Modeling Individual and Physical Environmental Factors with Adolescent Physical Activity

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Background: Recent calls have been made to consider both environmental factors and individual-level factors in the explanation of physical activity (PA). The present study tested a conceptual model that integrated past PA, relevant environmental-level and individual-level factors and their associations with adolescent PA, using the tenets of the Theory of Planned Behavior (TPB).

Methods: Data were gathered in an adolescent sample (n=221; 60% girls) using questionnaires. PA was assessed in May 2003 and November 2003. Theory of Planned Behavior cognitions regarding PA and the environmental factors under study were assessed in November 2003. Confirmatory factor analyses and path analyses were performed using AMOS software.

Results: The initial structural model did not provide an acceptable fit to the data. Including a direct path from past PA to current PA significantly improved model fit to an acceptable fit. Including a direct path from past PA to environmental perceptions did not significantly improve model fit. Including a direct path from the environmental variables to current PA did not significantly improve model fit. Current PA was most strongly influenced by past PA, while environmental aesthetics and distance to PA opportunities were indirectly related to adolescents' intention to be physically active. Significant standardized path coefficients ranged from 0.14 to 0.34 and explained 17% variance in current PA.

Conclusions: Combining past PA, Theory of Planned Behavior cognitions, and environmental factors increased our understanding of their relative influences on adolescent PA. Implications for future research on physical activity are discussed.

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Introduction

Lack of physical activity (PA) among adolescents presents a major burden to public health,[1,2] and its increasing prevalence rates and associated health risks underline the need to develop interventions that are aimed at increasing adolescents' PA levels. Theory provides the foundation for PA interventions[3] and one social-cognitive theory that has proven its worth in understanding PA is the Theory of Planned Behavior (TPB).[4] Briefly, the TPB proposes that the most proximal and intrapersonal determinant of volitional behavior is the intention to perform that behavior. In turn, intention is theorized to be predicted by three social-cognitive factors, namely, attitude, subjective norm, and perceived behavioral control (PBC). Both quantitative and qualitative reviews of the TPB provide support for its use in understanding PA.[5–7] Nevertheless, a large part of the variance generally remained unexplained,[5] leaving researchers to identify additional intrapersonal factors that can be usefully added to the TPB. Past behavior has frequently been suggested as one such factor. Empirical evidence shows residual effects of past PA on current PA when TPB cognitions are taken into account,[8–10] indicating that past PA is an important intrapersonal determinant of current PA. However, studies investigating the influence of past PA on adolescents' current PA are limited and generally assessed past PA retrospectively with a single item,[8,9] indicating that more research is needed, using longitudinal designs and more valid assessments of PA.

Although inclusion of such additional intrapersonal factors may allow for better understanding of the determinants of PA, recent empirical evidence highlights the importance of physical environmental

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influences on adolescent PA.[11–14] A focus on these broader determinants of health behavior is consistent with an ecologic perspective of behavior,[15] but there are significant conceptual and methodologic challenges in identifying how such physical environmental factors might influence PA,[16,17] with many studies on PA being atheoretical.[16] Because ecologic models have generally not included cognitive variables,[18] practical and theoretical progress in understanding PA might benefit from combining the environmental factors used in ecologic models with the behavior-specific cognitive factors used in social-cognitive models. Although some authors have argued for the existence of a direct unmediated influence of environmental factors on PA,[4,19] the TPB postulates that the influence of environmental factors is mediated by PBC and intention.[4] Mediation by social cognitions may provide a plausible explanation for why some studies fail to find a strong association between environmental factors and physical activity,[20,21] but PA determinant studies that have included both environmental-level and individual-level variables[22,23] have failed to address social cognitions as mediating variables in the environment–PA relationship.

When studying physical environmental influences on adolescent PA, most studies to date have focused on school environments.[24] Neighborhood influences have rarely been included in studies on adolescent PA,[25,26] even though neighborhood influences, such as attractiveness and proximity to local facilities, have been found to be positively associated with PA in adults.[27–29]

The present study tested a conceptual model that explored the relative influences of past PA, neighborhood attractiveness, local facilities, and behavior-specific cognitions on current PA, using the theoretical tenets of the TPB.

