis, Arnold, & Henkel, 2002; Wardle & Cooke, 2005; Wardle, Williamson, Johnson, Edwards, 2006; Zeller & Modi, 2008). Thus, the overarching goal of the present dissertation was to examine systematically the relationship between overweight and obesity, as assessed by body mass index (BMI), and mental health correlates, with a focus on internalizing symptoms, from late childhood into adolescence using a longitudinal, national Canadian sample. Within the present study, self-reported symptoms of anxiety and depression created the internalizing symptoms measure (Statistics Canada, 1995). More broadly, internalizing symptoms refer to problems which manifest within the individual (e.g., anxiety, depression; Achenbach, 1966). The manifestation of such problems are not typically evident externally.

The structure of the dissertation consists of several important components: a) a general introduction which provides the theoretical and a brief overview of the empirical basis upon which the research questions and hypotheses were made, as well as a brief discussion of the potential benefits of the research; b) two studies, each with their

respective relevant literature review, objectives and hypotheses, method, results, and discussion; and, c) a general discussion which provides an overview of the dissertation's main findings, directions for future research, and discussion of the critical implications of the research.

The present dissertation utilized data from Statistics Canada's National Longitudinal Survey of Children and Youth (NLSCY). Given that the present study employed secondary data analyses, two important issues warrant discussion at the outset. First, the NLSCY collected parent- and self-reported measurements of weight and height. BMI was calculated using the standard $\text{weight}(\text{kg})/\text{height}^2(\text{m})$ formula. The reliability of parent- and self-reported BMI measurement has been called into question (e.g., Phipps, Burton, Lethbridge, & Osburg, 2004). It has been noted that adult and adolescent self-reported BMI may be underestimated due to underestimations of weight but not of height, leading to conservative estimates of obesity (Phipps et al., 2004; Tremblay, Katzmarzyk, & Willms, 2002). However, there has been evidence that the bias inherent within self-reported measures of BMI is small with strong agreement between measured and self-reported BMI within a sample of adolescents ages 12 to 16 (Strauss, 1999). Further, when studying longitudinal trends over time, one would expect the same bias to be consistent over time (Phipps et al., 2004). In the present dissertation, BMI was used as a continuous variable, as opposed to classifications of BMI (e.g., Cole, Bellizzi, Flegal, & Dietz, 2000). The continuous variable has been suggested to be beneficial when studying changes over time (Phipps et al., 2004). However, international cut-offs for "overweight" and "obese" were used for describing the class-based BMI trajectories in the second

study (Cole et al., 2000). Cole and colleagues (2000) established specific age and sex BMI cut-offs for overweight and obese. Cut-off scores by age and sex were established using percentile curves that, at age 18, passed through the corresponding cut-off BMI scores of 25 kg/m² (overweight) and 30 kg/m² (obese) for adults (see Cole et al., 2000 for further details).

Second, in the NLSCY, different measures were collected based on the youth's age range. For example, the anxiety and emotional disorders subscale to assess internalizing symptoms was collected for youth ages 10 to 15 only. Further, the measure of depressive symptoms (12-item Centre for Epidemiologic Studies Depression Scale [CES-D]; Poulin, Hand, & Boudreau, 2005; Radloff, 1977) was collected for youth ages 16 and older. In addition, some measures (i.e., physical activity) were not available at older ages (16 and older). Thus, in order to maintain consistency in the present dissertation, all the developmental growth curve models were mapped from age 10 to 15. Measures collected for youth ages 16 and 17 were considered "follow-up" assessments.

In order to achieve the overarching goal of understanding the relationship between BMI and internalizing symptoms among Canadian youth, two sets of complex statistical analyses were employed. First, to examine the typical developmental trajectories of BMI and internalizing symptoms, the growth curve models of these constructs were mapped from late childhood until mid-adolescence (ages 10-15) for the full sample, and for both boys and girls separately. A parallel-process growth curve analysis was then employed to determine whether the BMI and internalizing trajectories were related to one another over time. As such, the trajectories were associated with one

another in a parallel-process analysis while controlling for socioeconomic status (SES), an important factor demonstrated to be associated with overweight and obesity (see Goodman, 2008 for review; Healthy Weight for Healthy Kids, 2007; Willms et al., 2003).

Not all adolescents develop in the same manner, specifically with regard to BMI (Kubzansky, Gilthorpe, & Goodman, 2012; Mustillo, Worthman, Erkanli, Keeler, Angold, & Costello, 2003). There may be groups of individuals with relatively homogeneous trajectories of BMI who are more vulnerable to mental health issues. Thus, the second component of the dissertation was to explore whether different classes of individuals with relatively homogeneous BMI trajectories could be identified using growth mixture modelling (GMM; Jung & Wickrama, 2008). This method also allowed the possibility of uncovering a nonlinear relationship between BMI and internalizing symptoms, such as might occur if both individuals with very low BMI and individuals with very high BMI are at risk for increased levels of internalizing symptoms. Then, the growth curve models of internalizing symptoms and physical activity for each of the classes were modelled to explore differences in these processes for individuals within the BMI classes over time. Physical activity was included in these analyses as it has been linked to mental health outcomes (Ahn & Fedewa, 2010; Camero, Hobbs, Stringer, Branscum, & Taylor, 2012) and is a major component in most prevention and intervention policies and strategies aimed to address childhood and adolescent weight problems (see Delamater, Jent, Moine, & Rios, 2008; Raynor, 2008 for reviews). Finally, parallel-process analyses between internalizing symptoms and physical activity were completed separately for each BMI class to determine whether BMI trajectory moderates

the relationship between physical activity and internalizing symptoms. This study provides a first look at the simultaneous developmental processes of BMI, internalizing symptoms, and physical activity from late childhood to mid-adolescence using a large, national sample of Canadian youth.

The present research was embedded within the developmental psychopathology perspective, which emphasizes a dynamic, interactive framework of studying psychopathology. Within this framework, individuals are thought to encounter numerous factors throughout the lifespan that have the potential to activate (i.e., risk and vulnerability factors) or protect against (i.e., protective factors) mental health problems (Cicchetti & Cohen, 1995). Given the developmental psychopathology context, the present dissertation examined the relationships between BMI and internalizing symptoms among children and youth. While conceptually it is important to understand the risk and protective nature of the study variables, the statistical basis necessary for determining true risk and protection (i.e., directionality and causality) could not be ascertained using the present data set. Instead, the dissertation provides evidence of the longitudinal relationships between BMI, internalizing symptoms, and physical activity as a first step in understanding these associations during late childhood and into adolescence.

Why Adolescence?

Adolescence is a particularly important stage in which to study the relationship between BMI and mental health issues, given the myriad of changes that occur during this developmental period. Below is a brief description of the physical, cognitive, and

socio-emotional changes that occur during adolescence that are particularly relevant to the present dissertation.

Physical development. The process that demarcates adolescence is pubertal development. Historically, gender differences in timing of puberty are consistent, with girls entering puberty approximately two years before boys (Tanner, 1962). The typical age ranges for pubertal development are 9.5 to 14.5 years for girls and 10.5 to 16 for boys (Marshall & Tanner, 1969; 1970). Further, secular trends suggest a decline in the age of menarche for girls (Harris, Prior, & Koehoorn, 2010). A bidirectional relationship between BMI and puberty has been implied, with higher BMI relating to earlier pubertal onset, particularly among girls (Arim, Shapka, Dahinten, & Willms, 2007; Biro, 2006; Davison, Susman, & Birch, 2003) and early puberty being related to higher susceptibility to overweight and obesity in adulthood (Harris et al., 2010). Other factors that have been associated with early pubertal timing include socioeconomic status (SES) and family factors (Arim et al., 2007). Early pubertal timing can have negative health consequences including earlier substance use, sexual activity, and mental health problems (Kaltiala-Heino, Kosunen, & Rimpelä, 2003). More specifically, and most relevant to the present dissertation, early pubertal timing has been linked to depressive symptomatology, with girls being more vulnerable than boys (Kaltiala-Heino, Kosunen, et al., 2003; Kaltiala-Heino, Marttunen, Rantanen, & Rimpelä, 2003). Given the observed associations between BMI and pubertal timing (Arim et al., 2007; Biro, 2006; Davison et al., 2003), children ages 10-11 were included in the present sample to investigate changes in BMI and internalizing symptoms in the midst of this important developmental process.

Further, physical activity has important implications for the physical and mental health of children and youth (Ahn & Fedewa, 2011; Camero et al., 2012) and is a major component of prevention and intervention strategies (see Delamater et al., 2008; Raynor, 2008 for review). However, physical activity levels typically decrease during adolescence, which may have important implications (McMurray, Harrell, Creighton, Wang, & Bangdiwala 2008). Given this decline in physical activity rates, adolescence is a valuable time to examine the longitudinal interplay between BMI, internalizing symptoms, and physical activity.

Cognitive development. Typically, individuals reach Piaget's formal operations stage of cognitive development during adolescence, a stage characterized by the ability for abstract thinking. Building upon Piaget's work, Elkind (1967) theorized the concept of the adolescent *personal fable*, such that adolescents are susceptible to thinking that others are as concerned about their physical appearance as themselves. Consequently, adolescents become more self-conscious, egocentric, and self- and body-evaluative during this stage (Elkind, 1967). Thus, it is not surprising that body image issues tend to emerge during adolescence, particularly among girls (Wertheim, Paxton, & Blaney, 2004). The cognitive vulnerability developmental framework (Abela & Hankin, 2008) posits that adolescents are particularly vulnerable to negative cognitions that can have implications for the development of mental health problems, with particular focus on depression and eating- and weight-related disturbances (EWRDs; Rawana, Morgan, Nguyen, & Craig, 2010). If an adolescent is overweight, or perceives himself or herself to be overweight, he or she may be more prone to various mental health issues including

depressive symptoms, self-esteem issues, and the development of eating disorders, as a result of the development of negative cognitions and affect related to their body or eating behaviours (Perrin, Boone-Heinonen, Field, Coyne-Beasley, & Gordon-Larsen, 2010; Rawana & Morgan, 2014; Rawana et al., 2010).

Socio-emotional development. Along with the aforementioned physical and cognitive considerations, socio-emotional development plays an important role in the relationship between weight and mental health during adolescence. Peer and intimate relationships become increasingly important for the developing adolescent (Brown, Eicher, & Petrie, 1986; Gavin & Furman, 1989). Peer victimization and stigmatization are common during this developmental stage, particularly among overweight and obese adolescents (Janssen, Craig, Boyce, & Pickett, 2004; Pearce, Boergers, & Prinstein, 2002). For example, Pearce and colleagues (2002) found that obese boys were more likely to experience overt victimization, whereas obese girls were more likely to experience relational aggression when compared to non-obese youth. The authors also found that obese girls were less likely to engage in typical dating behaviours (Pearce et al., 2002). Additionally, Storch, Milsom, Debraganza, Lewin, Geffken, and Silverstein (2007) found that peer victimization among overweight and obese youth was associated with internalizing and externalizing symptoms. Evidently, peer victimization among adolescents who are overweight or obese can not only deter typical developmental processes (i.e., dating), but have detrimental mental health consequences (Adams & Bukowski, 2008; Storch et al., 2007). Thus, adolescence may be a particularly important

time to study the relationship between BMI and internalizing symptoms to inform peer-based mental health preventive practices (Delamater et al., 2008).

With regard to emotional processes, mental health problems typically emerge during adolescence (Arnett, 1999; Kessler, Avenevoli, & Ries Merikangas, 2001) and have the potential to persist into adulthood (Lewinsohn, Rohde, Seeley, Klein, & Gotlib, 2003). For example, lifetime prevalence of depression dramatically increases during adolescence and a large percentage (i.e., 20 to 50%) of adolescents report experiencing some depressive symptoms (Kessler et al., 2001). Furthermore, adolescence is typically when gender differences in internalizing symptoms emerge, with girls having two to three times higher rates of depression compared to boys (Hankin, Wetter, & Cheely, 2008). These rates continue into adulthood (Hyde, Mezulis, & Abramson, 2008).

Gender considerations. Hyde and colleagues (2008) proposed a comprehensive model of depression to attempt to understand the gender differences that emerge around the ages of 12 to 13 and continue unto adulthood. Their model includes biological, affective, and cognitive vulnerabilities characterized by adolescence. Ample evidence exists supporting the notion that girls are more vulnerable to internalizing symptoms and disorders than boys (Galambos, Leadbeater, & Barker, 2004; Hankin et al., 2008; Hyde et al., 2008; Zarate, 2010). With regard to BMI, gender has been identified as a risk factor for psychological problems, with overweight and obese girls being the most vulnerable (Anderson, Cohen, Naumova, Jacques, & Must, 2007; The Health of Canada's Young People: A Mental Health Focus, 2011; Reilly et al., 2003). Thus, the development of BMI

among boys and girls is examined separately within the present dissertation to determine which processes and relationships are common to both genders and those that differ.

Research Questions

In sum, studying the interplay between BMI, mental health, and psychosocial factors during the adolescent developmental stage is critical. Understanding how and when relationships emerge should inform the development of effective prevention and intervention strategies for this population. Given the complexity of the research goals, the hypotheses and the method by which each of them were addressed (i.e., data analyses) can be found within their respective studies within this dissertation. Only the main research questions and a brief overview of the data set and methods are introduced below.

Study 1: Research questions. What are the developmental growth trajectories of BMI and internalizing symptoms from late childhood to mid-adolescence? Are these processes related to one another over time? Are there gender differences?

Study 2: Research questions. Are there different homogeneous subgroups of adolescents who follow different trajectories of BMI from late childhood to mid-adolescence? How do internalizing symptoms and physical activity differ among the subgroups? Do these associations vary by gender?

Data Set and Method

Adolescents ages 10 to 17 were selected from cycles 4 to 8 of the NLSCY. The NLSCY is a multi-informant, longitudinal, and nationally representative sample of children and youth. It was designed to measure various factors (e.g., social, emotional, and behavioural) that have the potential to influence a child's development (Statistics

Canada, 1995; see the Method section of Study 1 for further details on the NLSCY). The first wave of data collection occurred in 1994 and assessment continued biannually for eight waves. Cycles 4 to 8 were used in the present sample to provide the most recent trends in BMI and psychosocial development. The longitudinal nature of the NLSCY allowed for the examination of trajectories over time.

Growth curve modelling (e.g., Bollen & Curran, 2006) was used to identify the average trajectories of the main study variables (e.g., BMI, internalizing symptoms, and physical activity) from age 10 to 15. This statistical analysis provides estimates of the average latent variables of the trajectories (i.e., intercept, slope, and quadratic). The intercept provides the average level of an identified variable at age 10. The slope indicates the degree to which the trajectory increases or decreases from age 10 and the quadratic term indicates any changes in form of the trajectory (e.g., increasing, decreasing) across development. For Study 1, in order to examine the associations of the trajectories with one another, parallel-process analyses were employed. The latent variables of the trajectories were regressed on one another to study whether these processes were related to each other over time. For Study 2, growth mixture modelling (Jung & Wickrama, 2008) was used to identify homogenous classes (i.e., groups) of individuals with similar trajectories of BMI from ages 10 to 15. The internalizing symptoms and physical activity growth curves were then modelled by class to capture potential nonlinear relationships between the study variables. Descriptive statistics were completed using SPSS; all other analyses were completed using MPlus. The present

research was reviewed by Statistics Canada and the Social Sciences and Humanities Research Council to ensure that federal research ethics requirements were followed.

Implications

The present studies expand on the current literature by examining the relationships among the developmental trajectories of BMI, internalizing symptoms, and physical activity starting at age 10 and across adolescence using a national, longitudinal Canadian sample. The majority of previous research has utilized cross-sectional design or regression analyses with two data points (as discussed in further detail below). Thus, the prior research does not capture the complexity in the relationships among the variables during this developmental period. Results from the present studies address this gap in the literature and provide mental health researchers and clinicians with a more comprehensive model of the relationship between BMI and internalizing symptoms for adolescents. The findings highlight areas of resilience for these youth, which are critical for developing a constructive approach to address obesity and weight-related issues in this population. Further, understanding how physical activity is associated with these developmental processes informs the development of more effective prevention and intervention strategies to improve the physical and mental health of young Canadians.

Study 1: The Longitudinal Relationship Between Body Mass Index and Internalizing Symptoms: A Parallel-Process Analysis Among Canadian Youth

Child and adolescent overweight and obesity prevalence rates have been found to be 31.5% among Canadian youth ages 5 to 17 (overweight: 19.8%, obese: 11.7%; Roberts et al., 2012). Further, secular trends suggest that these estimates are on the rise (Tremblay et al., 2002; Willms et al., 2003). The psychosocial correlates of overweight and obesity have been highlighted within the childhood and adolescent mental health literature. For example, Reilly and colleagues (2003) conducted a systematic review of the physical and mental health costs of childhood obesity and concluded that obese children are at higher risk of experiencing psychological or psychiatric problems compared to non-obese children. Children and youth who are overweight or obese face compromised physical health, but are also hypothesized to encounter mental health problems, such as depression and anxiety, and lower levels of self-esteem and self-concept (Cornette, 2008; Reilly et al., 2003). However, the empirical research demonstrating the relationship between overweight and obesity and various mental health outcomes shows less consistent results among child and early adolescent populations (Lamertz et al., 2002; Wardle & Cooke, 2005; Wardle et al., 2006; Zeller & Modi, 2008). Thus, the primary objective of the present study was to investigate the relationship between overweight and obesity, as assessed using body mass index (BMI), and internalizing symptoms using a longitudinal, Canadian sample.

Adolescence

Adolescence is a particularly important time in which to study the relationship between BMI and internalizing symptoms, given the critical developmental processes occurring during this period, including physical (e.g., puberty), cognitive (e.g., abstract and egocentric thinking), and socio-emotional (e.g., peer relationships and mental health concerns) changes. For example, peers and intimate relationships become increasingly important during this developmental period and adolescents who are overweight or obese are at risk of peer teasing, stigmatization, and victimization (Janssen et al., 2004; Pearce et al., 2002), which can have negative mental health implications (Storch et al., 2007). Adolescence is also a time when youth become more body-evaluative and body image issues can arise. Further, associated related mental health symptoms, including internalizing symptoms, tend to surface (Arnett, 1999; Kessler et al., 2001; Wertheim et al., 2004). Thus, this may be a particularly important period within which to examine the relationship between BMI and internalizing symptoms to inform preventative and intervention practices.

Overview of the Cross-Sectional Literature

The link between obesity and depression for older adolescents and adults has been widely documented by systematic reviews and meta-analytic studies (e.g., Atlantis & Baker, 2008; Blaine, 2008; Luppiano et al., 2010). In general, these reviews provide evidence of a bidirectional relationship between obesity and depression for older adolescents and adults, with females being more at risk of experiencing depressive symptoms than males. However, the relationship between overweight and obesity and

various mental health outcomes has been documented less consistently within cross-sectional studies of child and early adolescent populations (Wardle & Cooke, 2005; Wardle et al., 2006; Zeller & Modi, 2008). For example, Wardle and Cooke (2005) reviewed studies using clinical and community-based samples investigating the relationships between childhood obesity and body dissatisfaction, self-esteem, and depression. Given that Wardle and Cooke (2005) found little to no association between obesity and self-esteem and depression for children and youth, the authors concluded that the relationship between obesity and these mental health outcomes is less substantiated for this population. In a subsequent research study, Wardle and colleagues (2006) examined the association between obesity and depression for two samples of adolescents and, again, found little to no association. The authors also found no moderating effects of hypothesized demographic variables (e.g., socioeconomic status [SES], ethnicity, gender). In contrast, a study which used the first wave of the Longitudinal Study of Adolescent Health (Add Health) data (youth ages 11 to 21) to examine the relationship between overweight status and depressive symptoms found that weight was associated with depressive symptoms for girls and that this association was stronger among younger adolescents (Needham & Crosnoe, 2005). The authors also found that dieting played an important role with regard to depressive symptoms for girls. Thus, although conclusions from review and meta-analytical papers suggest that children and youth who are overweight or obese experience some level of negative psychosocial impact (Cornette, 2008; Reilly et al., 2003), the cross-sectional research literature supporting these assumptions is inconsistent. Thus, longitudinal studies are required to improve

understanding of the directionality and underlying mechanisms of these potential relationships.

