Testing a conceptual model related to weight perceptions, physical activity and smoking in adolescents

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Abstract
The purpose of this study was to test a conceptual model based on theoretical and empirically supported relationships related to the influences of weight perceptions, weight concerns, desires to change weight, friends, age and location in relation to physical activity (PA) and smoking in adolescents. A total of 1242 males and 1446 females (mean age = 15.6 ± 1.3) were recruited from rural and urban Canadian schools. Study respondents provided self-reports of PA, ‘smoking’, ‘perceived body weight’, ‘desire to change weight’, ‘concern about weight gain’ and ‘friends’ smoking and PA behaviors’. Results revealed an acceptable fitting model $\chi^2 (40) = 155.63, P < 0.05$, root mean square error of approximation = 0.047 and comparative fit index = 0.98. Large effect sizes for both genders were observed between friends’ and adolescents’ smoking behavior, and between perceived body weight and desire to change weight. Further, significant differences were identified between the male and female models $[\chi^2$ difference $(24) = 65.28, P < 0.05]$. Several findings of this study point to the need to design programs to motivate adolescent females to adopt healthy weight-control practices and to target young peoples’ social networks to promote health behaviors, especially with regard to smoking.

Introduction
Physical inactivity and smoking are two behaviors that influence the development of many chronic health conditions. Research evidence has shown that physical inactivity is associated with an increased risk of cardiovascular disease, obesity, Type 2 diabetes, colon cancer and osteoporosis [1]. Smoking is believed to be the major cause of lung cancer and a cause of many other forms of cancer [2].

Physical activity (PA) and smoking are also two behaviors that some adolescents adopt as weight loss practices [3, 4]. In accordance with Festinger’s Social Comparison Theory [5] and Social Identity Theory [6], social and cultural norms reinforced by media messages emphasizing a thin and physically fit body make many adolescents become preoccupied with their body weight leading them to seek out various methods of weight loss [7]. Weight perception is an important aspect of self-representation during adolescence [8].

Many theories suggest that adolescents are likely to engage in certain behaviors when they associate with others who engage in these behaviors [9]. Social Learning Theory [10, 11] highlights the mechanism of social influence, and states that behaviors are learned through the observation of others engaged in a behavior and subsequent
modeling of that behavior. According to Primary Socialization Theory [12], norms and behaviors are learned in social contexts and this theory identifies peer clusters as an important primary influence of health behaviors. Social Network Theory [13–15] emphasizes the interdependence between individuals and the relational ties that exist between individuals within a social system, where a social system refers to a targeted population that can be identified by specific boundaries, such as children in a classroom, a school or a neighborhood setting. Influences of peer pressure and/or support from friends on PA [16] and smoking [17, 18] of adolescents behavior have been empirically supported in the literature.

‘Age’ has also been found to be consistently associated with both PA [19] and smoking [20]. There is evidence that smoking initiation and prevalence among adolescents typically rise with increasing age and grade [21–24], whereas PA, especially vigorous activity, significantly decreases as youth get older [20].

The literature on adolescent weight-management behavior suggests that regional differences (‘geographical location’) also play a role in weight perception and in weight-management goals and practices [25]. In general, individuals living in large cities seem to engage in better health-promoting behaviors [26]. Findings on rural–urban differences for PA have been inconsistent [27, 28], whereas for smoking, some studies have suggested that a higher proportion of rural youth report ‘trying smoking’ than urban school students [29].

Adolescents go through complex physical, psychological and social changes during their development into young adults, and therefore their ‘desire to change weight’ varies with age [30, 31]. Geographic location could also have effects on the desire to change weight in adolescents as a result of varying environmental, social and media influences [26]. Further, ‘friends’ PA’ as well as ‘friends’ smoking’ could also potentially influence the desire to change weight, as a result of social influences [9–18]. Further, desire to change (lose) weight has been linked to smoking behavior in adolescents [3, 32–34], although the relationship between desire to change weight and PA behavior has not been adequately explored. It is logical to assume that the desire to change weight could have a mediating role between the exogenous variables discussed above (age, location, friends’ PA levels and friends’ smoking behaviors) with PA and smoking behavior. It is also logical to assume that ‘perceived body weight’ and ‘weight gain concern’ may have a direct influence on the desire to change weight and in turn influence PA and smoking behavior. Indeed, evidence suggests that perceived body weight is strongly correlated with the desire to change (lose) weight in adolescents (8). It is important to elucidate how the above key variables may be playing a role in smoking and PA and to gain a better understanding of the interrelationships between these variables.

