Title: Perceived barriers to physical activity in adolescents: A cross-sectional analysis

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Study design: Cross-Sectional

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Competing interests

The authors have no conflicts of interest or financial disclosures to report.

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Abstract

Background: Perceived barriers to moderate-to-vigorous physical activity (MVPA) may contribute to the low rates of MVPA in adolescents. We examined the psychometric properties of scores from the Perceived Barriers to MVPA scale (PB-MVPA) by examining composite reliability and validity evidence based on the internal structure of the PB-MVPA and relations with other variables.

Methods: This study was a cross-sectional analysis of data collected in 2013 from adolescents ($N=507$; $M_{\text{age}}=12.40$, $SD=.62$) via self-report scales.

Results: Using exploratory and confirmatory factor analyses, we found that perceived barriers were best represented as two factors representing internal (e.g., “I am not interested in physical activity”) and external (e.g., “I need equipment I don’t have”) dimensions. Composite reliability was over .80. Using multiple regression to examine the relationship between perceived barriers and MVPA, we found that perceived internal barriers were inversely related to MVPA ($\beta=-.32$, $p<.05$). Based on results of the analysis of variances, there were no known-group sex differences for perceived internal and external barriers ($p>.26$).

Conclusions: The PB-MVPA scale demonstrated evidence of score reliability and validity. To improve the understanding of the impact of perceived barriers on MVPA in adolescents, researchers should examine internal and external barriers separately.

Keywords: Physical Activity, Behaviour, Barriers, Adolescents

Measuring perceived barriers to physical activity in adolescents

Introduction

Regular participation in moderate-to-vigorous physical activity (MVPA) during adolescence promotes positive physical and psychosocial health. For example, MVPA plays an important role in maintaining a healthy body weight, relieving depression, stress and anxiety, and fostering healthy growth and development among adolescents 6 to 18 years of age (37). MVPA is also an effective way to prevent and treat chronic diseases, such as type 2 diabetes, certain cancers, obesity, and cardiovascular diseases (23, 46). Considering its beneficial effects, the World Health Organization developed MVPA guidelines for children and adolescents to promote active living. These guidelines encourage adolescents to participate in at least 60 minutes of MVPA daily (29, 40). Yet, only 9% of boys and 4% of girls in Canada achieve the recommended levels of MVPA (11). Comparable rates have been reported in other developed countries (29, 41). For example, only 8% of adolescents in the United States (41) and only 2.5% of adolescents in England (31) met the MVPA guidelines. This pattern of low MVPA is concerning because physical activity levels tend to decrease during the transition from adolescence to adulthood (24, 45). Action is required to develop and implement behaviour change interventions to reverse these trends. However, participation in such interventions can present a challenge if strategies are not in place to address participants' barriers to physical activity.

Perceived barriers refer to an individual's judgement of the level of challenge of personal, social, environmental, and economic obstacles that hinder their ability to engage in a specific health behaviour such as MVPA (47). For example, lack of time and support, low motivation for physical activity, and negative attitudes toward physical activity are important perceived barriers

that can impede MVPA for high school students in grades 9 and 11 (3). According to theory (e.g., health belief model; 36) and empirical research (15, 47), perceived barriers are an important factor related to MVPA. However, results from two reviews synthesizing the literature on the relationship between perceived barriers and MVPA produced equivocal findings (34, 43). In Sallis and colleagues' (34) comprehensive review, perceived barriers were identified as inversely associated with physical activity in children 3 to 12 years of age, whereas Van Der Horst and colleagues' (42) systematic review found no evidence for an association between perceived barriers and physical activity in children 4 to 12 years of age. These equivocal findings raise questions about the measurement of perceived barriers because many of the studies reviewed used a combined score; that is, they summed all barrier responses into a single score. This approach may have obscured unique associations between different types of perceived barriers and MVPA. Given that researchers have used various strategies for creating perceived barrier scores, it remains unclear how to best operationalize perceived barriers to MVPA. The equivocal findings highlight the need for more research to further examine the operationalization of perceived barriers so that there can be consistency across studies.

