Changes in physical activity in adolescent girls: a latent growth modelling approach

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Abstract
Aim: To examine: (1) the developmental trajectory of physical activity as well the influence of body mass index (BMI) and friend support on initial physical activity and change of physical activity; and (2) the stability of physical activity in adolescent girls.

Methods: Participants were 193 urban adolescent girls and their best friends. Physical activity was measured using the 3-day physical activity recall. Best friend social support was assessed using a questionnaire. BMI was calculated based on height and body mass of the participants. Data were collected on four occasions over a 1.75-year period.

Results: The stability coefficients for moderate, vigorous and total physical activity were statistically significant and ranged from 0.25 to 0.62. There was a curvilinear decrease in physical activity and a curvilinear increase in BMI and friend social support across four measurement occasions. Latent growth modelling (LGM) revealed that initially higher level of friend social support was associated with higher physical activity, and higher level of BMI was associated with lower levels of physical activity. With the physical activity change factor, there were statistically significant and positive direct effect from friend social support change factor, and statistically significant and negative direct effect from BMI change factor.

Conclusion: Change in friend social support was positively and change in BMI was inversely associated with a change in adolescent girls’ physical activity.

INTRODUCTION
Physical activity is an important predictor of the short- and long-term health of children (1,2). Children and adolescents who participate in higher levels of physical activity are less likely to display risk factors for cardiovascular disease (3,4) and more likely to have positive outcome in weight regulation (5). There is also an agreement that participation in physical activity can promote social well-being and mental health among young people (6). Additionally, there is also evidence for the notion that patterns of physical activity established in youth may persist into adulthood (7). These benefits have led to the development of national physical activity recommendations for children and adolescents (8,9).

However, previous studies on the relationship between physical activity and adiposity in youths have produced inconsistent results. While some studies show overweight status or adiposity to be inversely related to physical activity participation, others report no association (13–15). These findings may, in part, be related to the cross-sectional nature of the studies that does not enable one to assess the influence of the physical activity/inactivity on the overweight and adiposity of the children and adolescents (11).

Social support has been cited as an important correlate of physical activity (7,16). Social support has been defined in numerous ways, generally referring to any behaviour that assists an individual in achieving desired goals or outcomes (9). Research in the physical activity domain has demonstrated the importance of peer or friend support in physical activity (16,17). Despite the importance of peers in influencing adolescent physical activity, few studies have examined this influence or have included peers as part of the physical activity support network for youths (17). Duncan et al. (16) found that friend support was a stronger influence on 10- to 14-year-olds’ physical activity than parent or sibling support. More recently, Duncan et al. (17) found that efficacy to overcome barriers, physically active friends and friend social support were all significant predictors of physical activity from ages 12–17 years.

Appropriate statistical methods for longitudinal data are necessary to best examine change in adolescent...
evaluated the impact of body mass index (BMI) and friend support on adolescent physical activity, no study has simultaneously examined these variables. Many variables have been identified as potential correlates of physical activity during this developmental period (20). Although few longitudinal studies on physical activity have been conducted during adolescence (17). To best determine how to encourage adolescent physical activity, an etiological and developmental longitudinal research is needed to understand the changing patterns and determinants of physical activity during this developmental period (20). Although many variables have been identified as potential correlates of adolescent physical activity, no study has simultaneously evaluated the impact of body mass index (BMI) and friend support on initial physical activity and change in physical activity. Thus, the purpose of the present study is to determine the effect of BMI and friend support on initial physical activity and change in physical activity. It was hypothesized that BMI is negatively and friend social support is positively related to physical activity. The second aim of the study was to examine the stability of physical activity in adolescent girls because during this developmental period a marked decrease in physical activity was demonstrated (3). Knowledge about when physical activity behaviour is most and least stable has implications for the timing of physical activity interventions. Developmental periods during which stability is relatively low may be easier targets of intervention programmes.

MEASURES

Body mass index
Body height was measured using the Martin’s metal anthropometer to the nearest 0.1 cm; body weight was measured with the medical scales to the nearest 0.1 kg and BMI (weight [kg]/height squared [m²]) was computed.