Research suggests that males and females differ with regard to factors influencing PA and smoking. A consistent finding across studies using both self-report and objective measures of PA shows females are less physically active than males across all ages [35], and smoking initiation is higher among female than male adolescents [36]. Further, body image and weight concerns have been found to be more important for females than males, and studies have reported females trying to lose weight were more likely to be current smokers [37, 38]. There also appears to be gender differences regarding peer influences on health-related behaviors. Many studies show that females may be more susceptible than males to peer influences on health-related behaviors [39, 40]; however, males appear more likely to be influenced by risk-taking behaviors [37].

The purpose of the present study was to test a conceptual model based on the above theoretical and empirically supported relationships related to the influences of weight perceptions, weight concerns, desires to lose weight, friends, age and geographical location related to PA and smoking. Since it is evident from the above discussion that there could be major differences for males and females, this study also examines whether the model significantly varies between adolescent males and females. Given the high prevalence of physical inactivity and smoking in adolescents and
the fact that obesity has emerged as the most common pediatric chronic illness in western countries [41], further research is needed to explore the relationship between these factors and behaviors. This is one of the few studies to examine the interrelationships between PA, smoking and weight perceptions in youth. Further, such potential variables to explain PA and smoking behavior to date have not been simultaneously examined within a structural model in an adolescent population.

Methods

This study reports secondary results from a prevalence study [29] on PA and smoking among Canadian high school students. Four rural schools in the province of Alberta and four urban schools in the province of Ontario were randomly selected from eligible provincial schools agreeing to be part of the survey. Twelve eligible public schools across four school districts in rural, central Alberta were initially contacted, of which four schools were chosen to participate in the study. The communities of these 12 schools were congruent on census-based, community-level socioeconomic characteristics. Forty-six schools (across two school districts) were contacted in urban Ontario, of which four schools were selected. All public schools within these two districts were also congruent on community-level, socioeconomic characteristics.

The total response rate across the eight schools was 81.5%. There were no exclusion criteria in this study. Permission to carry out the study was granted by the schools’ principals, parents and adolescents. Classroom teachers supervised the completion of the questionnaires with the researchers present to answer any questions. The questionnaires were completed anonymously. Ethics approval for this study was granted by University-based ethics committees.

Measures

The questionnaire items were initially pilot tested with high school students in Grades 9–12 to assess face and criterion validity (using a series of focus groups with youth, public health practitioners and school teachers). Further, a 2-week reproducibility study was undertaken with 200 adolescents. Questions demonstrating test–retest correlations >0.75 were retained. Questions below this criterion were either dropped or modified. A final pilot consisted of administering the modified instrument to 1714 students in one high school. Students in the current study completed a questionnaire consisting of measures listed below.

Physical activity

The PA measure was based on the estimation equation of energy expenditure reported in the Canada Fitness Survey [42, 43] and provided an estimate of PA in the past week. Participants self-reported the frequency and duration of moderate and hard PA over the period of 1 week. These scores were multiplied with a summary metabolic equivalent (MET) score for each intensity level to create energy expenditure scores. The MET score used was the mean of the range for each intensity level [i.e. MET (moderate) = 3.95, MET (hard) = 5.95]. These MET score ranges were adapted from the 7-day PA recall [44] and have been demonstrated as valid and reliable for 11th-grade children [45]. The sum of moderate and hard intensity energy expenditure scores created on estimation of the energy expenditure.

Smoking behavior

Smoking behavior was assessed using the item ‘think about the last 30 days. Did you smoke a cigarette, even just a few puffs?’ with the response options ‘every day or almost every day (1)’, ‘some days (2)’, ‘1 or 2 days (3)’, ‘not at all (4)’ and ‘I do not smoke (5)’ [46]. Friends’ PA was assessed with the item ‘how many of your closest friends participate in physical activity?’ with the response options ‘none of them (1)’, ‘a few of them (2)’, ‘most of them (3)’ and ‘all of them (4)’. Friends’ smoking was assessed with the item ‘how many of your closest friends smoke?’ with the response options ‘none of them (1)’, ‘a few of them (2)’, ‘most of them (3)’ and ‘all of them (4)’. 
Body weight perceptions
Perceived body weight was assessed with the item ‘do you think you are’ with the response options ‘underweight (1)’, ‘neither underweight nor overweight (2)’ or ‘overweight (3)’. Desire to change weight was assessed with the item ‘over the next 12 months would you like to’, with the response options ‘lose weight (1)’, ‘stay the same weight (2)’ or ‘gain weight (3)’. Weight gain concern was assessed with the item ‘with respect to gaining weight, are you’ with the response options ‘not concerned (1)’, ‘concerned (2)’, ‘very concerned (3)’ or ‘terrified (4)’.