Despite researchers acknowledging that perceived barriers are a multidimensional construct consisting of varied combinations of obstacles (3), inconsistencies exist regarding how the obstacles are grouped together across studies. Some researchers have categorized perceived barriers into three categories representing internal, interpersonal, and environmental dimensions (8, 47) or representing obstacles, social evaluations, and outcomes (13). Others have categorized barriers into two categories representing individual and environmental dimensions (35) or representing negative personal emotions and personal sense of immobilization (33). Investigators have also categorized perceived barriers into either internal or external dimensions (3, 12, 21). In

this case, perceived internal barriers encompass a variety of inner emotions and thoughts that people identify as reasons that interfere with their physical activity participation. Internal barriers include lack of enjoyment, low confidence, and low motivation. Perceived external barriers are those factors in people's environment that make it difficult to participate in physical activity (e.g., cost, lack of facilities, lack of time) or social relationships that can discourage physical activity (e.g., perceived lack of social support; 3). Although perceived internal and external dimensions are broad labels that can serve as umbrella terms, it is possible for items to represent both categories depending on how they are interpreted by the respondents. This ambiguity raises the issue that some barriers may fall into both categories. Therefore, psychometric testing is needed to confirm how different types of barriers cluster together to represent different categories of perceived barriers to MVPA. However, psychometric testing has not constituted an integral part of most research (see 3, 13, 16, 33 for exceptions). Furthermore, when psychometric investigations have been conducted (3, 13, 33), researchers have analyzed perceived barrier scores using disparate operationalizations or categories of perceived barriers, therefore providing little consensus across studies. Differences across studies underscore the importance of assessing the score validity and reliability of self-reported perceived barriers measures to ensure the results are meaningful (27). It is only through the accumulation of validity evidence that we can begin to build more generalizable findings across investigations examining perceived barriers to MVPA.

In the current research, we aimed to address the need for further score validity evidence on existing items that were developed in the Quebec Adipose and Lifestyle Investigation in Youth (QUALITY) study to assess adolescents' perceived barriers to MVPA (26). From this point forward, we refer to the existing items as the Perceived Barriers to MVPA (PB-MVPA)

scale. Our objective was to examine aspects of score reliability and validity of the PB-MVPA to ensure researchers can use it to assess common perceived barriers to MVPA that have been identified in the literature for adolescents (14, 26, 47). Specifically, we examined score reliability by examining composite reliability of latent factors. We used the validity theory and validation framework set forth by the *Standards for Educational and Psychological Testing (The Standards; 1)*, and examined: (I) evidence based on internal structure through examining factor structure (i.e., dimensionality), and (II) evidence based on relations to other variables through (a) examining the relationship between perceived barriers and MVPA, and (b) known-group comparisons by examining differences in perceived barriers scores across sex (see endnote 1). Because researchers have used various categorizations of barriers with differing numbers of factors (3, 12, 33), we did not hypothesize an *a priori* number of perceived barriers factors when examining the factor structure of responses. When examining the relationships between perceived barriers and MVPA, we hypothesized that perceived barriers scores would be negatively associated with MVPA (20, 28, 34). When examining known-group differences, we hypothesized based on results from previous studies (3, 39) that adolescent girls will report higher perceived barriers scores compared to boys. Examining sex differences is important to determine who is in greater need of strategies to overcome perceived barriers to MVPA.

Methods

Procedures

The data reported here represent one aspect of a larger cohort study entitled Monitoring Activities of Teenagers to Comprehend their Habits (MATCH). Details on the MATCH study and procedures are provided elsewhere (5). Briefly, 846 students (51% response proportion from those originally sent the recruitment package) in grades 5 and 6 in 17 schools were recruited in

the Fall of 2011. Primary language was French for 66% of participants and English for 34%. Based on a composite measure that comprised measures of quality of housing, household finances, employment, social stability, education, and accessibility to services in the area in which the school was located (18), 25% lived in low, 63% lived in moderate, and 12% lived in high socioeconomic status neighborhoods. Under the supervision of trained research assistants, participants completed self-report paper and pencil questionnaires three times per year (Fall, Winter, and Spring) in their classroom when the teacher deemed it convenient. The first questionnaire took 45-60 minutes to complete; the subsequent questionnaires took 20-30 minutes to complete because participants required less instruction. Scales were developed in English and translated into French if translated versions were not already available. Translation was accomplished through a rigorous back-translation process as described in Bélanger et al. (5). Ethical approval was obtained from the Comité d'Éthique de la Recherche du Centre Hospitalier de l'Université de Sherbrooke, and parental consent and participant assent was obtained prior to data collection.