Physical activity
Physical activity was assessed using the 3-day physical activity recall (3DPAR) (21). The 3DPAR required participants to recall physical activity behaviour from 3 previous days of the week (first Tuesday, then Monday, then Sunday); the instrument always was completed on Wednesday. Those 3 days were selected to capture physical activity on 1 weekend day and 2 weekdays. To improve the accuracy of physical activity recall, the 3 days were segmented into 34 30-min blocks, beginning at 7.00 a.m. and continuing through to 12.00 p.m. To further aid recall, the 34 30-min blocks were grouped into broader time periods (i.e. before school, during school, lunch time, after-school, supper time and evening). The 3DPAR included a list of 55 commonly performed activities grouped into broad categories (i.e. eating, work, after school/spare time/hobbies, transportation, sleeping/bathing, school and physical activities and sports) to improve activity recall. For each block of each day, participants entered the main activity in which they participated during each 30-min time period. Participants also rated the relative intensity of the designated activity as light, moderate, hard or very hard. The validity of the 3DPAR as a measure of usual activity has been established based on correlations with the objective measures (CSA 7164 accelerometer) of physical activity. Self-reported total METs, 30-min blocks of moderate-to-vigorous physical activity and 30-min blocks of vigorous physical activity were all significantly correlated with analogous CSA variables in adolescent girls (21). To help participants select the correct intensity level, the instrument provides pictorial representations of the four levels of relative intensity.

SUBJECTS AND METHODS

Participants and design
Participants were 193 adolescent girls recruited from four high schools in city Tartu, Estonia. The high schools were randomly selected from the complete list of the schools of the city. These four schools included 277 potential participants for the study, 233 (84 %) of which agreed to participate by signing (with parent signature) the consent form. Of these 233, 193 (83%) students completed the full four waves of the study. Data were collected on four occasions over a 1.75-year period. The four occasions were fall of 2004 (beginning of the sixth grade; baseline data), spring 2005 (end of the sixth grade), fall of 2005 (beginning of the seventh grade) and spring 2006 (end of seventh grade; follow-up data). The sample initially had a mean age of 12.6 years (standard deviation [SD] 0.5). In total, 74.5% of participants are from two-parent families. All procedures were approved by the University Ethics Committee. Written informed parental, child and school consent was obtained for all participants.

Friend social support
A questionnaire developed by Duncan et al. (16) was used to assess peer social support of adolescent physical activity. In this instrument, adolescents were asked the extent to which their friends provided different types of support. These included informational and emotional support (‘encourage you to do physical activities’, ‘talk with you about your physical activity’, ‘thinks I should be physically active’) and instrumental support (‘do a physical activity with you’). Questions asked how often during a typical week best friend did these things. Responses were on a 5-point scale ranging from 1 (never) to 5 (very often). The internal consistency for the friend social support scale in this was α = 0.72.
Data analysis
We used latent LGM to examine the stability in physical activity across time. LGM analyses were performed using LISREL 8.71 (for Windows; Scientific Software International, Lincolnwood, IL, USA) with full-information maximum likelihood estimation (22). This method can describe a single individual’s development trajectory and capture important group statistics in a way that allows the researchers to study development at the group level. LGMs are able to test both linear and nonlinear growth functions and determine which predictor variables affect the rate of development. In this study, adolescents’ physical activity was not represented by a single variable but as a latent factor reflecting three variables (total METs, 30-min blocks of moderate-to-vigorous physical activity and 30-min blocks of vigorous physical activity). LGM is a two-stage process that involves examining the pattern of change in a variable of interest, for example, physical activity, across time (the first stage). The second stage of LGM involves examining the relationship between measures of physical activity and BMI, as an example. This model includes the first stage of LGM plus the addition of paths (β-coefficients) between initial status latent variables and between the change latent variables. All of the β-coefficients are presented as completely standardized parameter estimates and, thus, can be more easily interpreted based on the standardized units rather than the original metric of the variables.

RESULTS
Descriptive statistics
Means and variances for physical activity and covariates (BMI and friend social support) are shown in Table 1. Differential stability coefficients for 3-day physical activity (METs, moderate physical activity and vigorous physical activity) are shown in Table 2.

The stability coefficients for moderate, vigorous and total physical activity (METs) were statistically significant and ranged from 0.25 to 0.62. As expected, the stability of the physical activity decreases when the time interval between measurements increases. In general, the present results indicate a moderate differential stability of the physical activity in adolescent girls.

<table>
<thead>
<tr>
<th>Time 1 to time 2</th>
<th>Time 1 to time 3</th>
<th>Time 1 to time 4</th>
<th>Time 2 to time 3</th>
<th>Time 2 to time 4</th>
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<tbody>
<tr>
<td>Physical activity</td>
<td>Stability</td>
<td>3DPA (METs/day)</td>
<td>MPA (blocks/day)</td>
<td>VPA (blocks/day)</td>
<td>BMI (kg/m²)</td>
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<tr>
<td>Time 1 to time 2</td>
<td>0.57*</td>
<td>0.62*</td>
<td>0.51*</td>
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<td>Time 1 to time 3</td>
<td>0.48*</td>
<td>0.52*</td>
<td>0.42*</td>
<td>0.43*</td>
<td>0.36*</td>
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<td>Time 1 to time 4</td>
<td>0.35*</td>
<td>0.40*</td>
<td>0.25**</td>
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<td>Time 2 to time 3</td>
<td>0.41*</td>
<td>0.43*</td>
<td>0.36*</td>
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<td>Time 2 to time 4</td>
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<td>Time 3 to time 4</td>
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*p < 0.005, **p < 0.001.