Longitudinal Studies

As previously discussed, the cross-sectional studies regarding the association between weight and mental health during late childhood and early adolescence are not consistent (Lamertz et al., 2002; Wardle & Cooke, 2005; Wardle et al., 2006; Zeller & Modi, 2008). Few longitudinal studies have examined the association between weight and mental health outcomes, with most utilizing regression analyses and two time points. From these studies, there is some evidence to support that weight status predicts subsequent internalizing symptoms (Anderson et al., 2007; Tiffin, Arnott, Moore, & Summerbell, 2011). For example, Anderson and colleagues (2007) conducted a longitudinal study of adolescent obesity and subsequent risk of development of major depressive disorder (MDD) and anxiety disorder. They found that obesity predicted an increased risk for MDD and anxiety disorders among girls, but not boys. The authors theorized that this relationship for girls is related to the increased social pressure for thinness in girls in Western society and speaks to studies of gender differences in body dissatisfaction, with girls being less satisfied than boys. Anderson and colleagues' (2007) study was unique in that it also included anxiety disorders as an outcome measure. The present study utilized a composite of internalizing symptoms that captured both depressive (i.e., low mood) and anxiety (i.e., worry) symptoms. Not only is this common practice within the literature (e.g., Goodman & Whitaker, 2002; Needham & Crosnoe,

2005; Wardle et al., 2006), but also childhood anxiety disorders and depression demonstrate considerable overlap with one another (King, Gullone, & Ollendick, 1990).

Some empirical support also exists for the relationship between internalizing symptoms and subsequent weight status (e.g., Goodman & Whitaker, 2002; Tanofsky-Kraff et al., 2006). For example, Goodman and Whitaker (2002) examined the bidirectional relationship between BMI and depressed mood using the Add Health data set. Adolescents from grades 7 to 12 were surveyed at baseline in 1995 and at one-year follow-up. Goodman and Whitaker (2002) found that obesity at baseline did not predict depressed mood (assessed using cut-off scores) at follow-up. The authors did, however, find that depressed mood independently predicted obesity one year later among youth who were non-obese and those who were obese at baseline. In contrast, Tanofsky-Kraff and colleagues (2006) also conducted a longitudinal investigation of whether depressive symptoms predicted body weight gain in a sample of children ages 6 to 12. These authors did not find evidence that depressive symptoms, nor disturbed eating attitudes, predicted body fat gain, but that binge eating and dieting did. Thus, it is evident that the literature surrounding the relationship between BMI and internalizing symptoms is conflicting. Further, regression analyses with two time points are common when researchers examine this relationship longitudinally, a method that is not optimal for examining potential relationships and processes that unfold over time (e.g., Bollen & Curran, 2006).

Longitudinal studies using growth-modelling procedures have typically examined the trajectories of either BMI or internalizing symptoms and their respective predictors separately. For example, BMI has been shown to increase linearly across adolescence

(e.g., Fuemmeler et al., 2012). This increase has been hypothesized to occur due to the physical changes associated with puberty and the growth spurt within this developmental period. In terms of internalizing symptoms, trajectories of depression and anxiety for this developmental stage have been mapped separately (e.g., Garber, Keiley, & Martin, 2002; Van Oort, Greaves-Lord, Verhulst, Ormel, & Huizink, 2009) and together as a composite of internalizing symptoms (e.g., Hussong, Flora, Curran, Chassin, & Zucker, 2008). With regard to depressive symptoms alone, developmental trajectories typically have a curvilinear trend across adolescence, increasing from early adolescence and leveling off or decreasing nearing late adolescence, again consistent with previous research (Garber et al., 2002).

Less work has examined trajectories of anxiety across adolescence; however, Van Oort and colleagues (2009) found that anxiety symptoms peak in early adolescence and decrease across mid-adolescence into late-adolescence. These authors hypothesized that this trajectory may be in part due to the pubertal and physical changes occurring during early adolescence and also the novelty and risk-seeking behaviours characteristic of later adolescence which promote autonomy and independence (Van Oort et al., 2009). Trajectories considering internalizing symptoms as a whole have shown that girls report relatively constant levels of internalizing symptoms across adolescence, whereas boys' levels decrease across time (Hussong et al., 2008). Although predictors of the BMI and internalizing symptoms trajectories have been examined, how each trajectory influences one another over time has yet to be determined but could offer important information regarding comorbidity. Consequently, the current research used sophisticated longitudinal

analyses of a Canadian sample of children and youth, with multiple data points over a longer period of time, to detect changes in relationships between BMI and internalizing over time. This was completed to help establish an advantageous developmental time interval when prevention and intervention strategies may be most beneficial.

Demographic Factors

Preliminary research suggests that gender and socioeconomic status may be important factors to the relationship between overweight and obesity and mental health outcomes, specifically depression (Wardle & Cooke, 2005). With regard to gender, girls have been shown to be more vulnerable to internalizing symptoms and disorders than boys (Galambos et al., 2004; Hankin et al., 2008; Hyde et al., 2008; Zarate, 2010). In terms of BMI in particular, gender has been identified as an important factor for psychological problems, with overweight and obese girls being most vulnerable (Anderson et al., 2007; The Health of Canada's Young People: A Mental Health Focus, 2011; Reilly et al., 2003). However, one paper reported an association between depression and chronic obesity in boys, but not girls (Mustillo et al., 2003). Thus, the development of BMI among boys and girls was examined separately within the present analyses to examine which processes and relationships are common to both genders and those that differ.

Another important factor to consider when examining the relationship between BMI and mental health is SES, as low SES can have a multitude of implications influencing both physical and mental health (see Goodman, 2008 for review; Goodman, Slap, & Huang, 2003). For example, Goodman and colleagues (2003) investigated the

impact of SES on physical (e.g., obesity) and mental (e.g., depression) health among adolescents. They found that low household income had adjusted population attributable risks of 32% and 26% for obesity and depression, respectively (i.e., adolescents with lower SES had significant increased risk of obesity and depression), concluding that low SES has considerable physical and mental health consequences among this population.

In general, demographic characteristics including gender and SES have been under-explored within the literature regarding BMI and mental health associations (Wardle & Cook, 2005). Further, the literature regarding these factors is not consistent, as one study found no evidence that gender or socioeconomic influenced the relationship between obesity and depression in two adolescent samples (Wardle et al., 2006). Thus, more research is necessary to clarify the potential role of gender and SES in the relationship between BMI and internalizing symptoms for adolescents.

Study 1: Objectives and Hypotheses

The present study aims to address some of the prominent limitations observed in the current literature. For example, the majority of the research is cross-sectional in nature and thus cannot capture the potential longitudinal associations between BMI and internalizing symptoms across adolescence. The longitudinal studies that do exist primarily used regression analyses with only two time points. Further, most studies use gender as a covariate, rather than examine the relationships separately by gender, which may allow for a detailed examination of the similarities and differences between boys and girls. Together, the existing literature highlights the importance of longitudinally examining the relationship between BMI and internalizing symptoms for children and

adolescents, among boys and girls, to illuminate these relationships to inform prevention and intervention practices.

As previously mentioned, the overarching goal of the current paper was to understand the relationships between BMI and internalizing symptoms in children and youth longitudinally (ages 10 to 17). In order to achieve this research objective, several complex longitudinal analyses were employed. First, the growth curve models of BMI and internalizing symptoms were mapped separately from late childhood until mid-adolescence (ages 10 to 15) for the full sample, and then for boys and girls separately, to examine the typical developmental and gender-specific trajectories of these processes during this important period. It was expected that BMI would increase linearly over time, consistent with previous research (Fuemmeler et al., 2012). It was expected that the trajectory of internalizing symptoms would remain relatively stable across adolescence among girls, but would decrease over time among boys (Hussong et al., 2008).

Second, the growth curve models of BMI and internalizing symptoms were then associated with one another in parallel-process analyses while controlling for SES (analyses explained in further detail within the results section). The parallel-process models were estimated to determine whether these processes (i.e., BMI and internalizing symptoms) were related to one another over time and also related to later assessment (at ages 16 and 17) of these parameters. Finally, gender differences were examined by completing the analyses separately for boys and girls to evaluate the similarities and differences among these relationships over time.

Method

Participants

Adolescents, ages 10 to 17, were selected from cycles 4 to 8 of the NLSCY (see below for details). The sample consisted of $N = 6,987$ (50.6% boys) youth at study entry (combined sample size of youth ages 10 and 11).

Data Set

The data set consisted of all adolescents (ages 10 to 17) from cycles 4 to 8 of Statistics Canada's NLSCY. The NLSCY is a comprehensive, longitudinal study of Canadian children (see Statistics Canada, 1995, for more detail). This survey included data across a number of domains of development gathered from early infancy to adulthood. Data were first collected in 1994/1995 (cycle 1) and data collection continued biannually until 2008/2009 (cycle 8). Children ages 0 to 11, their primary caregiver, and teachers participated in the first wave of the survey. The survey consisted of several important components, representing a comprehensive range of developmental factors: a) the child component completed by the person most knowledgeable (PMK) about the child; b) the adult component completed by the PMK; c) the self-report component completed by youth between the ages of 10 and 17; and d) the self-report component for youth over the age of 18. The PMK for the majority of the sample was the biological mother (90.2% of the full sample, 89.7% for boys only, and 90.8% for girls).

The NLSCY employed a multifaceted sampling procedure with participants (i.e., households) drawn from three possible sources. First, households with children ages 0 to 11 were selected from Statistics Canada's Labour Force Survey (LFS) using demographic

variables. Second, in partnership with the National Population Health Survey (NPHS), an additional sample was drawn with one individual randomly selected between the ages of 0 and 11 within each household. Third, given that the LFS excludes several populations (e.g., individuals living in the Yukon or Northwest Territories, individuals living in institutions, and individuals living on reserves) due to the sampling frame (Statistics Canada, 1995), the NLSCY and NPHS recruited another sample from the Yukon and Northwest Territories. Further, for the first cycle, up to four other children within the same economic family could also be randomly selected. Following cycle 1, due to response burden, a maximum of two children per household were followed for the remaining cycles.

The multiple cycles of the NLSCY provided data for estimating the current longitudinal models spanning late childhood across adolescence. The present project utilized data from cycles 4 to 8 to examine the most recent trends in BMI and mental health (i.e., within the past 15 years to limit potential cohort effects) and to provide generalizable and relevant findings. Essentially, all available data from children ages 10 to 17 from these cycles were utilized. For example, adolescents ages 10 and 11 in cycle 4 were ages 16 and 17 in cycle 7 and those ages 10 and 11 in cycle 5 were ages 16 and 17 in cycle 8, allowing the examination of developmental processes from late childhood through to mid- to late-adolescence. Given that data collection occurred every two years, these small intervals allowed the detection of distinct changes in BMI and mental health patterns over time. Such intervals may be indicative of appropriate periods in development in which interventions may be most effective. The five cycles of the

NLSCY were linked by age to form a common developmental trajectory across the ages of 10 to 17. Linking across age cohorts has been advocated as an appropriate approach in examining developmental trajectories over time (Duncan, Duncan, & Hops, 1996; Mehta & West, 2000; Miyazaki & Raudenbush, 2000).

Measures

Demographic characteristics. Several demographic variables from the PMK component of the survey were used for the present project, including the age of the child, the gender of child, estimated family income (used as estimate of SES), race of the child, child's country of birth, PMK's level of education, family composition, and size of the population of their present setting. Estimated family income was derived from an item from the PMK questionnaire, which asked the PMK to estimate the overall household income before taxes and deductions (Statistics Canada, 1995). In addition, a score for pubertal status was derived using three items from the NLSCY for boys and girls based on the Pubertal Development Scale (PDS; Petersen, Crockett, Richards, & Boxers, 1988). This measure was used only descriptively in the present study; for further details please see Study 2 in which this measure was utilized more systematically.

Body mass index (BMI). An individual's body mass index (BMI) was a main variable of the present study. BMI was calculated within the NLSCY using the standard BMI formula of $\text{weight}(\text{kg})/\text{height}^2(\text{m})$. Children ages 12 and older documented their own weight (kilograms) and height (metres) within the self-report component of the survey. The PMK reported the weight and height for children ages 10 and 11 years. In cycles 4 to 6 for parent-report measures of height, a discrepancy variable was present

within the data set. Parent-report of height was flagged if there was a discrepancy between present (e.g., cycle 5) and previous cycle (e.g., cycle 4) reports of child height (i.e., shrinkage). If a flag was present, the BMI score was omitted from the data set to limit response inconsistencies and potentially invalid parent-reports.

Internalizing symptoms. For participants ages 10 to 15, the seven-item anxiety and emotional disorder subscale of the Behaviours Checklist from the NLSCY was completed. This measure was based on items from the Ontario Child Health Study (Statistics Canada, 1995). The scale assesses an individual's feelings of distress and anxiety. Participants completed each item on a 0 (*never or not true*) to 2 (*often or very true*) scale, with higher scores indicating higher levels of internalizing symptoms. Sample items include; "I am not as happy as other people my age," "I am too fearful, nervous," and "I worry a lot." The seven items were used to create a total internalizing symptoms score ranging from 0 to 14. The scale demonstrated good reliability within the NLSCY data set (Statistics Canada, 1995). Within the present sample, the average coefficient alpha for this subscale was .78 across cycles 4 to 8.

Depressive symptoms. For participants ages 16 and 17, depressive symptoms were measured with a 12-item version of the Centre for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) created specifically for the NLSCY (Poulin et al., 2005). Participants were instructed to rate on a four-point scale how often in the past week they had experienced each symptom (i.e., item); the scale ranged from 0 (*rarely or none of the time*) to 3 (*most or all of the time*), with higher scores indicating higher levels of depressive symptoms. Sample items include; "I felt I could not shake off the blues

even with help from my family and friends,” “I felt that everything I did was an effort,” and “I felt depressed.” Rescaled total scores were calculated, providing a total depressive symptoms score ranging from 0 to 36. The scale has demonstrated good psychometric properties (see Poulin et al., 2005 for details). Within the present sample, the average coefficient alpha for this subscale was .83 across cycles 4 to 8.

Results

Descriptive Statistics

Demographic characteristics of the full sample (observed at ages 10 and 11; $N = 6,987$, 50.6% boys) and also by gender (boys $n = 3,537$, girls $n = 3,450$) can be found in Table 1. Independent t -tests and chi-square tests revealed no significant gender differences across any of the demographic variables ($ps > .05$). Descriptive statistics of the main variables of the study can be found in Table 2. At ages 10 and 11, boys had higher BMI scores than girls, $t(5,881.25) = 4.053$, $p < .001$. Initial pubertal status was higher for girls than boys, $t(4,142.74) = -9.234$, $p < .001$. There were no other gender differences across the study variables at study entry ($ps > .05$). Although initial levels of internalizing symptoms at ages 10 and 11 did not differ by gender, $t(4,586) = -1.077$, $p = .282$, girls had higher depressive symptoms scores on the CES-D at ages 16 and 17 than boys, $t(5,440) = -12.67$, $p < .001$.

A correlation matrix among the main study variables by gender can be found in Table 3. Among boys, correlations across the age groups ranged from .436 to .578 for BMI, .160 to .380 for internalizing symptoms, and .308 to .432 for physical activity. In general, correlations between BMI and internalizing symptoms were mostly positive (see

Table 3 for details), and correlations between BMI and physical activity as well as correlations between internalizing symptoms and physical activity were all negative. Among girls, correlations across the age groups ranged from .390 to .665 for BMI, .132 to .461 for internalizing symptoms, and .330 to .514 for physical activity. Correlations between BMI and internalizing symptoms were all positive for girls. Also, correlations between BMI and physical activity and between internalizing symptoms and physical activity were mainly negative (see Table 3).

Preliminary Growth Curve Analyses

Growth curve modelling (e.g., Bollen & Curran, 2006) was used during the preliminary analysis stage to examine the systematic changes for BMI and internalizing symptoms over time. These techniques were used to estimate linear and quadratic trajectories in these variables from late childhood to mid-adolescence (ages 10 to 15) for the entire sample, and for boys and girls separately. A number of fit statistics were used to evaluate the fit of each of the growth curve models, including the Bayesian information criterion (BIC), root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis index (TLI). Next, the parameter estimates of the means and variances of the latent growth factors (i.e., intercept, slope, and quadratic) were examined. In order to compare models and determine the model of best fit, two main criteria were considered. First, a decrease in BIC indicates a better fitting model. Second, the difference between the χ^2 statistic (χ^2 quadratic model - χ^2 linear model) was calculated. If the change in χ^2 was significant (using $df = df$ quadratic

model - *df* linear model), the quadratic model was considered to have better fit (Bollen & Curran, 2006).

Unconditional growth curve model of BMI. The quadratic model had the best fit for the full sample and among boys, whereas the linear model had the best fit for girls, as discussed below. The means and variances of the latent growth trajectory factors (i.e., intercept, slope, quadratic) are in Table 4, while Table 5 includes the covariances and correlations among the factors. Among the full sample, the BMI quadratic model best fit the data, $\Delta\chi^2(3) = 16.74, p < .001$, with overall fit statistics of BIC = 93,609.530 (linear model BIC = 93,599.002), RMSEA = .015, CFI = .996, and TLI = .994. The fitted growth curve and means can be reviewed in Figure 1. Overall, individuals' BMI increased after age 10, and then had steeper increases beginning around age 12.

Among boys, the quadratic model best fit the data, $\Delta\chi^2(3) = 23.86, p < .001$, with overall fit statistics of BIC = 46,724.017 (linear model BIC = 46,722.697), RMSEA = .012, CFI = .998, and TLI = .997. Similar to the full sample trajectory, among boys (Figure 2), BMI increased after age 10, and then had steeper increases beginning at age 12. In contrast to the overall sample and to boys, the linear model for BMI fit best among girls, $\Delta\chi^2(3) = .218, p = .975$, with overall fit statistics of BIC = 46,862.789 (quadratic BIC = 46,887.767), RMSEA = .015, CFI = .994, and TLI = .995. Among girls, levels of BMI increased steadily from ages 10 to 15 (Figure 2).

Unconditional growth curve model of internalizing symptoms. The quadratic model had the best fit to the data for all three samples, as discussed below. Tables 6 and 7 present the unconditional quadratic growth curve model estimates for the full sample and

for boys and girls separately. With the full sample, the internalizing symptoms quadratic model best fit the data, $\Delta\chi^2(3) = 71.28, p < .001$, with overall fit statistics of BIC = 85,371.759 (linear model BIC = 85,415.743), RMSEA = .006, CFI = .999, and TLI = .999. As seen in Figure 3, individuals' internalizing symptoms decreased after age 10, and then began to increase roughly around age 13. Among boys, the quadratic model best fit the data, $\Delta\chi^2(3) = 31.89, p < .001$, with overall fit statistics of BIC = 41,550.570 (linear model BIC = 41,557.240), RMSEA = .020, CFI = .989, and TLI = .983. Boys' scores on the internalizing symptoms measure decreased after age 10, and then began to level off from ages 13 to 15 (Figure 4). The quadratic model for internalizing symptoms also fit the data best among girls, $\Delta\chi^2(2) = 32.70, p < .001$, with overall fit statistics of BIC = 43,361.366 (linear model BIC = 43,377.259), RMSEA = .031, CFI = .976, and TLI = .971 for the quadratic model. Among girls, levels of internalizing symptoms decreased in late childhood, but began increasing at age 12 (Figure 4).