Methods

Data from the SMILE study (Study on Medical Information and Lifestyles in Eindhoven [SMILE]), an ongoing prospective cohort study, were analyzed. The SMILE study is a joint project of Maastricht University and 23 general practitioners (GPs) from nine family practice centers (FPC) in Eindhoven, a city of approximately 200,000 inhabitants located in the southern part of the Netherlands. The distribution of gender and age in Eindhoven is similar to that of the Netherlands.[30] The nine participating FPCs cover approximately 50,000 patients. Each patient aged over 12 years registered at the participating FPCs is requested every 6 months to complete a self-administered questionnaire that is sent to his/her home address. Participant addresses are obtained through the GPs. Anonymity is guaranteed, and respondents are informed that GPs would not be notified about participation. Present analyses focus on adolescents aged 12 to 18 years. In line with informed consent regulations, only adolescents for whom informed consent was received from both the individual and their parents were included in the present study. In May 2003 and November 2003, 476 (263 girls and 213 boys; mean age=15.0 years; SD=2.1) and 507 (303 girls and 204 boys; mean age=14.9; SD=2.0) adolescents, respectively, completed these questionnaires. Respondents who completed both questionnaires (n=221; 51%) were included in the present study (88 boys and 133 girls; mean age=15.1; SD=1.9). Attrition analyses revealed no significant differences in age (odds ratio [OR]=1.09; p=0.06) and past PA (OR=1.00; p=0.53), but boys were less likely (OR=.66; p=0.029) to complete both questionnaires.

Measures

Physical activity was assessed in May 2003 and November 2003, while environmental perceptions, behavior-specific cognitions, age, and gender were assessed in November 2003. Based on a validated questionnaire[31] for assessing adult PA, respondents were asked to indicate on how many days per week and for how many minutes per day they were engaged in walking, cycling, jogging, swimming, gymnastics, tennis, martial arts, field sports, and skating. Multiplying frequency and time and dividing that score by 7 computed an average PA score expressed in minutes per day.

Five-point Likert-type scales were used to assess social cognitions and environmental perceptions. Attitude was assessed with two items, tapping the good-bad aspect (+2=very good; −2=very bad) and pleasant-unpleasant aspect (+2=very pleasant; −2 very unpleasant) regarding the statement "I believe being physically active is . . .." Subjective norm was assessed with the item "people who are important to me believe I should be physically active" (+2=yes, definitely; −2=no, definitely not). PBC was assessed with two items regarding the able-unable aspect (+2=very sure I will be able; −2=very sure I will be unable) and the easy-difficult aspect (+2=very easy; −2=very difficult) of the preceding statement "If I want to be physically active, I am / this will be . . .." Intention was assessed with the item "I intend to be physically active in the next 6 months" (+2=yes, definitely; −2=no, definitely not).

Based on Pikora and colleagues[32] and empirical evidence,[29] the environmental characteristics of aesthetics and the availability of local facilities were used as key indicators of physical environmental perceptions. Aesthetics were assessed with five items ("My neighborhood is friendly"; "My neighborhood provides a pleasant living environment"; "My neighborhood is attractive"; "I feel safe when I am in my neighborhood; There is a lot of traffic in my neighborhood"). Local facilities were assessed with two items ("There are enough sport clubs in my neighborhood; there are enough opportunities for PA in my neighborhood"). Respondents were asked to indicate to what extent they agreed (+2=totally agree; –2=totally disagree) with these statements. Additionally, an open-item questioned respondents to indicate how far (in meters) they lived from the nearest opportunity to be physically active.

Data Analyses

Because structural equation modeling can be employed to test hypotheses about mediator variables,[33] path analyses were

Table 1. Mean scores, standard deviations, factor loadings for latent variables, and interfactor correlations from the overall measurement model