Physical activity first-stage LGM
The growth of physical activity was best described by an optimal growth function with a heteroscedastic residual structure. This model provided an excellent fit for the physical activity data (Chi-square 2.97, RMSEA 0.011, NNFI 0.958, CFI 0.963). The mean scores provided in Table 1 illustrate the curvilinear change in physical activity across time. There was a large initial decrease in physical activity at time 2 and time 3, followed by a smaller decrease in physical activity at the final measurement (time 4).

BMI first-stage LGM
The growth in BMI was best described by an optimal growth function with a homoscedastic residual structure. This model provided an excellent fit for the BMI data (Chi-square 2.97, RMSEA 0.011, NNFI 0.958, CFI 0.963). The mean provided in Table 1 illustrate the curvilinear change in BMI across time. There was a large initial increase in BMI, followed by a smaller increase in BMI at the following measurements.

Friend social support first-stage LGM
The growth in friend social support was best described by an optimal change function and a homoscedastic residual structure. This model provided an excellent fit for the data (Chi-square 1.35, RMSEA 0.005, NNFI 0.988, CFI 0.989). The mean scores provided in Table 1 illustrate the curvilinear change in friend social support across time. There was an initial increase in friend social support from time 1 to time 2 and from time 2 to time 3, which was followed by a smaller increase from time 3 to time 4.

Physical activity, BMI and friend social support second-stage LGM
We tested a model specifying direct effects of initial status and change factors for BMI and friend social support on initial status and change factors for physical activity. Based on our first-stage LGM analyses, physical activity was modelled as an optimal change function with heteroscedastic residuals; BMI and friend social support were modelled as optimal change functions with homoscedastic residuals. The model provided an excellent fit to the data (Chi-square 178.87, p < 0.001; RMSEA 0.038, NNFI 0.984, CFI 0.988). Figure 1 showed completely standardized path coefficients between BMI, friend social support and physical activity. With the physical activity initial status factor, there was significant
Figure 1 Model linking BMI, friend support and physical activity. PA = physical activity. The path coefficients are presented in completely standardized units. Y1–Y4 represent indicators of BMI; Y5–Y8 represent indicators of friend social support and Y9–Y12 represent indicators of physical activity.

and positive direct effect from friend social support ($\beta_{5,3} = 0.25$) initial status factor, and a negative direct effect from BMI ($\beta_{5,1} = -0.09$) initial status factor. Thus, initially higher level of friend social support was associated with initially higher physical activity, and higher level of BMI was associated with lower levels of physical activity. With the physical activity change factor, there were statistically significant and positive direct effect from friend social support ($\beta_{6,4} = 0.51$) change factor, and statistically significant and negative direct effect from BMI ($\beta_{6,2} = -0.17$) change factor. Thus, change in friend social support was positively and change in BMI was inversely associated with a change in physical activity across time.

DISCUSSION

The present study represents one of the few longitudinal studies examining the developmental trajectory of physical activity of adolescent girls. Moreover, the influence of BMI and social support from friends on initial physical activity and on the change in the physical activity was measured. As hypothesized, the results of the study provide evidence that BMI was found to be inversely and friend social support was found to be positively related to initial level and change in physical activity. In addition, results indicated moderate stability of adolescent girls' physical activity across a 1.75-year period.

Social relationships and social support are the key elements of the social environment that influences health-related behaviour. However, the impact of social support on adolescent physical activity has not been widely assessed (16). In general, the findings of this study support previous research indicating that friend social support is positively related to adolescent girls’ physical activity. Duncan et al. (16) found that friends who support and watch youths engage in activities were significantly and positively related to youth physical activity level. Voorhees et al. (23) reported that frequency of activity with friends was the most significant independent predictor of adolescent girls' own physical activity. Sallis et al. (24) found that peer support influenced vigorous physical activity among youths and was significant in the youngest groups of boys and girls, suggesting that peer support in physical activity is important for younger children as well as for adolescents.