Given that for both boys and girls the quadratic model best fit the data, it was reasonable to test gender differences across the intercept, slope, and quadratic factors by regressing these factors on gender using the full sample data. Gender was not related to the intercept of the internalizing symptoms trajectory, $b = -.138, SE = .095, p = .145$, suggesting that boys and girls have similar levels of internalizing symptoms at age 10. However, gender was related to the slope factor, $b = .332, SE = .076, p < .001$, indicating that girls had less steep decreases in internalizing symptoms scores at age 10 than boys (see Figure 4). Gender was not associated with the quadratic factor, $b = .002, SE = .014, p$

= .897, indicating that the curvature (i.e., the degree of change in the direction of the trajectory) was similar among both boys and girls.

Parallel-Process Analysis of BMI and Internalizing Symptoms

Preliminary growth model analyses with SES. Preliminary analyses regressed the latent factors of the BMI and internalizing symptoms trajectories on initial levels of SES; the observed BMI and CES-D scores at ages 16 and 17 (ages combined) were also regressed on initial levels of SES. Of note, SES was transformed (each score divided by 10,000) to improve interpretation and also to have comparable variance scales to the other measures in the model, which facilitated estimation convergence. Among boys, SES was related to initial levels of BMI, $b = -.071$, $SE = .017$, $p < .001$, and to BMI at ages 16 and 17, $b = -.072$, $SE = .019$, $p < .001$ (see Table 8), indicating that higher levels of SES were associated with lower BMI scores at age 10 and again at ages 16 and 17. SES was not related to the BMI slope and quadratic factors ($ps > .05$), suggesting that the change in BMI over time was consistent across levels of SES. In terms of the internalizing symptoms trajectory for boys, SES was not related to any of the trajectory factors nor depressive symptoms at ages 16 and 17 ($ps > .05$; see Table 8).

Similar to the results for boys, among girls, SES was related to initial levels of BMI, $b = -.056$, $SE = .016$, $p < .001$, and to later BMI at ages 16 and 17, $b = -.066$, $SE = .020$, $p = .001$ (see Table 8), indicating that higher levels of SES were associated with lower BMI scores at age 10 and again at ages 16 and 17. SES was not related to either the slope or quadratic terms of the BMI trajectory, indicating that trajectories were consistent across SES. In contrast to the results for boys, among girls, SES was associated with

initial levels of internalizing symptoms, $b = -.057$, $SE = .015$, $p < .001$, and with depressive symptoms at ages 16 and 17, $b = -.121$, $SE = .037$, $p = .001$, suggesting that higher levels of SES were related to lower levels of initial internalizing symptoms and depressive symptoms in mid-adolescence. Again, SES was not related to changes in internalizing over time (slope and quadratic $ps > .05$).

Parallel-process analyses. In order to examine the reciprocal relationships between the growth curve models of BMI and internalizing symptoms from late childhood to mid-adolescence, two sets of analyses were completed. First, the latent factors (i.e., intercept, slope, quadratic) of the internalizing symptoms trajectory from ages 10 to 15 were regressed on the parameters of the BMI trajectory from ages 10 to 15. Further, depressive symptoms in later adolescence, as assessed by the CES-D at ages 16 and 17, were regressed on the factors of the BMI trajectory to assess whether the BMI trajectory factors were associated with later depressive symptoms. These analyses essentially examined whether BMI trajectories predicted internalizing trajectories and later CES-D scores. Second, the factors of BMI trajectory from age 10 to 15 and BMI at ages 16 and 17 were regressed on the factors of the internalizing symptoms trajectory. In general, these analyses examined whether internalizing symptoms predicted BMI trajectories and later BMI scores. These analyses were completed separately for boys and girls, given the differences in the trajectory shape of BMI by gender. Given the aforementioned results involving SES, all of the analyses included SES as a covariate to obtain partialled effects over and above the influence of SES.

Boys. Table 9 presents the parallel-process analysis results of the internalizing symptoms trajectory and later depressive symptoms regressed on the BMI trajectory parameters, accounting for initial SES. Initial level of BMI at age 10 was associated with the initial slope, $b = .045$, $SE = .012$, $p < .001$, and quadratic, $b = -.009$, $SE = .003$, $p < .001$, factors of the internalizing symptoms trajectory, such that higher initial levels of BMI related to less steep decreases in internalizing symptoms at age 10 (initial slope effect) and also steeper increases (quadratic effect) in internalizing symptoms over time. There were no other significant relationships among these variables, such that *changes* in BMI were not associated with changes in internalizing symptoms or later depressive symptoms as assessed by the CES-D. The parallel-process analysis results of the BMI trajectory and later BMI regressed on the internalizing symptoms trajectory parameters, accounting for initial SES, can be found in Table 10. The internalizing symptoms trajectory factors did not predict any of the BMI trajectory factors nor BMI scores in mid-adolescence (see Table 10).

Girls. The parallel-process analyses results for girls are in Tables 11 and 12. Similar to boys, initial level of BMI was associated with the slope, $b = .074$, $SE = .019$, $p < .001$, and quadratic, $b = -.012$, $SE = .004$, $p = .003$, factors of the internalizing symptoms trajectory. Higher initial levels of BMI related to less steep decreases in internalizing symptoms at age 10 (initial slope effect) and also steeper increases in internalizing symptoms (quadratic effect) among girls. Furthermore, increases in BMI at age 10 (slope effect) were associated with higher levels of depressive symptoms at ages 16 and 17, $b = 1.515$, $SE = .476$, $p = .001$. In contrast to the results for boys, higher initial

levels of internalizing symptoms among girls were associated with both steeper increases in BMI at age 10 (initial slope effect; $b = .019$, $SE = .008$, $p = .015$), and also higher BMI at ages 16 and 17 ($b = .230$, $SE = .057$, $p < .001$; Table 12). Changes in internalizing symptoms over time were not associated with BMI at ages 16 and 17. Together, these findings partially support a bidirectional relationship between BMI and internalizing symptoms from ages 10 to 17 among girls.

Discussion

Overview Study 1 Findings

The present study aimed to examine the complex relationship between BMI and internalizing symptoms longitudinally among Canadian youth. First, the developmental trajectories of BMI and internalizing symptoms were examined and important gender differences were found. For example, the functional form (i.e., linear vs. quadratic) of the trajectory differed between boys and girls. Further, although boys and girls had similar levels of internalizing symptoms at age 10, girls developed higher levels of internalizing symptoms than boys consistently over time. With regard to examining the parallel-process of these developmental trajectories, important gender differences emerged, with evidence to support a bidirectional relationship between BMI and internalizing symptoms among girls, whereas only initial BMI predicted the internalizing trajectory for boys. Finally, girls from lower SES families may be most vulnerable to internalizing symptoms compared to those from higher SES families. These differential patterns among trajectories and processes have important implications for the development of effective

prevention and intervention programs and potential policy change. Each of the main findings and its implications are discussed below.

Growth Models of BMI and Internalizing Symptoms

The finding that the shape of the BMI trajectory among boys (quadratic) and girls (linear) differs has important implications. The difference in trajectories is hypothesized to be related to gender differences in pubertal development. Namely, girls enter puberty approximately two years prior to boys (Tanner, 1962). This age discrepancy in pubertal onset could explain why the BMI trajectory for girls increased from age 10 (i.e., girls enter puberty before or at age 10) whereas boys had a slight increase after age 10, but had steeper increases in BMI starting at age 12. These findings suggest that future research should account for gender differences in BMI during late childhood and early adolescence.

In terms of internalizing symptoms, the finding that boys and girls have similar levels of internalizing symptoms at age 10, but the trajectory among boys declined from age 10 whereas the trajectory among girls remained elevated is consistent with previous literature (Galambos et al., 2004; Hankin et al., 2008; Hussong et al., 2008; Hyde et al., 2008; Zarate, 2010). For example, using a comprehensive model of depression, Hyde and colleagues (2008) found that gender differences typically emerge around ages 12 and 13. This finding may have important clinical implications in that late childhood and pre-adolescence (before ages 12 to 13) may be a critical period for prevention practices among girls.

Consistent with hypotheses and previous research, SES was significantly associated with the BMI trajectory of both boys and girls, where youth with higher levels of SES had lower levels of BMI from ages 10 to 17 compared to youth with lower SES, a finding consistent with previous research (Goodman, 2008; Goodman et al., 2003). This finding is likely multifaceted, as proposed by Goodman (2008), such that youth with lower levels of SES may have poorer quality of food, less family structure and supervision at meal time, poorer knowledge regarding nutrition, and fewer scheduled exercise appointments (e.g., swimming, hockey, dance, etc.). SES was not significantly related to the internalizing trajectory of boys but the estimated effect was in the same direction. This finding may partially be attributed to the lower levels of internalizing symptoms among boys within a normative sample in general. This finding suggests that girls from low SES background may be most vulnerable to the development of internalizing symptoms. Future research would benefit from an examination of the mechanisms underlying this gender difference.

Parallel-Process Analyses

The parallel-process analyses were undertaken to examine the relationships between BMI and internalizing symptoms over time and to identify potential gender differences and potential key periods during which intervention may be most appropriate. BMI was associated to the trajectory of internalizing symptoms similarly among boys and girls. For boys, higher initial level of BMI at age 10 was associated with less steep decreases of internalizing symptoms from age 10 and steeper increases in symptoms over time. These findings are in contrast to the Anderson and colleagues' (2007) study that

found that the relationships between BMI and MDD and anxiety disorders were only present among girls. This discrepancy may be related to the fact the present study utilized internalizing symptoms as a continuous measure and did not use clinical diagnosis as an outcome. Using the Add Health data, Goodman and Whitaker (2002) did not find a moderating effect of gender between BMI and depressive symptoms when categorized using clinical cut-offs. However, the present study provides evidence of how the relationship between BMI and internalizing symptoms changes among boys over time. For example, given that BMI did not predict later depressive symptoms at ages 16 and 17, it may be that the relationship between initial BMI (i.e., at age 10) and changes in internalizing symptoms is transient in nature among boys, with associations only salient during early adolescence. Furthermore, internalizing symptoms may not capture the implications of BMI. More specifically, in boys, BMI has been linked to measures of body dissatisfaction, body change strategies, and body esteem (Flament, Hill, Buchholz, Henderson, Tasca, & Goldfield, 2012; Ricciardelli, McCabe, Lillis, & Thomas, 2006). Thus, it may be important to measure more specific body perception measurements, rather than more broad-based measures of mental health (i.e., internalizing or depressive symptoms) to capture the complexity of this issue. The finding that changes in BMI did not predict levels of internalizing symptoms over time suggests that increases in BMI might not be distressing to boys and may reflect that increased muscle mass in adolescence may benefit boys' self-concept (Cafri, Thompson, Ricciardelli, McCabe, Smolak, & Yesalis, 2005; Jones, Bain, & King, 2008). Thus a potential limitation in the

present study is that BMI does not sufficiently capture fat versus muscle composition, a critical difference in relation to self-concept, particularly among boys (Cafri et al., 2005).

For girls, initial level of BMI at age 10 was associated with less steep decreases in internalizing symptoms at age 10 and also steeper increases in symptoms over time. Further, among girls, steeper increases in BMI from age 10 (i.e., slope effect) were related to higher levels of depressive symptoms at ages 16 and 17. This finding suggests that changes in BMI from age 10 may be more detrimental for girls, such that steeper increases in BMI can have longer-term effects for girls into later adolescence (ages 16 and 17). This finding is consistent with previous literature and may be related to the previously theorized “drive for thinness” among women within the Western culture (Anderson et al., 2007; Goodman & Whitaker, 2002). Thus, clinicians working with early adolescent girls struggling with their weight need to be cognizant of developing internalizing symptoms and negative self-concept. Furthermore, depressive symptoms have been found to negatively predict adherence and attrition within weight loss programs among youth (White et al., 2004; Zeller et al., 2004). Thus, the interplay between weight and internalizing symptoms is crucial to consider during treatment planning.

Next, internalizing symptoms were not related to any components of the trajectory of BMI among boys. This finding is inconsistent with Goodman and Whitaker’s (2002) results, which may be due to important differences in analysis strategy. Namely, Goodman and Whitaker (2002) utilized a cut-off score to examine depressed mood and examined both boys and girls together, including gender as a moderator. The result that

internalizing symptoms did not predict any aspect of the BMI trajectory among boys in the present study may be related to several factors. First, it may be that boys have effective coping strategies when dealing with feelings of depression and anxiety during adolescence. Second, Tanofsky-Kaff and colleagues (2006) found that binge eating and dieting, activities that are less prevalent among boys, predicted body fat gain, not depressive symptoms, among children ages 6 to 12. Among girls, internalizing symptoms predicted steeper increases in BMI from age 10 and also higher levels of depressive symptoms at ages 16 and 17. This finding is consistent with previous research (Goodman & Whitaker, 2002) and provides evidence of a bidirectional relationship between BMI and internalizing symptoms for girls. Future research would benefit from examining mediating relationships, such as dieting and binge eating (Tanofsky-Kaff et al., 2006), to gain information regarding the behavioural mechanisms underlying these relationships.

Strengths and Limitations

The present study added to previous research in several ways. Most notably, the collection of data at several time points allowed for sophisticated analyses that provided more detailed information regarding the relationship between BMI and internalizing symptoms from late childhood into adolescence. The parallel-process analyses provided differential and complex information regarding these relationships over time and have important implications. Further, the study also provided evidence of relationships over and above the effect of initial SES by including it as a covariate within the models. Future research could examine SES longitudinally, as a time-varying covariate, to provide more information about its ongoing effects.

The present study is not without limitations, particularly given that the study employed secondary data analysis. First, it was hypothesized that the findings related to boys may be tarnished by the measurement of BMI, such that BMI does not discriminate between body fat and muscle (Cafri et al., 2005). This limitation has important implications for examining this phenomenon among boys, given that muscular stature is idealized within Western culture. Body fat mass may be a more informative tool for examining the relationship between weight and mental health, particularly among boys. Second, another shortfall of the present study was the inconsistency of available measures after age 15. The internalizing symptoms measure was only collected until age 15, thus the trajectories only spanned until this age. Although the CES-D was available at ages 16 and 17, there was no follow-up measure of anxiety. Thus, it was unclear how BMI related to anxiety as an outcome at these later ages. Future research would benefit from more consistent measurement of symptoms across time. Third, the present study utilized a community-based sample of children and youth and findings using clinical samples may not be consistent. Finally, given the complexity of the research questions, and in consideration of parsimony regarding the models tested, other covariates were not included within the models. Given the findings, it may be important to examine gender-specific factors (e.g., dieting and binge eating, steroid and substance use; Cafri et al., 2005; Tanofsky-Kaff et al., 2006) that may underlie these relationships to understand which aspects are most important during this developmental period for boys and girls.

Implications of Study 1

The present study provides a comprehensive model of the relationship between BMI and internalizing symptoms among Canadian youth from ages 10 to 17 and holds important implications for researchers, clinicians, and policy makers. Future research could use multiple group analyses (e.g., Bollen & Curran, 2006) to test statistically the differences in relationships between boys and girls and specify specific time periods when these gender differences emerge. Better understanding of the relationship between BMI and internalizing symptoms among boys is warranted, utilizing a measure of body fat in place of body mass index (Cafri et al., 2005; Tanofsky-Kaff et al., 2006). In terms of practical implications, the developmental trajectories suggest that late childhood may be an important period in which to implement prevention and intervention practices. Given that eating disorders begin to emerge during this time (Kirsh, McVey, Tweed, & Katzman, 2007), late childhood may be an appropriate time to implement healthy eating and body image programming (e.g., McVey, Leiberman, Voorberg, Wardrope, & Blackmore, 2003; McVey, Tweed, & Blackmore, 2007; Raynor, 2008). Further, clinicians would benefit from being cognizant of the bidirectional and potentially perpetuating relationship between BMI and internalizing symptoms among girls. For example, assessing for negative weight-related cognitions in intake interviews and incorporating healthy eating and body image modules within treatment planning would better address such mental health issues during adolescence (Luca, Birken, Grewal, Dettmer, & Hamilton, 2012).

Conclusion

Key findings of the present study include the identification of gender differences in both the development of BMI and internalizing symptoms and also the relationship between these variables from late childhood into adolescence. Findings highlight the need to consider these processes developmentally and implement prevention and intervention strategies in late childhood. Further, clinicians would benefit from incorporating both cognitive strategies and healthy eating resources when addressing these issues within this important developmental period.

Study 2: Growth Mixture Modelling of BMI Development: Longitudinal

Examination of Internalizing Symptoms and Physical Activity

Not all children and youth develop in the same manner, and some youth may be more or less susceptible to weight and mental health issues. Thus, the first purpose of the second study was to explore whether classes (i.e., groups) of youth could be identified who follow similar patterns of BMI over time, from late childhood into adolescence (i.e., ages 10 to 15). The second purpose was to determine whether particular classes of BMI were more or less vulnerable to internalizing symptoms and to investigate whether the relationship between BMI and internalizing symptoms from late childhood into adolescence is inconsistent across classes (implying a non-linear relationship overall). In addition, physical activity has been widely documented as a determinant of mental health for children and adolescents (see Ahn & Fedewa, 2011; Camero et al., 2012 for review). However, little is known regarding the dynamic, longitudinal relationships among BMI, internalizing symptoms, and physical activity. Thus, the overarching second goal of the present dissertation was to examine these processes concurrently from late childhood into adolescence to inform developmental theory, research, policy, and prevention and intervention strategies.

Heterogeneity of BMI

To the author's knowledge, two studies to date have examined homogeneous classes of BMI in children and adolescents. Kubzansky and colleagues (2012) investigated BMI class membership and its associations with psychological distress (i.e., anxiety and depression) for adolescents over a four-year span. The authors found five

classes of BMI that remained relatively flat across waves of data collection: normal weight, overweight, obese who became overweight, obese, and severely obese. Although higher distress at baseline was associated with BMI at baseline and thus class membership, the authors were not able to examine the relationships among *changes* in these variables over time due to the flat profile of their trajectories. This study also did not take a developmental perspective in examining time, but grouped participants together regardless of age (M_{age} at time 1 of 14.4). Boys and girls were also grouped together within the analyses.

The second study to investigate BMI classes, by Mustillo and colleagues (2003), utilized data from the Great Smoky Mountains Study, which is a representative sample of rural youth from the United States. Data were collected annually over an eight-year span. The authors examined BMI developmentally by age (9-16), and a four-class model was obtained: no obesity, chronic obesity, childhood obesity (high levels of BMI in childhood then decreased around age 13), and adolescent obesity (non-obese levels of BMI during childhood then increased around age 13). The authors found that lower and middle income and having uneducated parents (i.e., one or both parents with less than 11th-grade education) were associated with chronic obesity class membership compared to the no obesity class. In terms of psychological associations, Mustillo and colleagues (2003) found that boys and girls in the chronic obesity class were at greater risk for oppositional defiant disorder and that boys in the chronic obesity class were at greater risk of depression. The present study aims to build upon this important research and identify

classes of BMI trajectories among Canadian youth. Further, demographic and psychosocial predictors of class membership are investigated.

Associated Factors

Several important factors have been identified as important determinants of weight status. These factors span several ecological systems (Bronfenbrenner, 1979): individual, parent, social, and community factors (Healthy Weight for Healthy Kids, 2007). In terms of individual factors, gender has been shown to be important for examining the relationship between BMI and internalizing symptoms, especially during this sensitive time period. For example, it has been widely documented that girls are more vulnerable to internalizing symptoms and disorders than boys (Galambos et al., 2004; Hankin et al., 2008; Hyde et al., 2008; Zarate, 2010). Further, Hyde and colleagues (2008) documented that these gender differences tend to emerge around the ages of 12 to 13 and continue into adulthood. In addition, overweight and obese girls have been shown to be more vulnerable to psychological problems compared to boys (Anderson et al., 2007; The Health of Canada's Young People: A Mental Health Focus, 2011; Reilly et al., 2003). However, these results have not been consistent when using a class membership model of BMI. For example, Mustillo and colleagues (2003) found that chronically obese boys were vulnerable to depression. In the present study, girls' and boys' BMI development are examined separately to elucidate the important processes and factors relevant to each gender.