A conceptual model was developed and tested based on theoretical and empirical evidence presented in the Introduction section. School ‘location’ (urban versus rural), age, friends’ PA and smoking behaviors were considered as exogenous variables. Direct paths were hypothesized (see Figs 1 and 2 for all tested hypothesized paths) between the aforementioned variables, including body weight perceptions, desires and concern, PA and smoking behavior. Desire to change weight was tested as a mediator between the exogenous variables and PA and smoking. A direct relationship between perceived body weight and weight gain concern with desire to change weight was also tested.

Analysis
Gender specific bivariate correlations, means and standard deviations were computed for all variables. To test the conceptual model, a 2-group (males, females) simultaneous structural equation analyses using LISREL 8.20 for Windows [47] were employed. Our approach in model testing was to simultaneously evaluate all paths of our a priori conceptual model. Systematic testing procedures were focused on stacking this model by gender and testing (via chi-square differences and Cohen’s effect size $q$) the structural coefficient variance/invariance across models. Indicators were all single item and fixed for 25% error with the exception of age and location which were fixed at 5% error. The fixed error method represents an attempt to place constraint within single indicator models that may better represent the measurement model if multiple items were available [48]. Twenty-five percent error was utilized for broader domains of social cognition and behavior recall based on an estimated multi-item $z$ of 0.75. Since age and location are less abstract questions with less chance of random response error, these items were fixed at only 5% error.

One of the strengths of structural equation modeling is its ability to estimate a complete model fit, incorporating both structural and measurement considerations. A number of statistics exist to assess the adequacy of structural models [49]. For the current study, root mean square error of approximation (RMSEA) was included as an absolute fit index and the comparative fit index (CFI) was included as an index of incremental fit. General rules of thumb for acceptability of model fit using these indexes are $>0.94$ for the CFI and $<0.07$ for RMSEA [50].

Finally, to examine differences in the gender-based models, the unconstrained structural effects across the two groups were systematically compared with constrained (to be equal) effects. Using this analysis, evidence for a moderator relationship is apparent if the $\chi^2$ is significantly larger for the constrained model than the unconstrained model [47, 49].

Results
Mean age of the sample was $15.6 \pm 1.3$. The sample consisted of 46% females and 54% males. Of the females, 51.8% were from urban schools and 56.0% were from rural schools. Of the males, 48.2% were from urban schools and 44.0% were from rural schools. In total, 86% of our sample were white. Ethnicities included Asian (1.4%), Middle eastern (1.6%) and other ethnicities (10.7%). The mean Body Mass Index (BMI) calculated according to the Centers for Disease Control and Prevention classification for age percentiles by sex [51] was $21.5 \pm 3.8$ m$^{-2}$. In the urban sample, 10.0% females and 20.7% males were overweight/obese. In the rural sample, 15.1% females and 26.9% males were overweight/obese.
Listwise deletion of missing data resulted in a sample of 1184 males and 1414 females [a loss of 58 males and 32 females from the originally recruited sample (the subsamples of 58 males and 32 females did not significantly differ on demographic or behavioral characteristics with their corresponding gender groups that completed the entire questionnaire)]. Bivariate correlations and descriptive statistics are shown in Tables I and II for males and females, respectively. Males exhibited higher means on PA energy expenditure ($t = 10.74$, $P < 0.001$) and on the number of friends participating in PA ($t = 7.95$, $P < 0.001$). Males were less likely to report desire to change weight ($t = 27.48$, $P < 0.001$). Females were more likely to report that they are overweight ($t = 9.86$, $P < 0.001$) and that they are concerned with gaining weight ($t = 18.49$, $P < 0.001$).