	Mean (SD)	Factor loading	1	2	3	4	5	6	7	8	9
1. Past physical activity	72.67 (76.81)		1								
2. Current physical activity	65.55 (50.61)		**.37*****	1							
3. Intention	0.44 (1.14)		.04	.11	1						
4. Attitude			**.17***	**.31*****	**.58*****	1					
Good–bad	1.26 (0.67)	**.72*****									
Healthy–unhealthy	0.95 (0.82)	**.88*****									
5. Subjective norm	0.19 (1.07)		−.04	−**.14***	**.29*****	.10	1				
6. Perceived behavioral control			**.26*****	**.23*****	**.34*****	**.50*****	−.04	1			
Able–unable	0.94 (0.94)	**.92*****									
Easy–difficult	0.56 (0.98)	**.76*****									
7. Aesthetics			−.05	.03	.00	**.18***	−.14	.00	1		
Friendly	0.85 (0.91)	**.73*****									
Pleasant	0.85 (0.94)	**.92*****									
Attractive	0.44 (1.05)	**.76*****									
Safe	0.73 (0.92)	**.70*****									
8. Local facilities	0.76 (0.96)		.04	.01	−.02	.09	−.03	.07	**.30*****	1	
9. Distance to nearest opportunity	250.99 (551.99)		.06	**.14***	.10	**.15***	.00	.11	−**.19****	−**.33*****	1

*$p < 0.05$;
**$p < 0.01$;
***$p < 0.001$ (all bolded).
SD, standard deviation.

performed using AMOS 4.0 (Smallwaters, Chicago IL, 1999). Structural equation modeling allows for assessment of overall model fit, the statistical significance tests for theorized relations in the model, and the estimation of latent concepts free of measurement error. Because there were some missing responses (<1%), full-information maximum likelihood (FIML) was used to estimate parameters. FIML is an optimal method for treatment of missing data[34] and has shown more accurate fit indices than pairwise deletion, listwise deletion, or mean-imputation.[35]

Based on the recommendations by Anderson and Gerbing,[36] a two-step procedure was followed. In the first step, confirmatory factor analysis was used to test an overall measurement model, consisting of four latent variables (i.e., attitude, PBC, aesthetics, and local facilities) and five indicators (i.e., current PA, past PA, intention, subjective norm, and distance to local facilities), which were allowed to correlate. For the latent variables, the loading of the first indicator was set to 1 in order to create its metric. The measurement model served as the baseline model for the path analyses in the structural model.

The fit of these models was evaluated using the chi-square goodness-of-fit test, which assesses the adequacy of the theorized model's covariance matrix in comparison with the observed covariance matrix. Because the chi-square test has been criticized for its dependence on sample size, including absolute and incremental fit indices is recommended.[37] The root mean square of error approximation (RMSEA)[37] was used as an absolute fit index, while the normed fit index (NFI) and comparative fit index (CFI)[38] were used as indices of incremental fit. An adequate model fit is obtained when the NFI and CFI are >0.90 and the RMSEA is ≤0.08,[37] while a good model fit is obtained when the NFI and CFI are >0.95 and the RMSEA is ≤0.05.[37,39]

A stepwise procedure was followed in which nested models were tested. Based on the proposed relations in the TPB,[4] the first model included (1) paths from past PA and environmental variables to attitude, subjective norm, and PBC; (2) paths from attitude, subjective norm, and PBC to intention; (3) paths from intention and PBC to PA; (4) correlations between TPB cognitions; and (5) correlations between environmental variables. The second model differed from the first model by freeing the direct effect of past PA on current PA. The third model differed from the second model by freeing the effect of past behavior on environmental perceptions. The fourth model differed from the third model by freeing the direct effects of the environmental factors on current PA. Alternative models were compared with chi-square difference test.[39] Cohen's effect sizes[40] were used as the informational source for the explanatory value of the model. The data analysis was conducted in 2005.

Results

Descriptives

Mean total physical activity per day was 65.6 minutes (SD=50.6) and 72.7 minutes (SD=76.8) per day for current and past PA, respectively (Table 1). Most common activities for past and current PA were cycling, field sports, and gymnastics. Adolescents who were currently more physically active had a more positive attitude and perceived more behavioral control and less subjective norm toward being physically active. Additionally, they reported living farther away from the nearest opportunity to be physically active.

Confirmatory Factor Analyses

The overall measurement model provided good fit to the data (χ^2=100.53, degrees of freedom [df]=73,

p=0.02; NFI=0.97; CFI=0.99; RMSEA=0.04), but included two items ("There is a lot of traffic in my neighborhood" and "There are enough sports clubs in my neighborhood") with inadequate (<0.40) factor loadings. Deletion of these two items and re-estimating the measurement model provided good fit to the data (χ^2=64.40, df=47, p=0.05; NFI=0.98; CFI=0.99; RMSEA=0.04) with all factor loadings ≥0.70. Mean scores, standard deviation, factor loadings for the latent variables, and interfactor correlations for the final measurement model are shown in Table 1.