Another important individual factor is pubertal development. As previously discussed, BMI and pubertal timing have been shown to be highly related, with higher

BMI relating to earlier pubertal onset, particularly among girls (Arim et al., 2007; Biro, 2006; Davison et al., 2003) and early puberty being related to being overweight or obese in adulthood (Harris et al., 2010). Early pubertal timing can have negative physical and mental health consequences and has been identified as an important factor related to depressive symptomatology, particularly among girls (Kaltiala-Heino, Kosunen, et al., 2003; Kaltiala-Heino, Marttunen, et al., 2003). This knowledge base has two important implications for the present paper. First, given the observed associations between BMI and pubertal timing (Arim et al., 2007; Biro, 2006; Davison et al., 2003), children ages 10 to 11 were included in the present sample to capture changes in BMI and internalizing symptoms during this critical developmental process. Second, pubertal timing was also investigated as a potential determinant of BMI trajectory class membership, given that research suggests that pubertal timing is implicated in the developmental process of BMI.

In terms of family factors, parent obesity has been consistently shown to predict childhood obesity (Whitaker et al., 1997; 1998), with one study demonstrating that parent obesity more than doubled the risk of adult obesity in children under the age of 10 (Whitaker et al., 1997). SES has also been shown to be related to BMI, internalizing symptoms, and physical activity (see Goodman, 2008 for review). Thus, these important family factors were also examined as determinants of BMI trajectory class membership. However, as the present study utilized secondary data, it was not possible to study parent obesity directly. As such, an index of general parental health was used as a predictor.

At the community level, type of setting (e.g., rural, urban) has also been demonstrated to be related to the development of weight in children and youth. For

example, research within the United States has shown that adulthood obesity is more prevalent in rural communities (39.6%) compared to urban communities (33.4%) after controlling for demographic characteristics, diet, and physical activity (Befort, Nazir, & Perri, 2012). These trends have also been documented within studies among child and adolescent populations (Joens-Matre, Welk, Calabro, Russell, Nicklay, & Hensley, 2008; Liu, Bennet, Huran, & Probst, 2008). With regard to Canadian estimates, Ismailov and Leatherdale (2010) sought to examine the prevalence rates of overweight and obesity among youth in Grades 9 to 12 attending high school in Ontario living in urban, suburban, and rural areas. The authors found the highest prevalence rates of overweight and obesity in rural areas (15.1% overweight, 6.7% obese) compared to urban (14.6% overweight, 6.3% obese) and suburban (13.8% overweight, 6.0% obese) areas. Thus, community factors may be important to consider when tailoring prevention and intervention programs for children and youth.

Given the many factors that may play a role in the development of BMI in children and youth, several variables (i.e., pubertal status, parent self-reported health, SES, and rural vs. urban setting) spanning across ecological systems were investigated as potential predictors of BMI class membership. Furthermore, boys' and girls' BMI development were examined separately to investigate the potential differential processes by gender.

Internalizing Symptoms

To limit redundancy with Study 1, only the literature novel to the present study is discussed here. A discussion of the present state of the cross-sectional and longitudinal

literature regarding the relationship between BMI and internalizing symptoms can be found in Study 1. With regard to latent class analyses, Kubzansky and colleagues (2012) were not able to examine the associations longitudinally given the flat profiles of the BMI trajectories. As previously mentioned, the flat profiles may be a reflection of grouping participants by wave rather than age. Mustillo and colleagues (2003) examined depression developmentally and found chronically obese boys to have higher levels of depression than non-obese boys. The present study aims to build upon this research and examine these processes (i.e., BMI and internalizing symptoms) simultaneously over time to observe this phenomenon developmentally. Further, physical activity is also investigated longitudinally to provide some context within which these processes occur.

Physical Activity

Physical activity has been thought to have important implications for the physical and mental health of children and youth (Ahn & Fedewa, 2011; Camero et al., 2012; Wang, Wild, Kipp, Kuhle, & Veugelers 2009). Furthermore, physical activity for individuals who are overweight or obese is a main component of interventions for this population (see Delamater et al., 2008; Raynor, 2008 for review). However, physical activity levels have been demonstrated to decrease during adolescence, which can have important health consequences (McMurray et al., 2008). Thus, adolescence is a particularly important time to study the longitudinal interplay between weight, internalizing symptoms, and physical activity.

For example, McMurray and colleagues (2008) investigated the relationship between physical activity levels and weight change over a five-year span (from ages 9 to

11 to ages 14 to 16). Overall, the authors found that levels of physical activity decreased over time. With regard to weight status, overweight children at age nine were already engaging in lower levels of physical activity than normal weight children (McMurray et al., 2008). Further, the authors found complex relationships between physical activity and weight change over time such that girls who were overweight at ages 9 to 11 but normalized by five years later (ages 14 to 16), demonstrated less of a decline in their physical activity levels than girls who were of normal weight then increased to overweight into adolescence. This finding suggests that involvement in physical activity during this time period plays a protective role in weight development.

With regard to the Canadian population, Tremblay and Willms (2003) examined the relationship between children's (ages 7 to 11) physical activity, inactivity, and BMI while controlling for important covariates (e.g., sex, family structure, and socioeconomic factors). Using the NLSCY, the authors found that physical activity was negatively associated with BMI, while inactivity (watching TV/video game use) was positively associated. This study provided evidence of the cross-sectional link between physical activity and BMI in Canadian children. Another NLSCY project (Wang et al., 2009) examined the longitudinal associations between overweight and obesity, self-esteem, and physical activity. These authors found that excess body weight preceded the development of low self-esteem, but that physical activity was positively related to self-esteem and that boys were less likely to have low self-esteem than girls. Again, this study provided further evidence of the important role of physical activity on mental health outcomes for

young Canadians. However, the study utilized regression analyses with only three time points.

Study 2: Objectives and Hypotheses

In general, the present study examined the longitudinal relationships between BMI, internalizing symptoms, and physical activity among Canadian youth. Given the consistency and availability of measures over time in the NLSCY, the growth models were examined for youth from age 10 to 15. To capture the complexity of these relationships, growth mixture modelling was employed to identify prototypical trajectory patterns of BMI (Jung & Wickrama, 2008). Several sets of hypotheses and analyses were investigated. First, based Mustillo and colleagues' (2003) study, it was hypothesized that several prototypical trajectory patterns, or latent classes, of BMI would be identified: 1) individuals who have a consistent, healthy BMI from age 10 to 15; 2) individuals who start with a healthy BMI and increase to an unhealthy BMI (overweight, obese); 3) individuals with an overweight or obese BMI and then decrease to healthy levels; and 4) individuals who begin with an overweight and obese BMI and remain elevated across adolescence.

Second, demographic factors spanning several ecological systems (i.e., pubertal status, parent self-reported health, SES, and rural vs. urban setting) were examined as potential determinants of class membership. Given the research regarding each of these factors (see above), it was expected that higher scores on a pubertal status measure, lower levels of parental health and SES, and those residing in rural compared to urban settings

would be more likely to be members of groups with higher initial levels of BMI (i.e., classes 3 and 4 above).

Third, to study the processes of internalizing symptoms and physical activity longitudinally, the growth curves of these variables over time was modelled by class. It was expected that those who have a healthy BMI throughout adolescence (class 1 above) and those who have a healthy BMI by the end of adolescence (class 3 above) would have lower levels of internalizing symptoms and higher levels of physical activity over time than those in trajectory groups which develop or maintain unhealthy BMI across adolescence (classes 2 and 4 above).

Finally, exploratory analyses of the parallel-processes between internalizing symptoms and physical activity were examined by class to investigate whether there are particular BMI trajectory classes of individuals for which these relationships are strongest.

Method

Participants

Study 2 utilized the same data set as Study 1. Thus, all children and adolescents (ages 10 to 17) were selected from the NLSCY. Please see the Method section of Study 1 for further details. Demographic characteristics of the full sample ($N = 6,987$, 50.6% boys) and also by gender (boys $n = 3,537$, girls $n = 3,450$) can be reviewed in Table 1.

Measures

Given that a number of the measures were also used in Study 1, only a shortened description of each measure is provided here.

Demographic characteristics. Variables from the PMK component of the survey were used, including age and gender of the youth, estimated family income (used as proxy of SES), and size of the population of their present setting. The PMK selected the type of setting from the following choices based on population: rural, urban (< 30, 000), urban (30,000 to 99, 999), urban (100, 000 to 499, 999), and urban (> 500, 000) (see Table 1 for percentages). For the present analyses, this item was dichotomized into rural versus urban (i.e., rural vs. all other categories combined).

Parent health. The PMK's rated their current health on a 1 (*excellent*) to 5 (*poor*) scale. This score was then reverse coded so that higher scores were indicative of better parent health.

Pubertal status. A score for pubertal status was derived separately for boys and girls using three items based on the Pubertal Development Scale (PDS; Petersen et al., 1988). For girls, the three items surveyed whether or not menstruation had begun, breast development, and body hair growth. For boys, the three items assessed voice deepening, body hair growth, and facial hair growth. The items were responded to on a 1 (*has not yet started changing*) to 4 (*change seems completed*) scale. For girls, menstruation was coded as 1 (*no*) or 4 (*yes*) so that both boys and girls had comparable scales (i.e., ranging from 3 to 12) for this measure. Petersen and colleagues (1988) found the PDS to be a reliable and valid measure of pubertal status. For the present sample, average coefficient alpha was .68 for boys and .65 for girls across cycles 4 to 6.

Body mass index (BMI). An individual's body mass index (BMI) was calculated using the standard BMI formula of $\text{weight}(\text{kg})/\text{height}^2(\text{m})$.

Internalizing symptoms. The anxiety and emotional disorder subscale of the Behaviours Checklist from the NLSCY assessed internalizing symptoms (Statistics Canada, 1995). The average coefficient alpha for this subscale was .78 across cycles.

Physical activity. Several items were used to create an index of a participant's level of activity. First, a mean of three items regarding the frequency with which youth participated in a sport with and without a coach, and dance, gymnastics, and so on during the past 12 months was calculated. For example, participants were asked, "During the past 12 months, how often have you played sports or done physical activities with a coach or an instructor?" Responses were based on a 1 (*never*) to 4 (*4 or more times a week*) scale. Youth were also asked, "Thinking of the sport or physical activity that you do the most often, how long do you usually spend being active in one session?" Responses were given on a 1 (*I do not do physical activities*) to 6 (*more than two hours*) scale. This score was multiplied by the mean of the three frequency items to provide an composite of physical activity on a 1 to 24 scale, with higher scores indicating higher frequency and intensity of physical activity. The frequency variables were only asked of youth ages 10 to 15, thus the composite was created for these ages only.

Depressive symptoms. A 12-item version (Poulin et al., 2005) of Radloff's (1977) CES-D assessed depressive symptoms for youth ages 16 and 17. The average coefficient alpha for this subscale was .83 across cycles 4 to 8.

Results

Unconditional Growth Curve Models

Unconditional growth curve models of BMI and internalizing symptoms.

Given the unconditional growth curve models of BMI and internalizing symptoms were completed for the first study of the dissertation, only a brief overview of these findings are provided here. With regard to BMI, different shapes of trajectories were fit for boys (i.e., quadratic) and girls (i.e., linear; see Figure 2). For internalizing symptoms, quadratic models best fit the data for both boys and girls (see Figure 4).

Unconditional growth curve models of physical activity. Similar to estimating the growth curve models of BMI and internalizing symptoms, the unconditional growth curve models of the physical activity composite were estimated for the full sample, and for boys and girls separately. The quadratic model best fit the data for the full sample and for both boys and girls. Means and variances of growth factors are presented in Table 13, while covariances and correlations among the trajectory factors are in Table 14.

The unconditional quadratic model for the physical activity composite best fit the data with the full sample, $\Delta\chi^2(3) = 179.922, p < .001$, with absolute fit statistics of BIC = 76,070.980 (linear model BIC = 76,224.476), RMSEA = .029, CFI = .983, and TLI = .975. As seen in Figure 5, individuals' physical activity composite scores increased after age 10, and then began to decrease roughly around age 14. Among boys, the quadratic model also best fit the data, $\Delta\chi^2(3) = 65.988, p < .001$, with absolute fit statistics of BIC = 37,572.418 (linear model BIC = 37,614.047), RMSEA = .027, CFI = .983, and TLI = .975. Similar to the full sample, boys' scores increased after age 10, and then began to decrease roughly around age 14 (Figure 6). Again, the quadratic model for physical activity fit the data best among girls, $\Delta\chi^2(3) = 113.339, p < .001$, with absolute fit

statistics of BIC = 38,511.298 (linear model BIC = 38,600.301), RMSEA = .030, CFI = .984, and TLI = .976. Among girls, levels of physical activity increased after age 10, then began to decrease around age 14 (Figure 6).

As with the internalizing symptoms trajectory, given that the quadratic model best fit the data for both boys and girls, it was reasonable to test gender differences among the latent intercept, slope, and quadratic factors by regressing these factors on gender using the full sample data. The intercept of physical activity differed between boys and girls, $b = -.481$, $SE = .219$, $p = .028$, suggesting that girls have lower scores on the physical activity composite than boys at age 10. There were no gender differences for the slope factor, $b = .145$, $SE = .167$, $p = .386$, nor the quadratic factor, $b = -.056$, $SE = .030$, $p = .063$, indicating that the increases and changes in the direction of the trajectory were similar among boys and girls.

Growth Mixture Modelling of BMI Trajectories

In order to capture potential nonlinear relationships between BMI and internalizing symptoms, growth mixture modelling (GMM) was used to identify classes of individuals with similar trajectories of BMI from ages 10 to 15. Several criteria were considered to determine the appropriate number of classes of BMI trajectory, including the BIC value and Lo-Mendell-Rubin likelihood ratio test (LMR-LRT) p -value (see Jung & Wickrama, 2008). The LMR-LRT tests the hypothesis that the k -class (e.g., 2-class) model fits the data significantly better than the $k - 1$ -class (e.g., 1-class) model; thus, a significant p -value for this test indicates a better fitting model for k -classes versus $k - 1$ -classes. Given the differences in BMI growth curve model shape of boys (i.e., quadratic

model best fit the data) and girls (i.e., linear model best fit the data), the GMM analysis was completed separately for boys and girls. Table 15 presents the BIC values for one- to four-class models for boys and girls. Based on the BIC values, LMR-LRT hypothesis tests, and theoretical considerations, a three-class trajectory model had the best fit among both boys and girls, as discussed below. The GMM analysis provides posterior group membership probabilities for each participant for each of the three groups. Participants were thus classified into a trajectory group based on these posterior probabilities, creating a categorical variable representing trajectory class membership. However, it is important to note that this assignment is not without error. For example, an individual can have similar probabilities across classes (e.g., class 1 = .55; class 2 = .40; class 3 = .05), but would be assigned the highest probability class (class 1). Thus, it is important to be cautious when interpreting classes and not to consider them as distinct populations.

Boys. Figure 7 presents the fitted growth curves and means for the three BMI classes among boys. The majority of the sample of boys (90.9%) fell within a class that may be labeled ‘normative.’ Individuals within this class followed a trajectory that experienced gradual increases in BMI from late childhood through to mid-adolescence. The estimated trajectory, as well as the observed BMI means for the class, was within the normal range of BMI from ages 10 to 15 (see Figure 7; Cole et al., 2000). The second class (6.3% of the sample of boys) may be identified as the ‘increasing’ class, having a trajectory characterized by higher initial level of BMI at age 10 than the ‘normative’ group, followed by increases in BMI until mid-adolescence. The ‘increasing’ class had a mean intercept that was above the international overweight BMI cut-off at age 10 (Cole

et al., 2000). BMI increased after age 10 across early adolescence and was above the obese cut-off by age 15 (Cole et al., 2000). The final class (2.8% of the sample of boys) followed a trajectory characterized by higher initial level of BMI at age 10 than the 'normative' and 'increasing' classes, followed by decreases in BMI to age 15. At age 10, this class had a mean intercept above the obese cut-off and BMI then decreased into the normal range by age 15. Accordingly, the final class may be identified as 'decreasing.' The posterior probabilities of the 'normative' class had a mean probability of membership of 95.4%. Those of the 'increasing' and 'decreasing' classes were also high (79.6% and 80.8%, respectively). The high average probability of membership for each of the classes suggests that the three-class model adequately classifies individuals into BMI trajectories and supports selection of the three-class model for boys.

Girls. The fitted growth curves and observed means of the three BMI classes among girls are in Figure 8. The majority of the sample of girls (89.7%) fell within a class that may be labeled 'normative.' Individuals within this class followed a BMI trajectory that gradually increased from late childhood through mid-adolescence. Means of BMI remained within the normal range. The second class (7.4% of the sample of girls), identified as the 'increasing' class, had a trajectory characterized by higher initial level of BMI at age 10 than the 'normative' class, followed by increases until mid-adolescence. This class had a mean intercept that was above the international overweight BMI cut-off, increased across early adolescence, and was just above the obese cut-off by age 15. The final class (2.9% of the sample of girls), the 'decreasing' class, followed a trajectory characterized by the highest initial level of BMI at age 10 followed by

decreases in BMI to age 15. At age 10, this class had a mean intercept above the obese cut-off and then decreased into the normal range by age 15. The posterior probabilities of the 'normative' class had a mean probability of membership of 94.8%. Those of the 'increasing' and 'decreasing' class were also high (83.4% and 78.9%, respectively). The high average probability of membership for each of the classes suggests that the three-class model adequately classifies individuals into BMI trajectories and supports selection of the three-class model among girls.

Class characteristics. Multinomial logistic regression was used to predict class membership from several variables observed at ages 10 and 11. Table 16 provides the descriptive statistics for the regression variables across classes by gender. The 'normative' class was used as the reference category in all of the analyses. The odds ratio (i.e., the exponentiation of the regression coefficients) represents the change in the odds of being in a specified trajectory class rather than the 'normative' class (i.e., the reference category) as a function of a given predictor variable. An odds ratio less than one indicates a decrease in odds of being in the specified class rather than the 'normative' class, whereas an odds ratio greater than one indicates an increase in odds of being in the specified class instead of the 'normative' class. Initial SES (again divided by 10,000), initial pubertal status, and parent health were included as continuous predictors. The only dichotomous variable included was type of setting (recoded into rural vs. urban), given the literature on overweight and obesity rates in rural versus urban settings (Ismailov & Leatherdale, 2010; Joens-Matre et al., 2008). Although other demographic variables were

of interest (e.g., family composition), they were highly correlated with SES, thus were not included in analyses to avoid issues of multicollinearity.

Boys. Results from the multinomial logistic regression for boys are presented in Table 17. Higher initial level of SES, $B = -.06$, $SE = .02$, $p = .010$, and better parent health, $B = -.20$, $SE = .09$, $p = .020$, were associated with membership in the ‘normative’ class as compared to the ‘increasing’ class. The odds ratio for SES indicates that a \$10,000 increase (one unit) in SES was associated with a .94 multiplication the odds (i.e., a decreased probability) of membership in the ‘increasing’ class relative to the ‘normative’ class. Similarly, one unit increase in parent health was associated with .82 multiplication of the odds of membership in the ‘increasing’ class relative to the ‘normative’ class. No other associations were found among the variables for boys.