The results of the structural equation model analysis are shown in Fig. 1 for males, and in Fig. 2 for females. The results revealed an acceptable fitting model $\chi^2 = 155.63$, $P < 0.05$, RMSEA = 0.047 and CFI = 0.98. A significant difference, however, was identified between the male and the female models when all structural paths were constrained to equality and then compared with a model where these same parameters were estimated freely ($\chi^2$ difference = 65.28, $P < 0.05$). As a result, path coefficients were systematically compared between models to examine which paths were moderated by gender.

Paths of the same magnitude between males and females were identified for three of the structural coefficients. The highest associations were observed between friends’ smoking behavior and adolescents’ smoking behaviors in both males

### Table I. Bivariate correlations and descriptives (means and standard deviations) for males (n = 1184)

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<th>9</th>
<th>Mean (SD)</th>
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<tbody>
<tr>
<td>1. PA/energy expenditure/week</td>
<td>0.10**</td>
<td>-0.04</td>
<td>-0.15***</td>
<td>0.33***</td>
<td>-0.07*</td>
<td>-0.07*</td>
<td>0.12***</td>
<td>-0.07*</td>
<td>1560.45 (1000.05)</td>
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<tr>
<td>2. Smoking behavior</td>
<td>0.00</td>
<td>-0.26***</td>
<td>0.14***</td>
<td>-0.60***</td>
<td>-0.02</td>
<td>-0.04</td>
<td>-0.00</td>
<td>3.65 (1.60)</td>
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<tr>
<td>3. Location (1 = urban, 2 = rural)</td>
<td>0.06*</td>
<td>-0.10**</td>
<td>0.02</td>
<td>0.03</td>
<td>-0.06</td>
<td>-0.06</td>
<td>—</td>
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<tr>
<td>4. Age</td>
<td>-0.17***</td>
<td>0.24***</td>
<td>0.03</td>
<td>-0.01</td>
<td>-0.03</td>
<td>15.68 (1.33)</td>
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<td>5. Friends PA</td>
<td>-0.19***</td>
<td>-0.03</td>
<td>0.06*</td>
<td>-0.04</td>
<td>2.69 (0.74)</td>
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<td>6. Friends smoking</td>
<td>0.07*</td>
<td>0.05</td>
<td>—</td>
<td>2.15 (0.88)</td>
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<tr>
<td>7. Perceived body weight</td>
<td>-0.51***</td>
<td>0.16***</td>
<td>1.99 (0.61)</td>
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<td>8. Desire to change weight</td>
<td>-0.22***</td>
<td>2.20 (0.86)</td>
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<td>9. Weight gain concern</td>
<td>—</td>
<td>1.42 (0.74)</td>
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*P < 0.05; **P < 0.01; ***P < 0.001.

### Table II. Bivariate correlations and descriptives (means and standard deviations) for females (n = 1414)

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<th>Mean (SD)</th>
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<tbody>
<tr>
<td>1. PA/energy expenditure/week</td>
<td>0.06*</td>
<td>0.05</td>
<td>-0.07**</td>
<td>0.29***</td>
<td>0.01</td>
<td>-0.07**</td>
<td>0.03</td>
<td>-0.04</td>
<td>1168.47 (829.39)</td>
</tr>
<tr>
<td>2. Smoking behavior</td>
<td>-0.10***</td>
<td>-0.14***</td>
<td>0.15***</td>
<td>-0.61***</td>
<td>-0.04</td>
<td>0.04</td>
<td>-0.09***</td>
<td>3.61 (1.56)</td>
<td></td>
</tr>
<tr>
<td>3. Location (1 = urban, 2 = rural)</td>
<td>-0.05</td>
<td>-0.03</td>
<td>0.09**</td>
<td>0.07*</td>
<td>-0.01</td>
<td>-0.02</td>
<td>—</td>
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<tr>
<td>4. Age</td>
<td>-0.17***</td>
<td>0.11***</td>
<td>0.03</td>
<td>-0.04</td>
<td>0.03</td>
<td>15.58 (1.25)</td>
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<tr>
<td>5. Friends PA</td>
<td>-0.13***</td>
<td>-0.04</td>
<td>-0.03</td>
<td>-0.07**</td>
<td>2.47 (0.70)</td>
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<tr>
<td>6. Friends smoking</td>
<td>0.01</td>
<td>-0.05</td>
<td>0.08*</td>
<td>2.12 (0.82)</td>
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<tr>
<td>7. Perceived body weight</td>
<td>-0.51***</td>
<td>0.35***</td>
<td>2.22 (0.54)</td>
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<tr>
<td>8. Desire to change weight</td>
<td>-0.38***</td>
<td>1.39 (0.59)</td>
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<td>9. Weight gain concern</td>
<td>—</td>
<td>2.02 (0.89)</td>
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*P < 0.05; **P < 0.01; ***P < 0.001.
Friends’ PA behavior was also associated with males’ and females’ PA (standardized effect = 0.24 for both males and females). Perceived body weight was negatively associated with desire to change weight in both males (standardized effect = −0.65) and females (standardized effect = −0.57).