Path Analyses

Because the sample size was insufficient for latent variables,[41] path analyses were performed using observed variables. Mean scores for the multi-item scales of attitude, PBC, and aesthetics were computed using SPSS Version 11.0.4 (SPSS Inc, Chicago IL, 2005). Internal consistency analyses revealed good psychometric properties (attitude: α=0.77; PBC: α=0.82; aesthetics: α=0.86). Mean score for attitude was 1.10 (SD=0.80); for PBC .74 (SD=0.89); and for aesthetics 0.72 (SD=0.80).

Except for the RMSEA, the first model provided a good fit to the data (χ^2=47.32, df=14, p<0.001; NFI=0.97; CFI=0.97; RMSEA=0.10). The second model, where the direct effect of past PA on current PA was freed, resulted in a significantly better (χ^2−difference=26.3) model fit (χ^2=21.02, df=13, p=0.07; NFI=0.98; CFI=0.99; RMSEA=0.05). The third model did not significantly improve model fit (past PA−aesthetics: χ^2−difference=0.53; past PA−distance: χ^2−difference=1.16; past PA−local facilities: χ^2−difference=1.21). The fourth model also did not significantly improve model fit (aesthetics−PA: χ^2−difference=0.57; distance − PA: χ^2−difference=1.46; local facilities−PA: χ^2−difference=0.07). Consequently, the second model provided the best fit to the data. The structure and path coefficients of this model are shown in Figure 1. Environmental aesthetics were a significant positive predictor of attitude (β=0.16; p=0.02), while distance to PA opportunities was a significant positive predictor of both attitude (β=0.19; p=0.005) and PBC (β=0.14; p=0.04). Past PA was a significant predictor of attitude (β=0.14; p=0.03), PBC (β=0.23; p<0.001), and current PA (β=0.34; p<0.001). Intention was most strongly influenced by attitude (β=0.45; p<0.001) and subjective norm (β=0.24; p<0.001). Intention did not significantly predict current PA. This final model accounted for a total of 34% of the variance in intention and 17% variance in current PA, indicating medium effect sizes.[40]

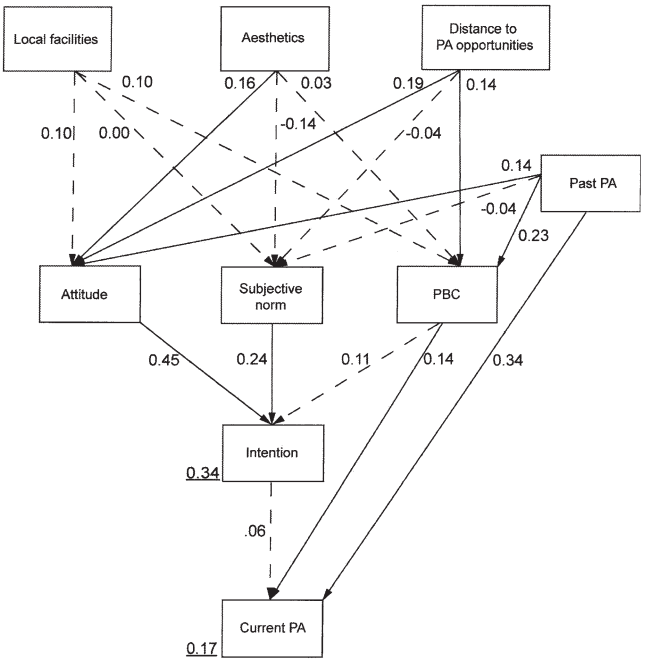

Figure 1. Standardized regression coefficients for final model. Solid lines indicate paths; dashed lines indicate non-significant paths. Underlined values indicate explained variance. For reasons of clarity, covariance and uniqueness are not shown. Chi-square=21.02; degrees of freedom=13; p=0.07; normed fit index=0.98; comparative fit index=0.99; root mean square error of approximation=0.05.
PA, physical activity; PBC, perceived behavioral control.