Girls. Table 18 provides a summary of the results for the multinomial logistic regression among girls. Initial pubertal status was associated with membership in the ‘increasing’ class for girls, $B = .11$, $SE = .04$, $p = .008$, such that one-unit increase in pubertal status was associated with a 1.11 multiplication of the odds (i.e., an increased probability) of ‘increasing’ class membership rather than ‘normative’. Similar to the results for boys, better parent health was associated with ‘normative’ class membership when compared to the ‘increasing’ class, $B = -.19$, $SE = .09$, $p = .030$, such that one-unit increase in parent health was related to a .82 multiplication of the odds of ‘increasing’ class membership relative to ‘normative’ class membership. With regard to the ‘decreasing’ class, pubertal status was also associated with ‘decreasing’ class membership as compared to the ‘normative’ class, $B = .16$, $SE = .07$, $p = .016$, such that

one-unit increase in pubertal status was associated with a 1.18 multiplication of the odds of ‘decreasing’ class membership rather than ‘normative.’ Furthermore, type of setting was associated with ‘decreasing’ class membership, $B = .66$, $SE = .32$, $p = .042$, such that being from a rural setting compared to an urban setting was related to a 1.93 multiplication of the odds of ‘decreasing’ class membership compared to the ‘normative’ class, suggesting that being rural almost doubles the odds of being classified into the ‘decreasing’ rather than the ‘normative’ group. No other significant associations were found among the variables.

Growth Curve Models by Trajectory Class

In order to investigate the patterns of internalizing symptoms and physical activity across the BMI classes, unconditional growth curve models of both of these variables were estimated for each class by gender. The fit statistics for linear and quadratic models by classes can be found in Tables 19 and 20 for boys and girls, respectively. Some problems were encountered for the analyses involving the ‘decreasing’ classes, given the small sample size and individual variability. For example, some of the fit statistics indicated poor fit for the final models among boys within the ‘decreasing’ class (see Table 19). Further, the quadratic models for the ‘decreasing’ class among girls could not be obtained due to non-convergence. Thus, discussion of the results primarily focuses on comparing the growth curve models of the ‘normative’ and ‘increasing’ BMI trajectory classes, as interpretation of the results for the ‘decreasing’ class was unsubstantiated.

Boys. The parameter estimates of the best fitting growth curve models of the internalizing symptoms and physical activity trajectories by classes can be found in Table

21. Figure 9 presents the fitted growth curve models and observed means of internalizing symptoms for each of the BMI trajectory classes. At age 10 (intercept), the ‘decreasing’ BMI class had the highest levels of internalizing symptoms, followed by the ‘increasing’ BMI class, and then the ‘normative’ BMI class. The ‘normative’ BMI class followed a similar pattern to that of the overall sample for boys (i.e., quadratic trajectory; see Figure 4), with decreases in symptoms after age 10 and a leveling off around age 12 and 13. In contrast, the ‘increasing’ and ‘decreasing’ BMI classes had linear models of internalizing symptoms over time. Both classes had higher initial levels of symptoms at age 10 than the ‘normative’ class, but steadily decreased over time. The three classes had comparable levels of internalizing symptoms by age 15 (see Figure 9).

Regarding physical activity, the fitted growth curve models and observed means for the BMI trajectory classes can be seen in Figure 10. Quadratic growth curve models had the best fit to the data for both the ‘normative’ and ‘increasing’ BMI classes. However, as seen in Figure 10, the ‘normative’ class had consistently higher levels of physical activity than the ‘increasing’ class at intercept and across time. Boys in the ‘decreasing’ class had similar levels of physical activity to boys in the ‘normative’ class at age 10, but their levels decreased linearly over time.

Girls. Table 22 presents the parameter estimates of the best fitting growth curve models for internalizing symptoms and physical activity for the three BMI classes among girls. The ‘normative’ BMI class had consistently lower levels of internalizing symptoms than the ‘increasing’ BMI class at age 10 and across late childhood into mid-adolescence (Figure 11). The ‘normative’ BMI class had a quadratic trajectory where symptoms

slightly decreased after age 10 and then began to increase at age 13, whereas internalizing symptoms among the ‘increasing’ BMI class increased linearly after age 10 (Figure 11).

Regarding physical activity, the fitted growth curve models and observed means for the BMI trajectory classes among girls can be reviewed in Figure 12. Similar to the findings for boys, the quadratic growth curve models had the best fit for both the ‘normative’ and ‘increasing’ BMI classes. However, as seen in Figure 12, the ‘normative’ BMI class had consistently higher levels of physical activity than the ‘increasing’ BMI class at age 10 and over time. The ‘decreasing’ BMI class had a linear trajectory, starting with the lowest levels of physical activity at age 10, compared to the ‘normative’ and ‘increasing’ BMI classes, and then increased linearly over time.

Relationships among growth model parameter estimates by BMI class.

Parallel-process analyses between the internalizing symptoms and physical activity growth model factors by BMI trajectory class was used to investigate whether the associations between these growth models varied by BMI trajectory class. The latent factors (i.e., intercept, slope, quadratic) of the physical activity growth model were correlated with the latent factors of the internalizing symptoms growth model as well as CES-D scores at ages 16 and 17. Results can be reviewed in Tables 23 and 24 for boys and girls, respectively. Among both boys and girls in the ‘normative’ BMI trajectory class, initial levels of physical activity were negatively associated with initial levels of internalizing symptoms, such that higher levels of physical activity were related to lower levels of internalizing symptoms in late childhood (i.e., age 10). Further, among boys in the ‘normative’ group, initial levels of physical activity were negatively related to

depressive symptoms at ages 16 and 17, such that higher levels of physical activity at age 10 was related to lower levels of depressive symptoms in later adolescence. There were no other significant associations, suggesting that the internalizing symptoms and physical activity growth models were largely unrelated to one another within classes.

Discussion

Overview of Study 2 Findings

In general, the present paper sought to identify different classes of BMI trajectories from late childhood to mid-adolescence among Canadian youth. The trajectory groups of BMI that emerged (i.e., ‘normative,’ ‘increasing’ BMI, and ‘decreasing’ BMI) were mostly consistent with previous findings (Mustillo et al., 2003). Significant predictors of class memberships varied by gender, although directionality remained consistent across boys and girls. Specifically, among boys, SES was a significant determinant of membership in the ‘increasing’ class; whereas for girls, pubertal status and rurality were significant predictors of ‘increasing’ and ‘decreasing’ class membership. Parent self-reported health predicted ‘increasing’ class membership for both boys and girls. Consistent with hypotheses, youth in the ‘increasing’ class exhibited higher levels of internalizing symptoms and lower levels of physical activity than those in the ‘normative’ class. Finally, parallel-process analyses by BMI class found no significant associations between internalizing and physical activity trajectories, possibly due to statistical and methodological issues. Together, the findings highlight the potential usefulness of fostering healthy coping strategies and physical activity in late childhood to prevent the development of unhealthy BMI through adolescence.

Classes of BMI and Characteristics

A three-class model of BMI emerged for both boys and girls, characterized by ‘normative,’ ‘increasing,’ and ‘decreasing’ classes. These results were consistent with Mustillo and colleagues’ (2003) findings. However, Mustillo and colleagues also found a fourth class characterized by chronic obesity. It is possible that this discrepancy is due to the assessment time intervals of the present study, given that participants were only surveyed every two years and not every year, as in the Mustillo and colleagues (2003) study. Perhaps individuals in the present study who were chronically obese were captured within the ‘increasing’ class, given that this class demonstrated a trajectory that was classified as overweight at age 10 and increased to obese by age 15, or the ‘decreasing’ class, given the distributions of youth across the classes, as this class demonstrated a trajectory that was classified as obese at age 10 and decreased to the normal range by age 15. Future research would benefit from smaller time intervals between assessments to differentiate classes of BMI development better.

Furthermore, the distribution of youth in each of the classes was surprising and inconsistent with Mustillo and colleagues’ (2003) findings. In particular, Mustillo and colleagues found the following trajectories: no obesity (73%), chronic obesity (15%), childhood obesity (5%), and adolescent obesity (7%); whereas the present research found three trajectories of BMI: ‘normative’ (90.9% of boys and 89.7% of girls), ‘increasing’ (6.3% of boys and 7.4% of girls), and ‘decreasing’ (2.8% of boys and 2.9% of girls). Thus, Mustillo and colleagues (2003) reported a lower percentage within the no obesity class (73%) than the present ‘normative’ class (~90% for both boys and girls) and much

higher percentages within the adolescent obesity (7%) and chronic obesity (15%) classes than the present ‘increasing’ class (6.3% of boys and 7.4% of girls). These differences could reflect the underestimation of BMI due to parent- and self-reported measurement in the present study (Phipps et al., 2004). Mustillo and colleagues (2003) collected actual measurements of weight and height, whereas the present data set was based on potentially biased parent- and self-reported measurements. This difference in distribution could also again reflect the measurement issues within the present sample (i.e., two-year assessment intervals) such that youth with chronically high BMI may have been captured within the ‘increasing’ sample. Future research would benefit from *in vivo* measurement of weight and height and, possibly, from smaller assessment intervals to better detect changes in BMI over time with greater specificity.

Several important determinants of class membership were found on various ecological levels (Bronfenbrenner, 1972). For both boys and girls, parent self-reported health was associated with membership in the ‘increasing’ class compared to the ‘normative’ class. This finding is consistent with previous research (Whitaker et al., 1997; 1998) that has found parent overweight and obesity status to be predictors of childhood overweight and obesity. Given this association, family-based models of treatment may be most suitable for children and youth and some research has focused on the role of the parent in evidence-based treatments for childhood obesity (e.g., Luca et al., 2012; see Raynor, 2008 for review). The present study was limited to using parent self-reported health as a proxy of parent overweight and obesity; thus, it is unclear from the present findings that this measure captures the intended construct. Further research

specifically measuring parent overweight and obesity and perhaps other related health issues (e.g., heart disease, diabetes) to better understand this relationship is required.

For boys, lower levels of SES were significantly associated with ‘increasing’ versus ‘normative’ class membership. This finding is consistent with hypotheses and previous research (Mustillo et al., 2003), as SES has multiple implications for BMI development (see Goodman, 2008 for review; Goodman et al., 2003). It may be that boys from lower levels of SES have poorer nutritional and health knowledge, access to activity resources, and poorer meal-time planning and supervision, resulting in unhealthy levels of BMI (Goodman, 2008). It would be important for future research to examine which aspects of SES contribute to BMI development to better inform prevention and intervention strategies. SES did not significantly predict latent class membership among girls, however.

For girls, but not boys, higher pubertal status at ages 10 and 11 was also associated with ‘increasing’ class membership versus the ‘normative’ class. This finding is consistent with past research that has demonstrated associations between early pubertal timing and BMI (Arim et al., 2007; Biro et al., 2006; Davison et al., 2003; Harris et al., 2010). The finding that this was the case solely among girls is not surprising, given that the negative consequences of early pubertal timing are greater among girls (e.g., Kaltiala-Heino, Kosunen et al., 2003; Kaltiala-Heino, Marttunen et al., 2003). However, the present finding is important, as early pubertal timing has been shown to be related to overweight and obesity in adulthood (Harris et al., 2010) and is consistent with the present ‘increasing’ trajectory class that increases into mid-adolescence. Thus, girls who

demonstrate early pubertal timing seem to be vulnerable to weight-related issues across adolescence into adulthood and early interventions may need to be tailored for this subpopulation. Although the present analyses used pubertal status at ages 10 and 11 as a “predictor” of BMI, the ongoing relationship is likely bidirectional in nature and future research should examine pubertal status longitudinally to better capture this relationship over time.

Finally, girls from rural communities were almost twice as likely to be in the ‘decreasing’ class compared to the ‘normative’ class. This finding may be attributed to physical activity levels among rural compared to urban youth. Some research has demonstrated that physical activity levels among rural youth are higher than that of urban youth (Joens-Matre et al., 2008). Although rural girls in the ‘decreasing’ group appear to continue to be physically active into adolescence (see Figure 12), it is unclear whether this is the case within the present sample given the variability of the ‘decreasing’ class. It may also be that these girls use other means (i.e., dieting, binging) to normalize their weight status. More information about the mechanisms by which these girls achieve normal levels of BMI is needed.

BMI, Internalizing Symptoms, and Physical Activity

Overall, youth in the ‘increasing’ classes demonstrated higher levels of internalizing symptoms and lower levels of physical activity than those in the ‘normative’ classes. These findings are consistent with hypotheses and have several important implications, as discussed below. Given the small percentage of youth in the ‘decreasing’ group, the trajectories for these classes are potentially unreliable (see Figures 8 through

11). Thus, the majority of the discussion is focused on comparing the ‘increasing’ and ‘normative’ classes.

Internalizing symptoms. Among boys, initial level of internalizing symptoms was higher for the ‘increasing’ and ‘decreasing’ classes compared to the ‘normative’ class; however, internalizing symptoms by age 15 were comparable across groups. This result suggests that increases of BMI across adolescence may not have a negative impact emotionally for boys. This may be also attributed to a methodological issue, as it calls into question the appropriateness of BMI as a measure of overweight and obesity. BMI does not differentiate between muscle and fat percentages; thus, an adolescent boy who is gaining muscle would also have a higher BMI, which may, in fact, be protective (Cafri et al., 2005). Future research would benefit from a better measurement of weight status in order to tease apart these factors, particularly among boys.

Among girls, youth in the ‘increasing’ class had consistently higher levels of internalizing symptoms from late childhood through age 15 compared to youth in the ‘normative’ class. This finding is consistent with hypotheses and previous research (Anderson et al., 2007; Tiffin et al., 2011) and has important implications. First, it appears that differences in internalizing symptoms between the ‘increasing’ and ‘normative’ classes emerge around age 10 (see Figure 11), suggesting that mid- to late-childhood may be an important time to implement prevention and intervention strategies. Research suggests that early detection and the implementation of evidence-based treatments in early childhood has strong long-term benefits (see Raynor, 2008 for review). Findings from the present study suggest that the purposes of prevention and

intervention approaches could be two-fold, focusing on providing evidence-based healthy eating and body image treatment and also targeting cognitive-behavioural strategies to guard against internalizing symptoms (e.g., Luca et al., 2012). With regard to methodological implications, future research would benefit from extending lower bound age limits of the trajectories to better understand exactly when these differences emerge.

Physical activity. Overall, the physical activity trajectories are consistent with previous research and theory, such that physical activity declined across adolescence and boys demonstrated higher levels of physical activity than girls (McMurray et al., 2008). Among both boys and girls, the trajectories were quadratic with initial increases in activity from age 10 and declines into adolescence (Figure 6). Consistent with hypotheses, both boys and girls in the ‘normative’ class demonstrated consistently higher levels of physical activity than those in the ‘increasing’ class (see Figures 10 and 12). This finding is consistent with research by McMurray and colleagues (2008) who found that overweight children as young as nine participated in less physical activity than children with normal weight. McMurray and colleagues (2008) also found that girls who started as overweight but normalized across adolescence had less of a decline in activity levels, consistent with the present findings. Again, this pattern may suggest that the girls in the ‘decreasing’ class normalized their weight status by continuing to engage in physical activity (see Figure 12). Overall, findings suggest that physical activity plays a protective role in weight status from late childhood into adolescence. However, how physical activity interacts with weight and the subsequent effect of this interaction on mental health remains unclear. Future research would benefit from extending the current

findings to examine the moderating effects of physical activity to create strategies that promote both the physical and mental health of youth.

Parallel-process analyses. Among both boys and girls in the ‘normative’ trajectory class, initial level of physical activity was negatively associated with initial level of internalizing symptoms, such that higher initial level of physical activity was related to lower initial level of internalizing symptoms in late childhood (i.e., age 10). Further, among boys in the ‘normative’ group, initial level of physical activity was negatively related to depressive symptoms at ages 16 and 17, such that higher initial level of physical activity at age 10 was related to lower depressive symptoms in later adolescence. These findings are consistent with research suggesting that physical activity is associated with enhanced mental health among children and adolescents (Ahn & Fedewa, 2011; Camero et al., 2012). However, there were no other significant associations, suggesting that changes in the internalizing symptoms and physical activity trajectories were largely unrelated to one another over time within classes. These null findings may be possibly attributed to the flat profiles obtained (Kubzansky et al., 2012) or to statistical power, as the sample sizes within the ‘decreasing’ classes were small. How physical activity and internalizing symptoms interact with one another over time in consideration of BMI development would have significant implications for treatment programs, such that there may be individuals for which increased physical activity alone may be effective.

Strengths and Limitations

Overall, the present study built upon the existing literature by examining these relationships separately among boys and girls and providing a first look at the pattern of

internalizing symptoms and physical activity among different BMI trajectory classes from late childhood into adolescence. Given that the data were analyzed secondarily, several limitations warrant discussion. For example, surveying participants each year instead of biannually may enhance the specificity of the classes. Also, only a selected number of determinants of class membership were examined and some of the measures were suboptimal (e.g., parent health as a proxy of parent weight status). More specific and valid scales are needed to enhance understanding of the characteristics of each of the classes. Finally, future research would also benefit from more complex analyses (e.g., longitudinal moderation analysis) to increase understanding of the moderating effect of physical activity to inform effective prevention and intervention strategies.

Implications of Study 2

The present study is the first, to the author's knowledge, to map latent classes of BMI among Canadian youth. The findings provide insight into the determinants of the classes and the patterns of internalizing symptoms and physical activities from late childhood into adolescence for both boys and girls. The results imply that youth who are 'increasing' in BMI have higher levels of internalizing symptoms and engage in less physical activity than youth with 'normative' levels of BMI across adolescence. The findings suggest that policy makers, service providers, and clinicians need to be cognizant of these complex relationships when developing and creating effective interventions. Such interventions that address both weight and internalizing symptoms may be best suited for this population. Finally, early detection and intervention is

necessary to improve the physical and mental health of young Canadians in the long-term.

Conclusion

Three trajectory classes of BMI emerged for both boys and girls: ‘normative,’ ‘increasing,’ and ‘decreasing.’ The majority of the sample fell within the ‘normative’ class (90.9% and 89.7% for boys and girls, respectively), followed by the ‘increasing’ class (6.3% and 7.4%), and then the ‘decreasing class’ (2.8% and 2.9%). SES predicted class membership for boys and pubertal status and community setting predicted class membership for girls. Parent self-reported health was a common predictor among both boys and girls. In general, the ‘increasing’ classes demonstrated higher levels of internalizing symptoms and lower levels of physical activity over time. Findings highlight the complex relationship among these processes during this developmental stage and promote early prevention and intervention strategies to address weight and mental health issues in Canadian youth.

Overall Discussion

With the rise of rates of childhood and adolescent overweight and obesity, more knowledge about the physical and mental health correlates is required. Given the paucity of consistent findings regarding the relationship between BMI and mental health issues among child and adolescent populations (Wardle & Cooke, 2005; Wardle et al., 2006; Zeller & Modi, 2008), the present dissertation broadly aimed to enhance the understanding of the relationship between BMI and internalizing symptoms for Canadian adolescents ages 10 to 17. The present dissertation was embedded within the developmental psychopathology perspective that emphasizes the complex and dynamic interaction of factors that act to increase (i.e., risk factors) and protect against (i.e., protective factors) mental health issues. The results provide evidence of important, complex relationships between the examined factors that have important implications for researchers, service providers and clinicians, and policy makers. Adolescence is an especially important time to investigate these processes, given the physical, cognitive, and socio-emotional changes emerging during this critical developmental stage. The results of the present dissertation provide important information regarding the timing and potential tailoring of interventions during this time period.

Summary of Findings

Study 1 explored the relationship between the trajectories of BMI and internalizing symptoms among boys and girls ages 10 to 17. In sum, boys and girls differed in the shape of BMI trajectory, potentially due to differences in pubertal development in early adolescence (Tanner, 1962). With regard to internalizing

symptoms, boys and girls had similar levels of internalizing symptoms at age 10; however, girls developed higher levels of internalizing symptoms than boys over time, consistent with past research (Galambos et al., 2004; Hankin et al., 2008; Hyde et al., 2008; Zarate, 2010). Furthermore, a bidirectional relationship between BMI and internalizing symptoms emerged for girls, whereas only initial BMI was related to changes in internalizing symptoms for boys. Given the potential of a nonlinear relationship between BMI and internalizing symptoms (i.e., youth with either low BMI or high BMI may be vulnerable to internalizing symptoms), growth mixture modelling was employed to investigate this issue.