Two paths significantly differed by gender when comparing the two models. Friends’ smoking behavior was significantly ($\chi^2$ difference = 5.41, $P < 0.05$) related to ‘concern about weight gain’ more for females than males (effect size $q = 0.10$). Moreover, weight gain concern was associated with the desire to change weight significantly ($\chi^2$ difference = 3.98, $P < 0.05$) more for females than males (effect size $q = 0.12$).

Based on Cohen’s [52] effect size estimates for standardized path coefficients (small = 0.10, medium = 0.30, large = 0.50), large effects were found for friends’ smoking and adolescent’s smoking behavior and perceived body weight and desire to change weight. Furthermore, close to medium effects were obtained for friends’ PA and adolescents’ PA and for females’ weight gain concern and desire to change weight.

**Discussion**

Since PA levels among young people decline rapidly from childhood to adolescence [19], and most adults begin smoking before 18 years of age [53], it is crucial to examine factors associated with these behaviors in youth. Further, in view of the fact that obesity has reached epidemic levels in the developed world [54], exploring interrelationships between weight perceptions, PA and smoking among adolescents is important.

The strong direct effect of friends’ smoking with adolescents’ smoking behavior and adolescents’ PA behavior with the number of friends...
engaging in PA observed in our model is consistent with empirical and theoretical evidence presented in the Introduction. However, an interesting finding of this study is that the association between number of friends who smoke and adolescents’ smoking behavior was much stronger than the respective association with PA. This large and close to medium effect sizes found for smoking and PA, respectively, underscore the importance of targeting adolescents’ social networks when implementing intervention programs to promote healthy behaviors, especially for smoking cessation. There is evidence that schools are ideal and convenient settings in which to base health behavior interventions [55], as adolescents spend the majority of their day in this context and come in contact with their peers, who may also be part of their after-school social network.

The large direct effect revealed between perceived body weight and desire to change weight, for both males and females, is consistent with the literature [8]. Further, in our study, females exhibited significantly higher means (according to our t-test results) on weight perceptions and desire to change weight than males. This is consistent with other studies that have found that females are more likely to consider themselves overweight, and more likely to try to lose weight in comparison with males [56–58], perhaps suggesting that females may be targeted as a priority population in weight-control intervention programs.

Two significant differences between the male and female models were detected. Although the effect sizes for these differences were small, according to Cohen’s [52] classification, the findings are nevertheless interesting. The first was the higher association found between weight gain concern and desire to change weight among females than males. As mentioned before, the modern female image portrayed through mass media, may lead to social pressures for females to lose weight, is a potential explanation for this.
finding, and is also supported by empirical evidence that suggests females express greater peer and family influences on weight concern than males [59]. An implication of this social pressure might be that females seek a number of strategies to reduce their body weight, thus risking employing unhealthy weight-control practices. In one prospective study [60], females who dieted more than once per week at baseline had four times the adjusted odds of becoming smokers at 20-month follow-up in comparison with females who did not diet. These findings are also supported with cross-sectional studies where frequency of cigarette smoking was related to adolescent females’ attempts to lose weight [8, 61].

The second difference between the male and female models was that friends’ smoking was significantly related to weight gain concern for females, but not for males. This perhaps suggests that females who have concern about their weight are more likely to have friends who smoke. Although it is not exactly clear what this result signifies, it is possible that this finding relates to social influences of smoking as well as the use of unhealthy practices of weight maintenance. Previous studies suggest that early stages of smoking initiation are highly related to friends’ smoking behavior [4] and highlights the importance of helping adolescents, especially females improve their social skills [62], and to develop positive self-concepts [63] so as to resist the social pressure for smoking. Adolescent females who smoke report to have less positive self-concepts and poorer body image in comparison with non-smokers, and rely more on others to cope with stressful situations [63]. With regard to using unhealthy practices of weight maintenance, it is important to dispel the notion of tobacco use as a method of weight control, as well as motivate individuals to use other weight loss practices that do not have the health risks that are associated with smoking. Lack of association between weight perceptions and smoking behavior in the present study may be partly explained by under-reporting of this behavior; smoking may not be considered a socially desirable behavior by some adolescents, in light of broad national antismoking campaigns taking place across Canada.