Discussion

In line with recent calls for advancing research methodologies and integrating theoretical approaches in the study of determinants of PA,[17,19,33] the present study sought to identify determinants of adolescent PA by integrating relevant individual-level and environmental-level factors in a single study, using the theoretical relationships of the TPB.

Results regarding the individual-level factors showed that past PA was a significant unmediated predictor of current PA, replicating earlier findings in similar age groups.[8,9] However, the direct influence of past behavior has frequently been dubbed an "empty" concept.[4,42,43] One of the mechanisms that may account for this direct influence is habit strength.[44] Empirical findings[45,46] indicate the additional explanatory value of habit in PA-related behaviors. While TPB-based interventions are generally based on informational strategies (i.e., providing people with information on the health outcomes of being physically active), attitudinal and subsequent behavioral change will occur only if the recipient of the message is likely to pay attention to the new information.[47] Yet, research indicates limited and selective information processing when behavior is guided by strong habits rather than intentions[46] and suggests the necessity of additional strategies be-

yond merely providing information.[48] Although using past behavior as a measure of habit strength has been criticized by Ajzen,[49] Verplanken and Orbell[44] have argued that habit is a psychological construct rather than mere past behavioral frequency and have developed a script-based measure of habit to stimulate further development of habit research and theory. Empirical evidence of this measure in determinant studies of adolescent PA is lacking, but because these results indicated that intention did not significantly influence PA, one may question the tenet that adolescent physical activity is largely explained by their personal motivation. Habit includes factors such as automaticity and unawareness[44] and the inclusion of habit strength in future studies may provide a more sufficient account of the individual-level determinants of adolescent PA.

Regarding the environmental variables, freeing the direct effect of past PA on current environmental perceptions did not significantly increase model fit, suggesting that an adolescent's previous PA does not influence current environmental perceptions. Additionally, these environmental perceptions were not directly related to current PA, but adolescents who lived in a more attractive neighborhood had a more positive attitude toward being physically active. In contrast, adolescents who indicated that the nearest opportunity for PA was farther away also had a more positive attitude and perceived more control toward being physically active. Because TPB cognitions and environmental factors were assessed simultaneously in this study, this finding may reflect an inverse cause-and-effect relationship. Those who perceived a greater behavioral control and who had a more positive attitude may have been more likely to seek out more convenient opportunities for PA, beyond the opportunities provided by the immediate neighborhood. Indeed, Bandura[50] has conceptualized the influence of self-efficacy beliefs on one's perceptions of environmental barriers and opportunities.

The present study is subject to certain limitations. First, the study cohort consisted of more females than the general Dutch population. Because females were also more likely to respond to both questionnaires, caution is needed to generalize findings. Second, although PA was assessed using frequency and duration for a wide range of common activities in Dutch adolescents, the questionnaire was validated in an adult sample. Third, perceived environmental factors were used, as opposed to objective environmental factors. While a recent study[21] reported some similar associations between perceived and objective environmental factors with PA, little is known about the accuracy of such perceived environmental survey data.[51] As noted, self-efficacy beliefs influence environmental perceptions and underline the need for objective measurements in the study of environmental influences on PA. Finally, TPB cognitions were assessed with few and fairly crude items that did not fully comply with Ajzen and Fishbein's[52] recommendations. Theoretically, physical activity should be considered as a behavioral category rather than a single act,[52,53] and, therefore, cannot serve as an attitude object. However, considering the limited space available in the questionnaire and avoiding questionnaires that are too long for adolescents to complete,[53] direct measures of cognitions regarding "being physically active" were chosen.

In past decades, the TPB has provided researchers with a plausible mechanism to account for reasoned action in PA, but many scientists agree that such a social-cognitive theory falls short of capturing all of the issues and domains that are specific to PA.[54] On the other hand, relatively broad conceptual models of putative environment–behavior relationships are currently being used to guide research.[17] For instance, in line with the results of this study, a recent study[55] found environmental aesthetics to be unrelated to PA. The current results, however, showed that aesthetics had an indirect positive influence on adolescents' intention to be physically active, underlining the need for targeting both environments and individuals in order to increase current low activity levels. Future studies on physical activity determinants need to extend beyond behavioral sciences alone[54] and include environmental factors and social-cognitive factors in a single study.[17,48] Moreover, social-cognitive factors should be used to test and explain the relationship between the physical environment and physical activity.

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