Thus, Study 2 investigated the patterns of internalizing symptoms and physical activity among trajectory classes of BMI. Further, socio-demographic factors were examined as predictors of class membership. A three-class trajectory model of BMI emerged for both boys and girls: 'normative,' 'increasing' BMI, and 'decreasing' BMI classes. Predictors of class membership varied by gender; however, parent health was an important predictor regardless of gender. Among boys, SES was an important predictor of membership in the 'increasing' class; whereas for girls, pubertal status and rurality predicted membership in the 'increasing' and 'decreasing' classes. Overall, boys and girls in the 'increasing' classes demonstrated higher levels of internalizing symptoms and lower levels of physical activity than those in the 'normative' classes, consistent with hypotheses and previous research. Finally, the parallel-process analyses mostly showed no significant relationships between the trajectories of internalizing symptoms and physical activity by class. However, some evidence indicated that higher initial level of

physical activity was related to lower initial level of internalizing symptoms for the ‘normative’ classes. Together, these findings have multipronged implications for developmental and mental health researchers, service providers and clinicians, and for policy change.

Implications for Researchers

The present dissertation aimed to build upon the literature by examining the relationship between BMI and internalizing symptoms longitudinally using complex statistical methods. The present findings highlight the need for researchers to consider gender differences when examining the development of BMI among children and adolescents. Several important gender differences were found in the present studies that validate this necessity. First, boys and girls differed in the shape of the developmental trajectory of BMI, hypothesized to be due to the physiological changes occurring from late childhood into adolescence (Tanner, 1962). Further, a bidirectional relationship between BMI and internalizing symptoms emerged for girls and not boys. For boys, BMI was related to later internalizing symptoms, but internalizing did not predict BMI. Although similar classes of BMI were found for boys and girls (i.e., a three-class model), the relationships among important factors differed. For example, SES and parent health were important predictors of trajectory class membership for boys, whereas pubertal status, parent health, and rurality were important for girls. Simply including gender as a covariate within longitudinal analyses examining the relationship between BMI and internalizing symptoms might not adequately capture the complexities of the

relationships. Thus, the present findings significantly add to the literature by describing the complex gender differences within the context of BMI development and its correlates.

There are few extant longitudinal studies of BMI and mental health correlates among children and adolescents (i.e., Kubzansky et al., 2012; Mustillo et al., 2003). More research is needed to comprehend the underlying mechanisms of these relationships. Future research would benefit from several methodological improvements including prospective research design, smaller intervals between assessment periods, better measurement of fat versus muscle mass, and a greater age range given that differences in internalizing symptoms and physical activity between classes may have been present before the lower bound age of 10. Finally, multiple-group analyses (e.g., Bollen & Curran, 2006) would allow for the detection of statistically significant differences both between boys and girls and between classes in terms of the relationships among variables. Thus, future longitudinal prospective work is still needed.

Implications for Clinicians

With regard to prevention and intervention strategies, several implications emerged from the present research. First, and as previously discussed, it is important to understand the differences between boys and girls and the differences in possible outcomes of boys and girls who struggle with weight. For example, the present findings highlight the need for service providers and clinicians to be aware of the potential development of internalizing disorders among overweight or obese boys and girls and, among girls, the development of weight issues among those who experience internalizing symptoms. As depressive symptoms have been shown to have a negative impact for weight management

programs (White et al., 2004; Zeller et al., 2004), the bidirectional relationship between weight and internalizing symptoms among girls is an important consideration for treatment. Interventions that address both weight and internalizing symptoms may be most appropriate, particularly among young girls (e.g., Luca et al., 2012).

Implications for Policy Makers

The present dissertation provides several important considerations for policy makers. First, upon examination of the trajectories of internalizing symptoms and physical activity across classes, it is evident that these processes begin as early as age 10. Thus, early intervention is necessary to promote healthy, active lifestyles among young Canadians to produce better long-term outcomes through to adulthood (Raynor, 2008). Second, and related to the first consideration, there is some evidence to suggest that introducing healthy eating and body image programming with a cognitive focus into the school setting is beneficial in addressing body dissatisfaction, disordered eating, and internalized ideals (e.g., McVey et al., 2003; McVey et al., 2007). The school may be an ideal setting within which to develop and implement these programs to best reach Canadian youth. In addition, late childhood may be an appropriate time to put these services into practice.

Third, the distribution of the three classes may highlight underestimations of BMI given that parent- and self-reported weight and height were collected (Phipps et al., 2004). National databases would benefit from more accurate collection of weight and height rather than relying on parent- and self-report (Phipps et al., 2004). Phipps and colleagues (2004) made several important suggestions on how to address these issues

(e.g., priming parents to measure children before the assessment, actual measurements of weight and height) in order to most accurately assess this information. Further, given the gender differences found, it may be beneficial to collect information on fat vs. muscle composition, particularly among boys.

Strengths, Limitations, and Future Directions

The major strengths of the present dissertation include the longitudinal nature of the research design, the complex analyses that allowed for the examination of important developmental processes over time, and the large sample size that facilitated the investigation of differences in relationships and processes for boys and girls separately. Given the dissertation utilized secondary data analyses, several important limitations exist. First, several of the measures could be improved upon in future prospective studies. For example, in addition to the issue concerning self-reported BMI, a composite of internalizing symptoms was utilized. Although the composite surveyed both depressive and anxiety symptoms, it may be useful to have two separate measures of depressive and anxiety symptoms to increase specificity and better differentiate the outcomes, although these constructs have been shown to be highly related to each other in childhood (King et al., 1990). Most research focuses on depressive symptoms (e.g., Goodman & Whitaker, 2002; Tanofsky-Kaff et al., 2006) and more information is needed on anxiety as an outcome for children and adolescents (Anderson et al., 2007). Furthermore, the predictors of class membership (e.g., parent health and pubertal status) could be further refined (e.g., parent eating habits, physical activity, meal time supervision) to improve specificity

and to ensure the measures capture the intended constructs. A larger array of predictors (e.g., peer factors) could also be examined in future research.

Next, although the NLSCY is a representative Canadian sample, the results have limited generalizability to clinical populations given the use of a community-based sample. Clinic samples may be important for examining how these processes develop over time. The present community-based sample had relatively low levels of internalizing symptoms over time, particularly among boys. Thus, it would be important to investigate how BMI is related to clinical levels of depression and anxiety and the role physical activity could play within evidenced-based treatments (Delamater et al., 2008).

Finally, future research could build upon the present study by using multiple-group analysis (e.g., Bollen & Curran, 2006) to detect significant differences in the trajectories between boys and girls. Multiple-group analyses could also detect significant differences in trajectories and also relationships between the BMI classes. Further, the complex relationships between BMI, internalizing symptoms, and physical activity still remain to be deconstructed. Physical activity is hypothesized to reduce mental health issues as it works to improve self-efficacy and self-confidence, provides positive social interactions, and has calming biological effects (see Camero et al., 2012 for brief review). Moderation analyses may be beneficial in determining the role of physical activity in fostering healthy physical and mental health development among adolescents.

Conclusion

In conclusion, the present dissertation modelled the trajectories of BMI, internalizing symptoms, and physical activity among Canadian boys and girls. The

findings provide evidence of key gender differences among the relationships that have important implications. Future prospective research should build upon these findings by continuing to examine these relationships longitudinally using sophisticated statistical methods. Examining these developmental processes simultaneously provides a unique overview into the potential underlying mechanisms. Further research is necessary to further elucidate the relationship between BMI and internalizing symptoms to inform specific areas for effective prevention and intervention programming for children and youth.

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Appendix A

Table 1
Characteristics of the Study Sample at Ages 10 and 11 (Total N = 6,987)

	Full Sample (N = 6,987)	Boys (n = 3,537)	Girls (n = 3,450)
	M (SD) or N (%) for categorical variables	M (SD) or N (%) for categorical variables	M (SD) or N (%) for categorical variables
Gender	----	3,537 (50.6%)	3,450 (49.4%)
Household income	69,899.60 (46,541.65)	70,699.27 (49,197.07)	69,079.52 (43,642.98)
Parent education (PMK)			
High school or less	1,368 (19.6%)	691 (19.5%)	677 (19.6%)
Some postsecondary	3,367 (48.2%)	1,699 (48.0%)	1,668 (48.3%)
Postsecondary completed	979 (14.0%)	508 (14.4%)	471 (13.7%)
Other	1,228 (17.6%)	621 (17.6%)	607 (17.6%)
Race			
White	6,242 (89.3%)	3,161 (89.4%)	3,081 (89.3%)
Chinese	54 (.8%)	32 (.9%)	22 (.6%)
Black	54 (.8%)	26 (.7%)	28 (.8%)
Native	141 (2.0%)	77 (2.2%)	64 (1.9%)
Other	163 (2.3%)	75 (2.1%)	88 (2.6%)
Country of birth			
Canada	6,744 (96.5%)	3,410 (96.4%)	3,334 (96.6%)
Family structure			
Two biological parents	5,058 (72.4%)	2,549 (72.1%)	2,509 (72.7%)
Two-parent non-traditional ^a	692 (9.9%)	370 (10.5%)	322 (9.3%)
Single-parent	1,195 (17.1%)	598 (16.9%)	597 (17.3%)
Does not live with parent or other	42 (.6%)	20 (.6%)	22 (.6%)
Type of setting (based on population)			
Rural	1,434 (20.5%)	737 (20.8%)	697 (20.2%)
Urban (< 30, 000)	2,253 (32.2%)	1,158 (32.7%)	1,095 (31.7%)
Urban (30, 000 to 99, 999)	765 (10.9%)	383 (10.8%)	382 (11.1%)
Urban (100, 000 to 499,999)	1,229 (17.6%)	614 (17.4%)	615 (17.8%)
Urban (> 500, 000)	1,306 (18.7%)	645 (18.2%)	661 (19.2%)

^aStep, adoptive, foster.

Note. Percentages may not equal 100% due to missing data.

Appendix B

Table 2
*Means and Standard Deviations (in Parentheses) for the Main Variables of the Study at
 Ages 10 and 11*

	Full Sample	Boys	Girls
Body mass index (BMI)*	19.17 (3.86)	19.38 (3.96)	18.97 (3.75)
Internalizing symptoms	3.59 (2.65)	3.55 (2.67)	3.64 (2.63)
Physical activity composite	11.87 (4.99)	12.02 (4.79)	11.73 (5.17)
Pubertal status*	5.27 (1.90)	5.01 (1.80)	5.54 (1.96)
<i>Ages 16 and 17 only^a</i>			
Depressive symptoms (CES-D)*	8.42 (6.00)	7.39 (5.37)	9.39 (6.40)

^aAges 16 and 17 (Total $N = 5525$; boys $n = 2694$, girls $n = 2831$)

Note. *Denotes significant gender difference ($p < .05$).

Appendix C

Table 3
Correlation Matrix Between Body Mass Index (BMI), Internalizing Symptoms, and Physical Activity Over Time by Age Group and Gender

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. BMI 10-11	----	.492*	.469*	.390*	.026	.060	.050	.021	-.098	-.104*	-.066
2. BMI 12-13	.519*	----	.585*	.492*	.038	.103*	.072	.083	-.052	-.122*	-.115*
3. BMI 14-15	.436*	.534*	----	.665*	.042	.073*	.071*	.070	.001	-.063	-.117*
4. BMI 16-17	.456*	.490*	.578*	----	.068	.113*	.042	.050	-.165	-.049	-.116*
5. INT 10-11	.050	.044	.019	.001	----	.354*	.241*	.132*	-.126*	-.112*	-.087*
6. INT 12-13	.050	.042	.024	.013	.380*	----	.461*	.312*	-.084	-.114*	-.131*
7. INT 14-15	.020	.024	-.014	-.014	.245*	.361*	----	.339*	-.055	-.105*	-.159*
8. CES-D 16-17	.049	.007	-.001	.024	.160*	.223*	.273*	----	.114	-.012	-.129*
9. PA 10-11	-.082	-.067	-.009	-.040	-.129*	-.120*	-.071	-.134	----	.388*	.330*
10. PA 12-13	-.079	-.057	-.028	-.032	-.086*	-.139*	-.093*	-.114	.383*	----	.514*
11. PA 14-15	-.069	-.066	-.079*	-.015	-.035	-.135*	-.118*	-.081	.308*	.432*	----

* $p < .001$

Note. Given the large sample size, only correlations with $p < .001$ are reported. Correlations for boys are presented below the diagonal and correlations for girls are presented above the diagonal. "INT" represents the internalizing symptoms score, "PA" represents the physical activity composite score.

Appendix D

Table 4
Parameter Estimates of the Body Mass Index (BMI) Growth Curve Models

	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
Full Sample	18.911*** (.059)	15.635*** (.395)	.463*** (.046)	4.065*** (.486)	.029*** (.008)	.106*** (.027)
Boys	19.161*** (.085)	16.374*** (.581)	.332*** (.067)	3.661*** (.732)	.053*** (.013)	.079 ⁺ (.041)
Girls	18.638*** (.068)	7.839*** (.653)	.623*** (.017)	.279*** (.059)	----	----

⁺ $p < .10$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix E

Table 5
Relationships Among the Parameter Estimates of the BMI Growth Curve Models

	Parameter	Slope	Quadratic
Full Sample	Intercept	-5.445*** (.306) $r = -.683^{***}$	.743*** (.071) $r = .578^{***}$
	Slope		-.618*** (.113) $r = -.943^{***}$
Boys	Intercept	-5.326*** (.442) $r = -.688^{***}$	.675*** (.103) $r = .593^{***}$
	Slope		-.514** (.171) $r = -.954^{***}$
Girls	Intercept	-.489** (.168) $r = -.330^{***}$	----
	Slope		----

*** $p < .001$

Note. Unstandardized covariances with standard errors in parentheses; standardized correlations below.

Appendix F

Table 6
Parameter Estimates of the Internalizing Symptoms Growth Curve Models

	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
Full Sample	3.707*** (.047)	3.474** (1.165)	-.298*** (.038)	.819 (.619)	.053*** (.007)	.039* (.016)
Boys	3.786*** (.068)	6.776*** (1.591)	-.472*** (.053)	2.274** (.831)	.054*** (.010)	.076** (.022)
Girls	3.646*** (.067)	6.975*** (.288)	-.139* (.054)	2.835*** (.304)	.055*** (.010)	.091*** (.012)

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

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix G

Table 7
Relationships Among the Parameter Estimates of the Internalizing Symptoms Growth Curve Models

	Parameter	Slope	Quadratic
Full Sample	Intercept	-0.496 (.801) $r = -.294$	.012 (.124) $r = .033$
	Slope		-.142 (.100) $r = -.796^{***}$
Boys	Intercept	-2.709* (1.090) $r = -.690^{***}$	.354* (.168) $r = .493^{***}$
	Slope		-.380** (.134) $r = -.915^{***}$
Girls	Intercept	-2.990*** (.214) $r = -.672^{***}$	.404*** (.046) $r = .508^{***}$
	Slope		-.463*** (.061) $r = -.914^{***}$

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

Note. Unstandardized covariances with standard errors in parentheses; standardized correlations below.

Appendix H

Table 8
*Relationship Between SES and the BMI and Internalizing Symptoms Growth Curve
 Model Parameter Estimates and BMI and CES-D Scores (Ages 16 and 17) Among Boys
 and Girls*

		Boys	Girls
BMI Trajectory	Intercept	-.071*** (.017)	-.056*** (.016)
Parameter Estimates	Slope	.014 (.013)	-.001 (.004)
	Quadratic	-.002 (.002)	----
	BMI	-.072*** (.019)	-.066** (.020)
Internalizing	Intercept	-.020 (.014)	-.057*** (.015)
Symptoms Trajectory	Slope	.006 (.011)	.012 (.012)
Parameter Estimates	Quadratic	.000 (.002)	-.002 (.002)
	CES-D	.024 (.027)	-.121** (.037)

** $p < .01$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix I

Table 9
*Parameter Estimates of the Parallel-Process Latent Growth Curve Analysis: BMI
 Predicting Internalizing Symptoms Trajectory and CES-D Among Boys*

Predictor Variables	Outcome Variables			
	INT Intercept	INT Slope	INT Quadratic	CES-D at ages 16-17
Initial SES	-.020 (.014)	.008 (.011)	-.001 (.002)	.028 (.027)
BMI Intercept	----	.045*** (.012)	-.009*** (.003)	.009 (.063)
BMI Slope	----	----	.001 (.003)	-.213 (.607)
BMI Quadratic	----	----	----	-.045 (4.939)

*** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses. All regressions controlled for initial socioeconomic status divided by 10,000. "INT" represents the internalizing symptoms.

Appendix J

Table 10

*Parameter Estimates of the Parallel-Process Latent Growth Curve Analysis:
Internalizing Symptoms Predicting BMI Trajectory and later BMI Among Boys*

Predictor Variables	Outcome Variables			
	BMI Intercept	BMI Slope	BMI Quadratic	BMI at ages 16-17
Initial SES	-.075***(.017)	.016 (.013)	-.002 (.003)	-.046* (.023)
INT Intercept	----	.050 (.032)	-.008 (.007)	.056 (.091)
INT Slope	----	----	.009 (.006)	.081 (.349)
INT Quadratic	----	----	-	.304 (1.702)

* $p < .05$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses. All regressions controlled for initial socioeconomic status divided by 10, 000. "INT" represents the internalizing symptoms.

Appendix K

Table 11
*Parameter Estimates of the Parallel-Process Latent Growth Curve Analysis: BMI
 Predicting Internalizing Symptoms Trajectory and CES-D Among Girls*

Predictor Variables	Outcome Variables			
	INT Intercept	INT Slope	INT Quadratic	CES-D at ages 16-17
Initial SES	-.057*** (.015)	.014 (.012)	-.002 (.002)	-.110** (.037)
BMI Intercept	----	.074*** (.019)	-.012** (.004)	.089 (.079)
BMI Slope	----	----	.014 ⁺ (.007)	1.515*** (.476)

** $p < .01$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses. All regressions controlled for initial socioeconomic status divided by 10, 000. "INT" represents the internalizing symptoms.

Appendix L

Table 12
*Parameter Estimates of the Parallel-Process Latent Growth Curve Analysis:
 Internalizing Symptoms Predicting BMI Trajectory and later BMI Among Girls*

Predictor Variables	Outcome Variables		
	BMI Intercept	BMI Slope	BMI at ages 16-17
Initial SES	-.056*** (.016)	.000 (.004)	-.058** (.020)
INT Intercept	----	.019* (.008)	.230*** (.057)
INT Slope	----	----	.032 (.158)
INT Quadratic	----	----	-.889 (.870)

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

Note. Unstandardized coefficients with standard errors in parentheses. All regressions controlled for initial socioeconomic status divided by 10,000. "INT" represents the internalizing symptoms.