A number of small effects were also detected in the ‘within’ model analyses. Interestingly, age was inversely related only to males’ PA. One study [19] reported the greatest decreases in males’ objectively assessed vigorous PA were between Grades 4–9, whereas in females’ activity, the largest decreases were found between Grades 1–6. More studies are needed to determine crucial ages for interventions designed to prevent PA declines.

A further discrepancy between males and females observed in this study is that in the male model, friends’ smoking had an indirect effect on adolescents’ PA through its effect on desire to change (gain) weight, which was not observed in the female model. Although this is a somewhat unexpected finding, it may be that males are motivated to find a more healthy weight change alternative in spite of having friends who smoke (note that these friends could be females). The desire to gain weight in males is in accordance with the findings of Middleman et al. [8] where hard exercise, stretching and toning were associated with trying to gain weight in males only. The desire to gain weight in males may be related to building muscle mass and gaining a masculine appearance as portrayed in media.

A further gender difference was that in the female model, number of friends engaging in PA was related to females’ desire to change weight. This finding is encouraging as it suggests that females who have friends who participate in PA have the desire to change (lose) weight. However, the lack of a relationship between PA and the desire to change weight among females in the present study suggests there is a need to find ways of motivating females to engage in PA (although another potential explanation can be related to the sample’s relatively small proportion of obese/overweight females versus the proportion of obese/overweight males).

In examining mediating effects, friends’ smoking had an indirect effect on the desire to change weight through its association with weight gain concern, perhaps suggesting that it is more important to address weight gain concern rather than the desire to change weight in intervention programs geared
toward a group of adolescent females. It is important to keep in mind that youth need to be educated to accurately assess whether their own body weight is within healthy limits [56], as evidence from other research studies suggests that youth and young adults tend to overestimate their weight. In a study of college students, Lowry et al. [57] found that although 35% of college students were overweight or obese (based on BMI), 42% considered themselves to be overweight, and 46% reported that they were trying to lose weight (although it is also possible that BMI is not an accurate measure of adiposity). Another mediating effect observed in the male model revealed weight gain concern and perceived body weight had an indirect effect on PA through its association with desire to change weight. This was not observed in the female model.

In our study, a significant bivariate relationship between PA and smoking was observed. However, the order of magnitude of this relationship was very small (0.10 and 0.06 for males and females, respectively). According to the literature, the relationship between these two behaviors is known to be complex even among adults [64, 65] and inconsistent findings have been reported for adolescents [66, 67].

Strengths of the present study include the large sample employed from two different Canadian provinces, and being the first study to simultaneously examine interrelationships between discussed variables using structural equation modeling. There are however some limitations of this study that must be acknowledged. First, the cross-sectional nature of this study lowers the level of causal inference relative to prospective observational studies. Second, this study reported data from only two provinces in Canada. Third, the single-item variables adopted in the present study may have eliminated our ability to estimate latent variables for our structural model. Although, we attempted to compensate for this limitation by adding reasonable fixed error estimates, these estimates may have suppressed or enhanced the strength of association between different measures depending on the accuracy of our estimates. Fourth, the reliance on self-reports for the surveyed items, such as for friends’ behaviors and self-reported BMI and behaviors, is a limitation. Fifth, our study did not include the assessment of parental influences, which according to the literature is an important determinant of adolescent PA and smoking behaviors. Finally, other measurement limitations include (i) friends’ PA behavior did not include a time frame or intensity levels and (ii) friends’ smoking behavior did not differentiate between experimental and heavy smokers. Future research should address these limitations.

**Implications for practice**

Several findings of this study point to the need to design programs to motivate adolescent females to adopt healthy weight-control practices, and to specifically address weight gain concern in females. Associations found between friends’ smoking and friends’ PA with the adolescents’ respective behaviors suggest that targeting young peoples’ social networks may be an effective strategy for promoting health behaviors, especially with regard to smoking.

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**Conflict of interest statement**

None declared.

**References**

1. Kesaniemi YK, Danforth E, Jensen MD et al. Dose-response issues concerning physical activity and health: an
Physical activity, smoking and weight perceptions in adolescents


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