In the current study, the perceived friend social support was positively associated with physical activity of adolescent girls. Specifically, the results of LGM analyses demonstrated that initial status and change in friend social support were independently associated with initial status and change in physical activity. The present findings provide evidence that the cross-sectional association between friend social support and girls physical activity was weaker ($\beta_{5,3} = 0.25$) than the longitudinal association ($\beta_{6,4} = 0.51$). The stronger longitudinal association between changes in friend social support and adolescent girls' physical activity has greater health importance than the weaker cross-sectional association. The longitudinal association demonstrates that naturally occurring changes in friend social support have a positive relationship with naturally occurring changes in leisure-time physical activity. Thus, health promotion and health education interventions should pay more attention to the behaviour-specific social networks during adolescence (23). These social networks include not only friends but also the
interrelations with significant others (parents, coaches and teachers) in a broader social environment (at home, at school, etc.). Clearly, more research investigating adolescents’ activity-related social support is needed using objectively measured physical activity (25) and applying longitudinal rather than cross-sectional research.

Lack of physical activity is hypothesized to be an important contributing factor in the development and/or maintenance of childhood obesity (12). However, previous studies on the relationship between physical activity and adiposity in youths have produced inconsistent findings (14). While some studies show overweight status or adiposity to be inversely related to physical activity participation, others report no association (13,26). Such contradictory findings may, in part, be related to the difficulties associated with obtaining valid and reliable measures of physical activity in children and adolescents (13). A novel finding of the present study was that a decrease in physical activity participation was associated with an increase in BMI during early adolescence. The second-stage LGM analyses demonstrated the stronger longitudinal association between changes in BMI and girls’ physical activity when compared to cross-sectional association between these variables. Such findings encourage the development interventions that attempt to increase physical activity levels as a method of reducing adiposity among adolescents (26).

Many of the values and beliefs that regulate health-related behaviour are learned during adolescence, and habits are formed that may last a lifetime (27). Despite this, few studies have been conducted that assessed the stability (or tracking) of physical activity during adolescence. However, a better understanding of the stability of physical activity has implications for the timing of physical activity interventions. In line with previous research (27–29), our results indicate a moderate differential stability of physical activity in adolescent girls. As expected, the longer the time interval between measurements, the lower the differential stability coefficients for the physical activity. Additionally, the stability of moderate-intensity physical activity was higher when compared with the stability of vigorous physical activity across a period of 1.75 years. This finding is consistent with previous research (50), which indicates that high-intensity physical activity is less stable compared to low-intensity physical activity in adolescent female population. Knowing the stability of physical activity provides insight as to when root determinants and early antecedents of this behaviour occur. In addition, knowledge about when physical activity is most and least stable has implications for the timing of physical activity interventions. Developmental period during which stability is relatively low may be an easier target for intervention programmes (29). The findings from present study indicate that early adolescence can be a critical developmental period during which different physical activity interventions could be applied. The transition from childhood to adolescence is associated with rapid maturational changes, shifting societal demands and exploration of new roles. These changes may impact the health-related behaviour of adolescent girls, which, in turn, may explain a decrease in physical activity participation.

Some limitations of this study warrant consideration. First, the measurement of physical activity in children and youths using self-report questionnaires has some limitations. Measurement of youth physical activity is difficult, with no measure being perfect for every situation. Because results of the study are affected by the physical activity measures, it must be noted that other studies with different methods may yield different results. Second, although growth was thoroughly studied, no other anthropometric measures of adiposity, such as skin-fold measurements or waist circumference, were obtained at any data point. As BMI does not directly measure body fat, it is recognized as a practical surrogate for adiposity (31). Third, the study was conducted in and around only one town of Estonia and only girls’ physical activity level was examined. Further studies are encouraged to use a longer time interval and a more representative sample of adolescent girls and boys.

The present study also has several strengths. Previous research on children and adolescents’ physical activity participation has been conducted largely with Western European and North American children and adolescents, and there are limited research data on this topic from Baltic and East European countries. Therefore, it is important to note the cross-cultural importance of our results. In addition, longitudinal data across four time points were collected and analysed using LGM. One of the most notable merits of LGM in describing change is the capability of modelling and analysing change at the individual level. This does not mean that an LGM estimates the change parameters of every person, but rather, that an LGM estimates the between-person variation as well as the mean of individual change. The latent variable approach is a powerful technique for the operationalization of physical activity as it offers an efficient and appropriate way to combine several physical activity variables into one factor for analysis (18). The inclusion of individual (BMI) and peer covariates (friend social support) is also the strength of the present study.

In summary, our findings indicate that adiposity, assessed by BMI, was found to be inversely and friends’ social support was found to be positively related to initial level and change in physical activity. A positive social support from friends to adolescent physical activity indicates that the influence of friends should be carefully taken into account when planning physical activity interventions for that age group. In addition, our findings have implications for the timing of interventions aimed to increase physical activity participation because only ‘moderate’ stability of physical activity across a 1.75-year period was demonstrated. Our results suggest that interventions should target early adolescence because the stability of physical activity is relatively low.

References