Appendix M

Table 13
Parameter Estimates of the Physical Activity Growth Curve Models

	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
Full sample	11.593*** (.110)	12.507* (4.912)	.755*** (.084)	3.852 (2.634)	-.199*** (.015)	.173* (.070)
Boys	11.839*** (.149)	13.958* (6.649)	.660*** (.116)	4.756 (3.532)	-.165*** (.021)	.207* (.094)
Girls	11.359*** (.162)	12.538 ⁺ (7.185)	.826*** (.121)	3.813 (3.877)	-.227*** (.021)	.161 (.102)

⁺ $p < .10$, * $p < .05$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix N

Table 14
Relationships Among the Parameter Estimates of the Physical Activity Growth Curve Models

	Parameter	Slope	Quadratic
Full Sample	Intercept	-2.359 (3.404) $r = -.340$	.329 (.529) $r = .224$
	Slope		-.727 ⁺ (.426) $r = -.891^{***}$
Boys	Intercept	-3.373 (4.601) $r = -.414$	.448 (.716) $r = .264$
	Slope		-.903 (.572) $r = -.910^{***}$
Girls	Intercept	-2.403 (4.978) $r = -.348$	.366 (.772) $r = .258$
	Slope		-.691 (.626) $r = -.883^{***}$

⁺ $p < .10$, $^{***}p < .001$

Note. Unstandardized covariances with standard errors in parentheses; standardized correlations below.

Appendix O

Table 15
Growth Mixture Model Analysis Bayesian Information Criteria (BIC) Scores Among Boys and Girls

	1 class	2 classes	3 classes	4 classes
Boys	46,724.017	46,155.716*	45,785.495*	45,567.286
Girls	46,862.789	46,300.999***	46,045.801***	46,019.572

* $p < .05$, *** $p < .001$

Note. Significant p -values indicated better fit than the previous $k - 1$ model as assessed by the LMR-LRT hypothesis test.

Appendix P

Table 16
Descriptive Statistics for the Regression Variables by BMI Trajectory Classes Among Boys and Girls

	Boys			Girls		
	'Normative'	'Increasing'	'Decreasing'	'Normative'	'Increasing'	'Decreasing'
SES	72,270.20 (50,428.67)	61,896.77 (39,683.17)	60,019.43 (43,368.84)	70,334.08 (44,591.88)	61,429.15 (37,622.82)	59,223.38 (29,406.80)
Pubertal Status	4.99 (1.78)	5.17 (1.82)	5.23 (2.32)	5.50 (1.95)	5.97 (1.96)	6.17 (1.77)
Parent Health	3.93 (.92)	3.71 (1.00)	3.76 (.94)	3.92 (.92)	3.72 (1.02)	3.77 (.97)
% Rural	20.1%	27.6%	25.2%	19.4%	25.4%	29.9%

Note. Means and standard deviations (in parentheses) or percentage provided.

Appendix Q

Table 17
Results of the Multinomial Logistic Regression Among Boys

	'Increasing' BMI Trajectory Class					'Decreasing' BMI Trajectory Class					χ^2
	B	SE	Wald	Exp(B)	95% C.I.	B	SE	Wald	Exp(B)	95% C.I.	
SES	-.06	.02	6.67	.94*	.90, .99	-.04	.03	1.59	.96	.90, 1.02	9.25*
Pubertal Status	.04	.05	.85	1.04	.96, 1.14	.07	.07	1.11	1.07	.94, 1.22	1.81
Parent Health	-.20	.09	5.44	.82*	.69, .97	-.19	.13	2.09	.83	.64, 1.07	6.97*
Rural	.29	.19	2.26	1.32	.92, 1.95	-.06	.32	.03	.95	.51, 1.77	2.25
Overall model fit											
-2LL null model = 1,664.58											
-2LL final model with all variables = 1,638.46; $\Delta\chi^2_{(df=8)} = 26.12^{**}$											

* $p < .05$, ** $p < .01$

Note. 95% confidence interval provided for Exp(B). The reference is the 'normative' BMI trajectory class.

Appendix R

Table 18
Results of the Multinomial Logistic Regression Among Girls

	'Increasing' BMI Trajectory Class					'Decreasing' BMI Trajectory Class					χ^2
	B	SE	Wald	Exp(B)	95% C.I.	B	SE	Wald	Exp(B)	95% C.I.	
SES	-.02	.02	.82	.98	.94, 1.02	-.04	.04	.76	.97	.89, 1.05	1.63
Pubertal Status	.11	.04	6.95	1.11**	1.03, 1.21	.16	.07	5.82	1.18*	1.03, 1.34	11.40**
Parent Health	-.19	.09	4.69	.82*	.69, .98	-.16	.15	1.12	.85	.63, 1.15	5.46 ⁺
Rural	.33	.20	2.63	1.39	.93, 2.06	.66	.32	4.12	1.93*	1.02, 3.63	6.00 ⁺

Overall model fit
-2LL null model = 1,472.57
-2LL final model with all variables = 1,444.25; $\Delta\chi^2_{(df=8)} = 28.32***$

⁺ $p < .10$, * $p < .05$, ** $p < .01$

Note. 95% confidence interval provided for Exp(B). The reference is the 'normative' BMI trajectory class.

Appendix S

Table 19
Model Fit Indices for the Growth Models of Internalizing Symptoms and Physical Activity by BMI Trajectory Class Among Boys

Internalizing Symptoms		BIC	RMSEA (90% C.I.)	CFI	TLI
'Normative' BMI Class	Linear model	35,199.491	.038 (.028, .049)	.935	.944
	Quadratic model [^]	35,187.328	.017 (.000, .034)	.933	.989
'Increasing' BMI Class	Linear model [^]	2,862.113	.000 (.000, .067)	1.000	1.032
	Quadratic model	2,879.440	.037 (.000, .107)	.962	.943
'Decreasing' BMI Class	Linear model [^]	1,177.422	.058 (.000, .132)	.774	.830
	Quadratic model	1,189.190	.080 (.000, .167)	.733	.679
Physical Activity Composite		BIC	RMSEA (90% C.I.)	CFI	TLI
'Normative' BMI Class	Linear model	32,823.884	.056 (.044, .068)	.882	.899
	Quadratic model [^]	32,793.140	.032 (.016, .049)	.978	.967
'Increasing' BMI Class	Linear model	2,807.103	.091 (.048, .058)	.515	.636
	Quadratic model [^]	2,806.543	.027 (.000, .100)	.972	.967
'Decreasing' BMI Class	Linear model [^]	1,169.856	.070 (.000, .154)	.000	-.505
	Quadratic model	1,178.509	.058 (.000, .173)	.323	-.016

Note. [^]Denotes model of best fit.

Appendix T

Table 20
Model Fit Indices for the Growth Models of Internalizing Symptoms and Physical Activity by BMI Trajectory Class Among Girls

Internalizing Symptoms		BIC	RMSEA (90% C.I.)	CFI	TLI
'Normative' BMI Class	Linear model	37,125.872	.046 (.036, .057)	.927	.937
	Quadratic model [^]	37,100.786	.023 (.009, .039)	.989	.984
'Increasing' BMI Class	Linear model [^]	3,332.272	.039 (.000, .083)	.948	.961
	Quadratic model	3,349.114	.064 (.011, .114)	.912	.894
'Decreasing' BMI Class	Linear model [^]	1,260.241	.02 (.000, .111)	.982	.987
	Quadratic model	----	----	----	----
Physical Activity Composite		BIC	RMSEA (90% C.I.)	CFI	TLI
'Normative' BMI Class	Linear model	33,854.969	.075 (.063, .087)	.832	.856
	Quadratic model [^]	33,772.451	.029 (.013, .046)	.985	.978
'Increasing' BMI Class	Linear model	3,070.771	.100 (.062, .141)	.557	.668
	Quadratic model [^]	3,070.102	.051 (.000, .117)	.942	.914
'Decreasing' BMI Class	Linear model [^]	1,086.163	.056 (.000, .141)	.750	.812
	Quadratic model	----	----	----	----

Note. [^]Denotes best-fitting model.

Appendix U

Table 21
Parameter Estimates of the Internalizing Symptoms and Physical Activity Growth Curve Models by BMI Class Among Boys

Internalizing Symptoms	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
'Normative'	3.682*** (.071)	6.790*** (.360)	-.490*** (.055)	2.337 (.395)	.060*** (.010)	.074** (.023)
'Increasing'	4.368*** (.235)	3.592 ⁺ (1.830)	-.317*** (.064)	.194 (.163)	----	----
'Decreasing'	5.063*** (.393)	8.196 ⁺ (4.212)	-.508*** (.106)	.580* (.229)	----	----
Physical Activity	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
'Normative'	11.974*** (.160)	13.455* (6.839)	.654*** (.122)	3.450 (3.616)	-.160*** (.022)	.155 (.096)
'Increasing'	11.319*** (.516)	17.834*** (3.329)	.381 (.443)	15.593*** (4.263)	-.167* (.081)	.586*** (.161)
'Decreasing'	12.114*** (.912)	32.940* (15.639)	-.466 ⁺ (.274)	2.474 (1.695)	----	----

⁺ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix V

Table 22

Parameter Estimates of the Internalizing Symptoms and Physical Activity Growth Curve Models by BMI Class Among Girls

Internalizing Symptoms	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
'Normative'	3.593*** (.071)	2.097 (1.748)	-.182** (.057)	.558 (.941)	.065*** (.011)	.037 (.025)
'Increasing'	3.850*** (.223)	5.498** (1.711)	.201** (.063)	.578*** (.117)	----	----
'Decreasing'	4.056*** (.370)	8.573*** (2.022)	-.002 (.103)	.623** (.195)	----	----
Physical Activity	Intercept		Slope		Quadratic	
	Mean	Variance	Mean	Variance	Mean	Variance
'Normative'	11.520*** (.171)	10.077 (7.536)	.875*** (.128)	2.465 (4.076)	-.233*** (.023)	.121 (.108)
'Increasing'	9.866*** (.551)	18.280 (23.027)	.954* (.417)	11.277 (12.210)	-.279*** (.074)	.418 (.317)
'Decreasing'	8.324*** (.795)	18.630*** (5.207)	.374 (.244)	2.707** (.842)	----	----

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

Note. Unstandardized coefficients with standard errors in parentheses.

Appendix W

Table 23

Relationships Among the Parameter Estimates of the Growth Curve Models and CES-D by BMI Class Among Boys

		Internalizing Symptoms Trajectory Parameters			
'Normative' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	-2.022*** (.491) <i>r</i> = -.208**	.560 (.459) <i>r</i> = .098	-.082 (.097) <i>r</i> = -.081	-6.062* (2.651) <i>r</i> = -.316*
	Slope	.341 (.414) <i>r</i> = .068	-.567 (.362) <i>r</i> = -.193	.112 (.072) <i>r</i> = .215	2.495 (1.691) <i>r</i> = .252
	Quadratic	.009 (.085) <i>r</i> = .009	.074 (.070) <i>r</i> = .121	-.018 (.013) <i>r</i> = -.168	-.350 (.258) <i>r</i> = -.171
'Increasing' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	-.910 (1.720) <i>r</i> = -.114	-.082 (.508) <i>r</i> = -.046	----	-6.162 (7.743) <i>r</i> = -.302
	Slope	.084 (1.483) <i>r</i> = .012	.043 (.421) <i>r</i> = -.027	----	4.694 (5.574) <i>r</i> = .251
	Quadratic	-.042 (.280) <i>r</i> = -.302	-.017 (.076) <i>r</i> = -.055	----	-.864 (.887) <i>r</i> = -.238
'Decreasing' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	.071 (4.138) <i>r</i> = .004	.613 (1.178) <i>r</i> = .116	----	-7.291 (8.698) <i>r</i> = -.198
	Slope	-.257 (1.175) <i>r</i> = -.041	-.149 (.325) <i>r</i> = -.087	----	-1.824 (2.557) <i>r</i> = -.152
	Quadratic	----	----	----	----

p* < .05, *p* < .01, ****p* < .001

Note. Unstandardized covariances with standard errors in parentheses; standardized correlations below.

Appendix X

Table 24

Relationships Among the Parameter Estimates of the Growth Curve Models and CES-D by BMI Class Among Girls

Internalizing Symptoms Trajectory Parameters					
'Normative' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	-1.312* (.510) $r = -.241^+$	.284 (.507) $r = .088$	-.011 (.110) $r = -.016$	1.539 (3.842) $r = .077$
	Slope	.267 (.433) $r = .100$	-.745 ⁺ (.394) $r = -.467$	.115 (.080) $r = .328$	-.845 (2.355) $r = -.086$
	Quadratic	-.046 (.087) $r = -.078$	.142 ⁺ (.074) $r = .406$	-.026 ⁺ (.014) $r = -.336$	-.079 (.345) $r = -.037$
'Increasing' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	-2.832 (1.781) $r = -.291$	.484 (.635) $r = .153$	----	.085 (10.487) $r = .003$
	Slope	.580 (1.345) $r = .079$	-.003 (.443) $r = -.001$	----	6.466 (6.822) $r = .285$
	Quadratic	-.104 (.243) $r = -.074$	-.024 (.073) $r = -.052$	----	-1.631 (1.061) $r = -.374$
'Decreasing' BMI Trajectory Class		Intercept	Slope	Quadratic	CES-D
Physical Activity Trajectory Parameters	Intercept	1.059 (2.460) $r = .085$	.426 (.735) $r = .131$	----	.774 (11.427) $r = .032$
	Slope	-.465 (.872) $r = -.096$	-.176 (.246) $r = -.014$	----	-.777 (3.145) $r = -.082$
	Quadratic	----	----	----	----

⁺ $p < .10$, * $p < .05$

Note. Unstandardized covariances with standard errors in parentheses; standardized correlations below.

Appendix Y

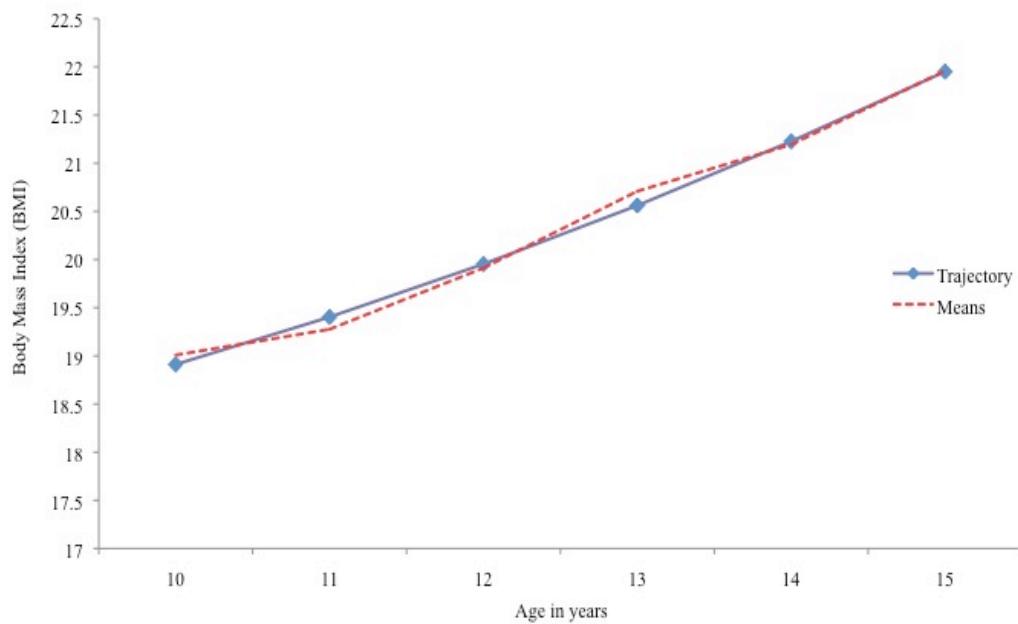


Figure 1. Fitted growth curve and means of body mass index (BMI) among the full sample. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix Z

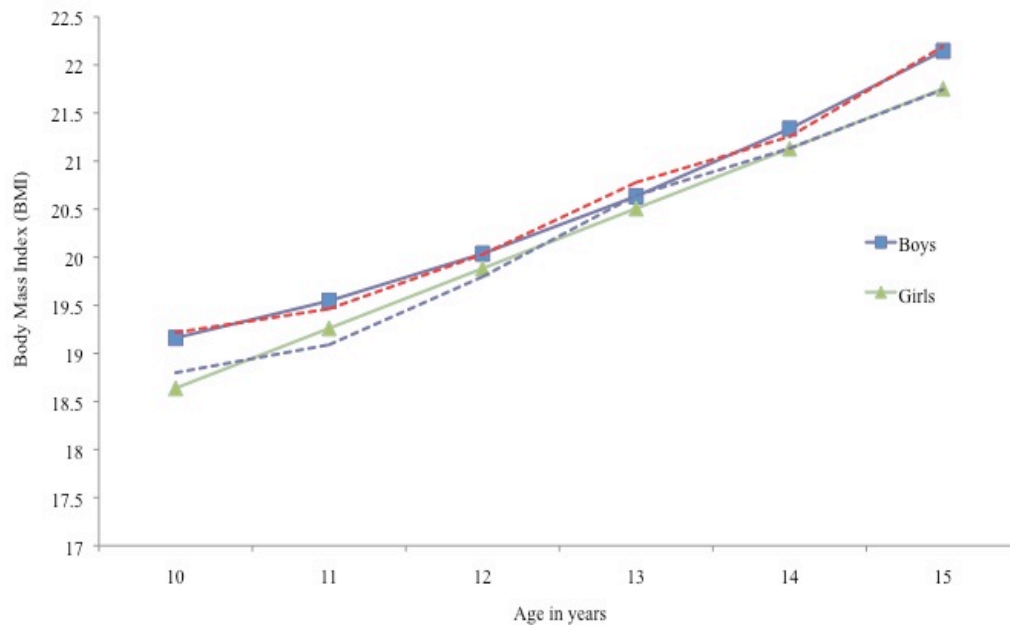


Figure 2. Fitted growth curves and means of body mass index (BMI) scores among boys and girls separately. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix AA

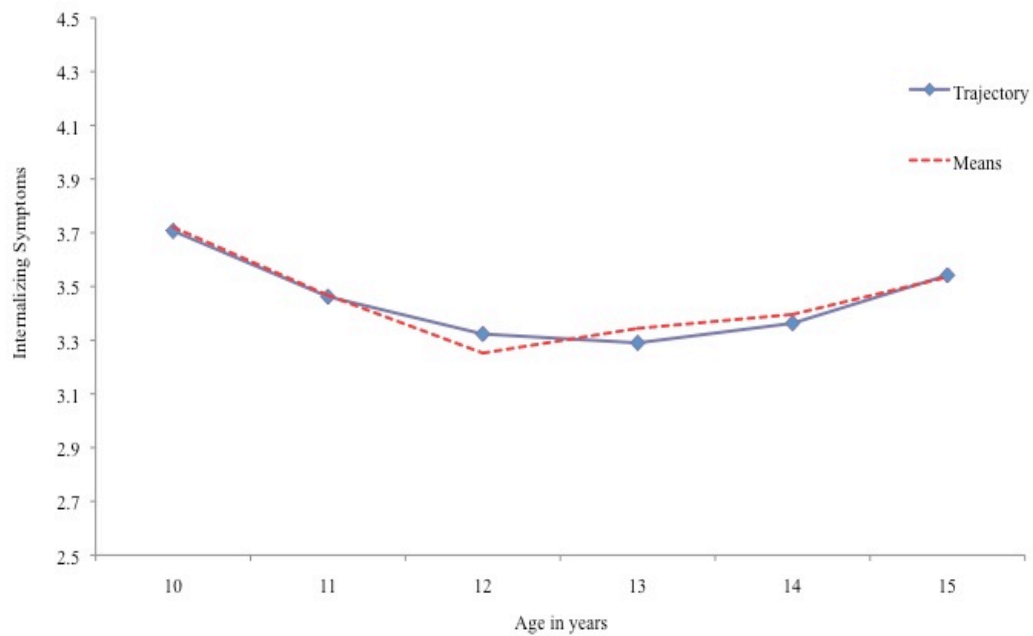


Figure 3. Fitted growth curve and means of internalizing symptoms among the overall sample. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix BB

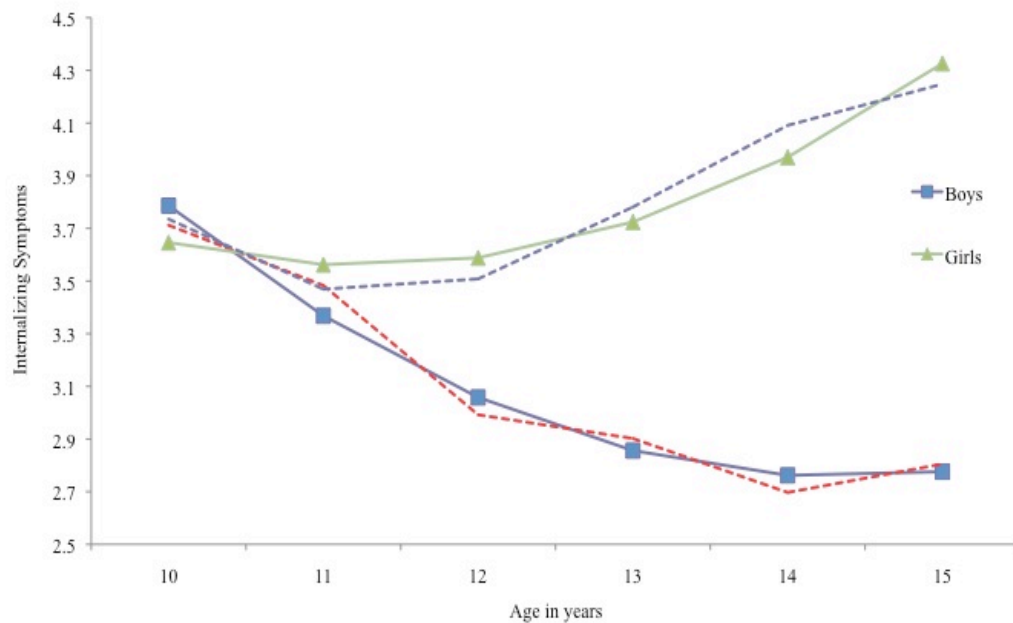


Figure 4. Fitted growth curves and means for internalizing symptoms among boys and girls separately. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix CC

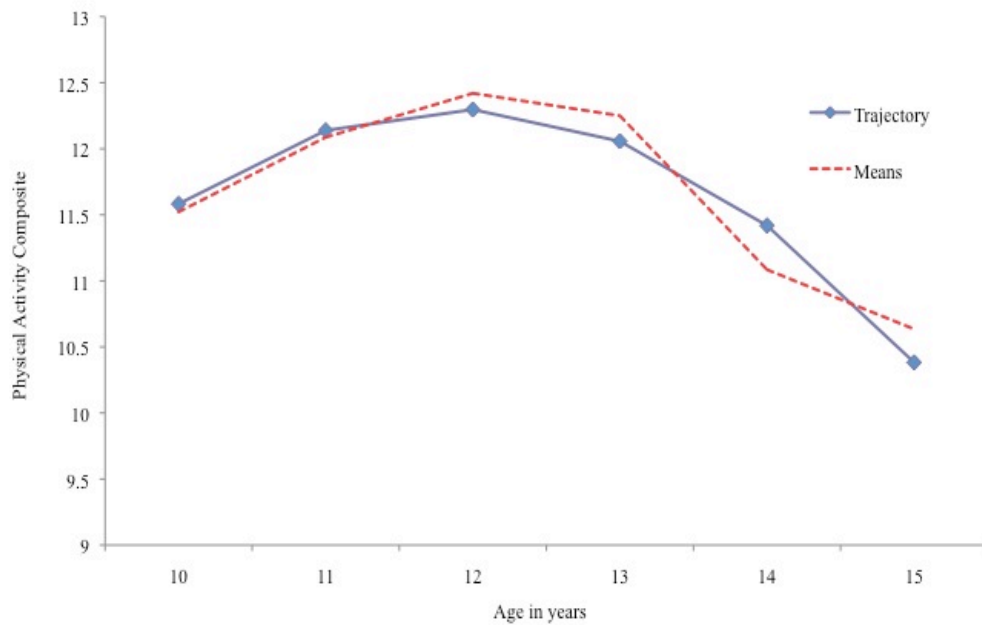


Figure 5. Fitted growth curve and means of the physical activity composite among the full sample. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix DD

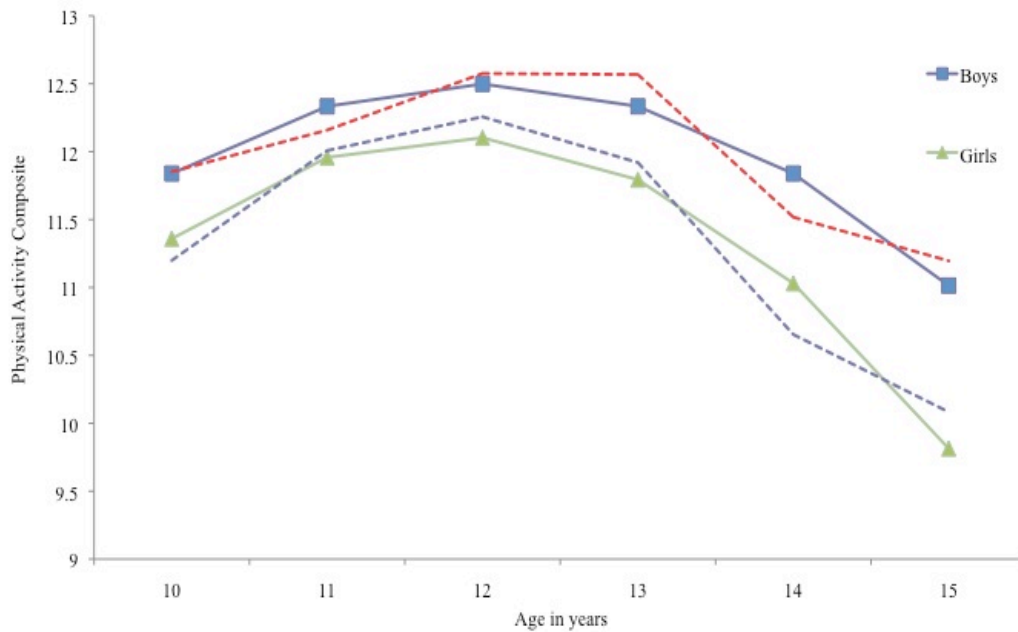


Figure 6. Fitted growth curves and means of the physical activity composite among boys and girls separately. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix EE

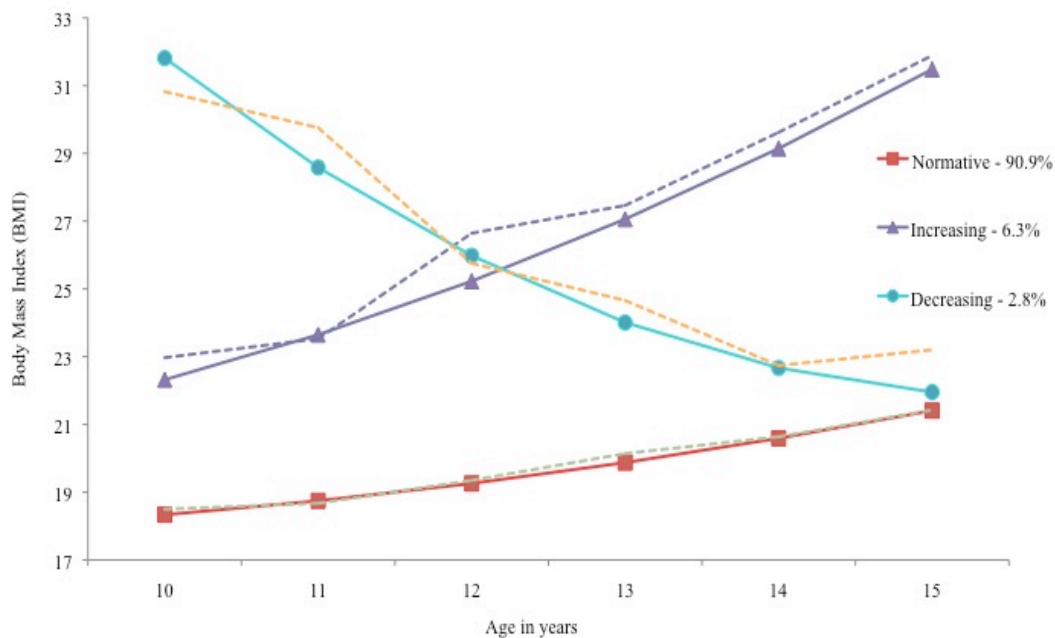


Figure 7. Fitted growth curves and means of the three BMI classes among boys. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix FF

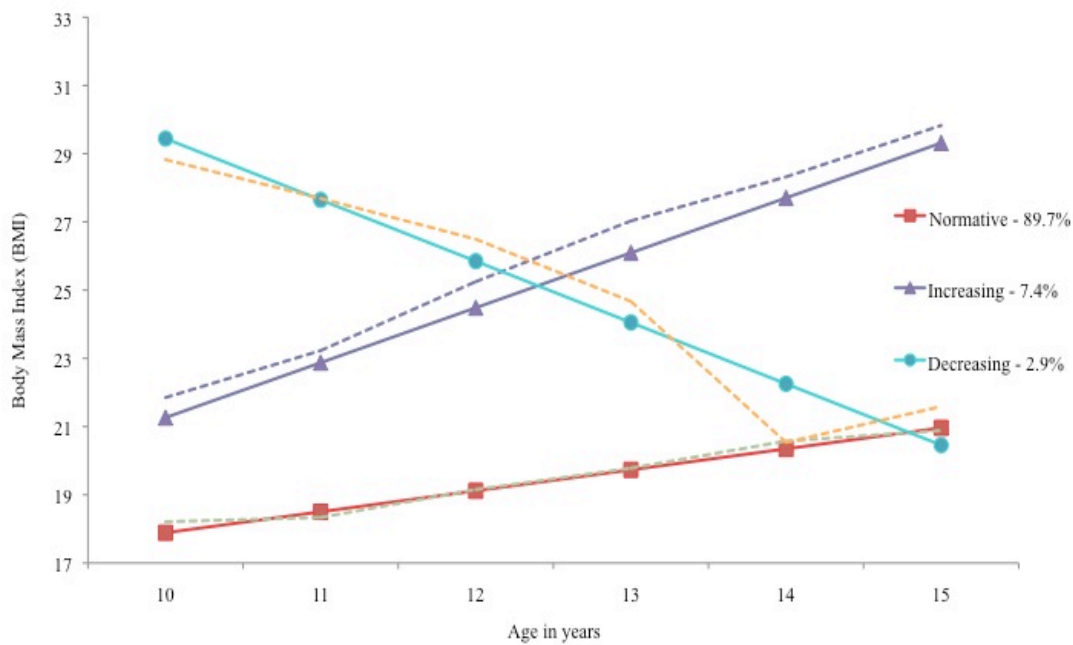


Figure 8. Fitted growth curves and means of the three BMI classes among girls. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix GG

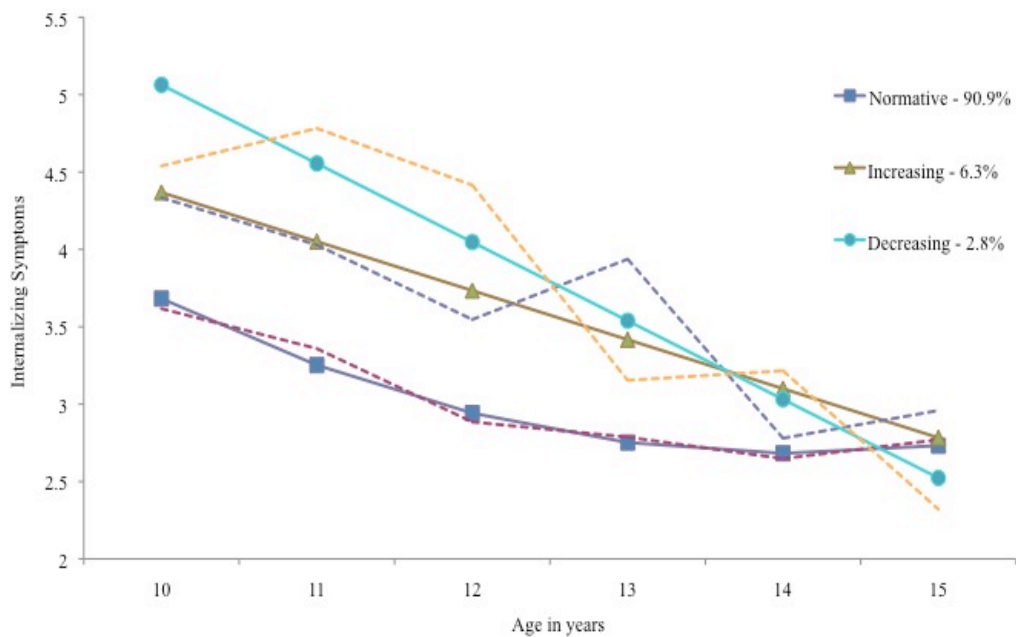


Figure 9. Fitted growth curves and means of internalizing symptoms among the three BMI classes for boys. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix HH

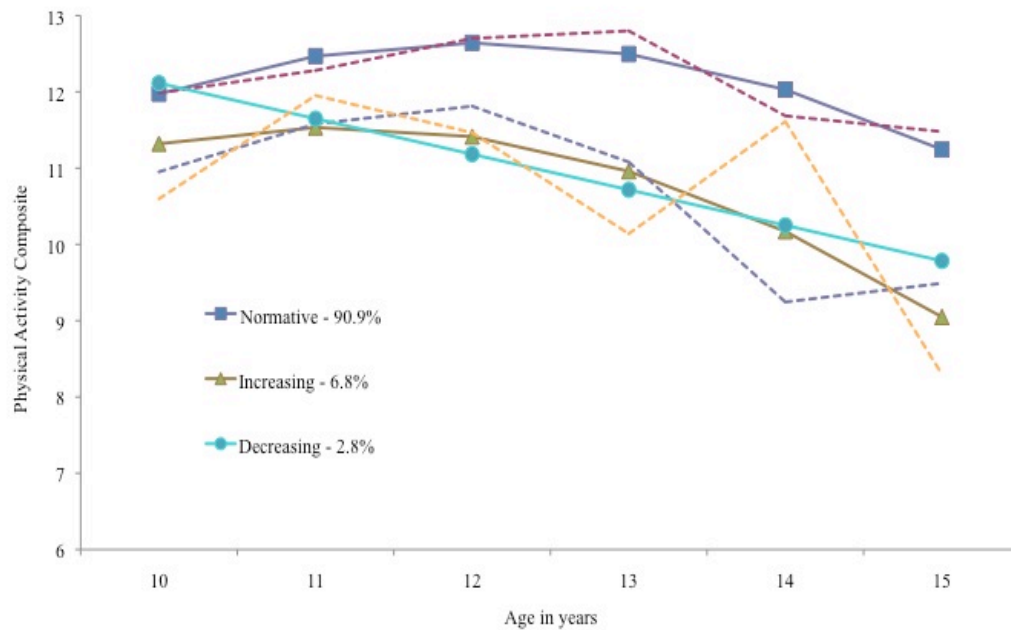


Figure 10. Fitted growth curves and means of the physical activity composite among the three BMI classes for boys. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix II

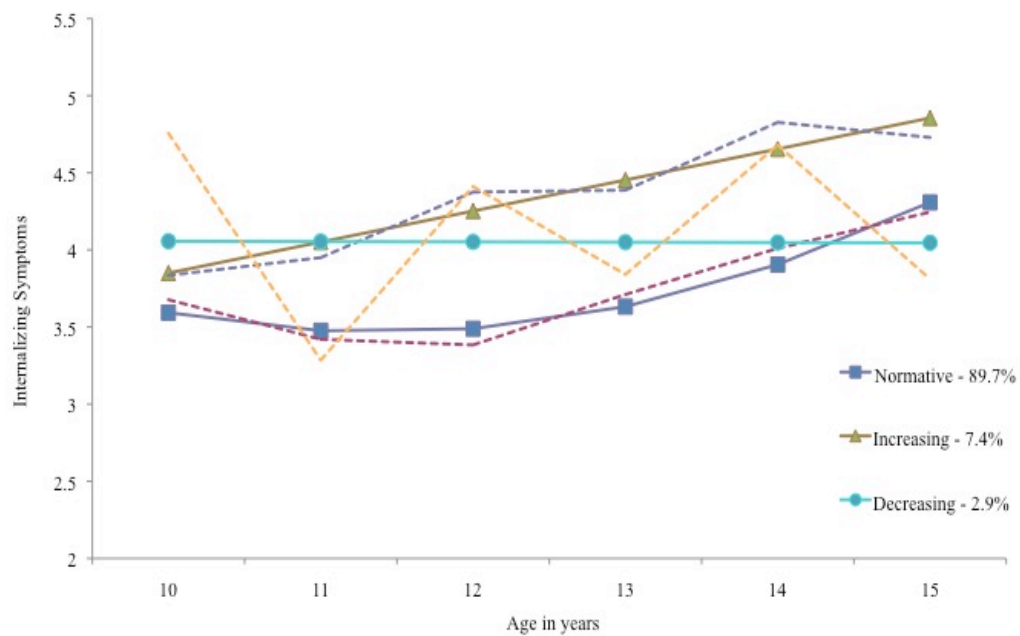


Figure 11. Fitted growth curves and means of internalizing symptoms among the three BMI classes for girls. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.

Appendix JJ

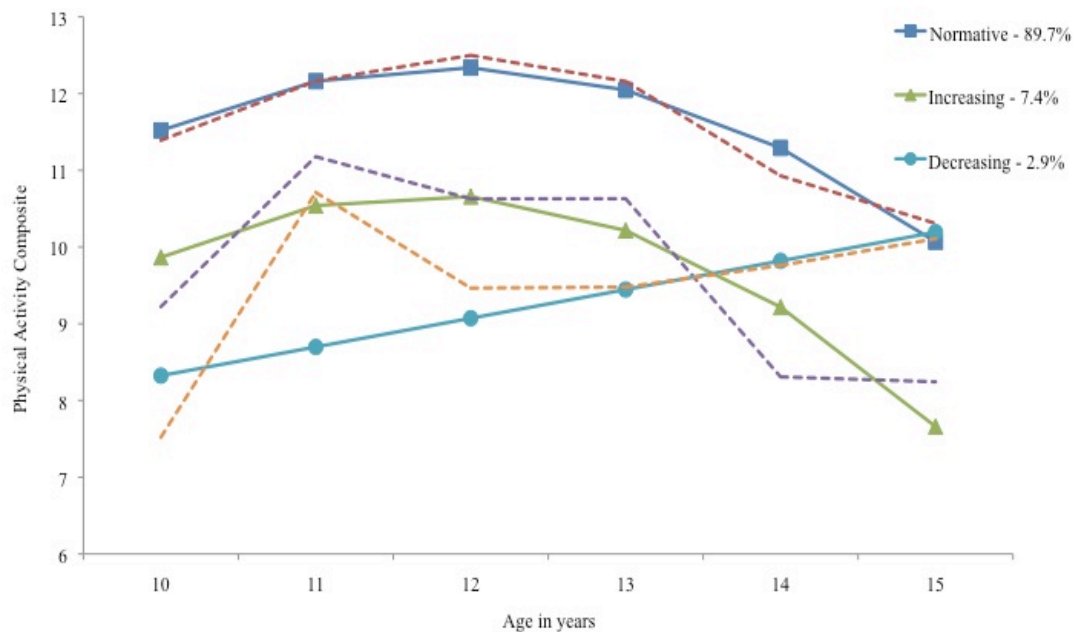


Figure 12. Fitted growth curves and means of the physical activity composite among the three BMI classes for girls. *Note.* Solid line represents the prototypical trajectory; whereas dashed line represents the observed means.