Participants

Data analyzed for this investigation were drawn from survey cycle 6 (Spring 2013, corresponding with the end of the second year of data collection), and included 225 boys and 282 girls between the ages of 10 to 14 years ($M_{\text{age}} = 12.40$, $SD = .62$; 1 participant did not report her birthdate) who were in grade 6 (52.7%) or 7 (47.3%). Survey cycle 6 was chosen because the PB-MVPA scale was only included in cycle 3 and cycle 6 when this study was undertaken. At cycle 6, 29 extra participants completed the barriers scale – 25 of whom were absent during cycle 3 and 4 new participants who joined the MATCH study. In addition to having a larger sample size and fewer outliers at cycle 6, using data from this cycle had the advantage of

participants being more familiar with filling in self-report scales, which we believe would provide more accurate results.

Scales

MVPA. Physical activity was assessed using a 2-item MVPA screening scale developed for adolescents (30). We provided participants with a statement describing MVPA (i.e., “Physical activity is an activity that increases your heart rate and makes you get out of breath some of the time. Physical activity can be done in sports, playing with friends, or walking to school. Some examples of physical activity are running, brisk walking, rollerblading, biking, dancing, skateboarding, swimming, soccer, basketball, football, and surfing.”), and asked them: “Over the course of the week (past 7 days), how many days were you physically active for a total of at least 60 minutes per day?” and “Over the course of a typical or usual week, how many days are you physically active for a total of at least 60 minutes per day?” Responses were recorded on a scale ranging from *0 days* to *7 days*. Scores on this scale have demonstrated adequate reliability and validity compared with accelerometer data (30). We created a total continuous MVPA score by averaging both items as recommended by Prochaska and colleagues (30). In the current study, both items were correlated at .80 ($p < .001$). In addition, based on current guidelines for MVPA (40), we calculated an MVPA status score by classifying participants as meeting MVPA guidelines (i.e., average MVPA score = 7 days) or not meeting the MVPA guidelines (i.e., average MVPA score < 7 days).

Perceived Barriers to MVPA (PB-MVPA). Perceived barriers to MVPA were assessed using 18 items drawn from the QUALITY study that have also been used in previous research (14, 26, 47). Following the stem “How true are each of the following statements for you. I often don’t do physical activity because...” we asked participants to rate each item on a 4-point scale. Response

options were: 1 (*false*), 2 (*sometimes true*), 3 (*usually true*), and 4 (*very true*). All items are presented in Table 1. Higher total mean scores indicated greater perceived barriers. Pilot testing of the MATCH questionnaire with students in grade 5 and 6 confirmed there was no difficulty understanding or answering the questions.

Demographics. We had participants report their sex (male/female) and date of birth (year/month/day) in the questionnaire.

Data Analysis

Our preliminary analyses involved examination of outliers and missing data in SPSS Version 21. We removed participants with $\geq 50\%$ missing data ($n = 246$; 19) on the PB-MVPA and MVPA scales, and cases with univariate outliers ($n = 81$). Figure 1 depicts how the sample sizes varied across the stages of data preparation. After removing univariate outliers, we examined the factor structure of responses to the PB-MVPA using exploratory factor analysis (EFA) while taking into account the categorical nature of the response format. The EFA was conducted in Mplus 7.0 using Weighted Least Square Means and Variances Adjusted (WLSMV) estimation. Based on previous research demonstrating correlations between perceived barriers factors (3), we used oblique rotation to account for the *a priori* hypothesized correlations between factors (9). We then analyzed the obtained factor structure in a confirmatory factor analysis (CFA) framework to obtain factor scores that could be used to examine the relationships between perceived barriers and MVPA and known-group differences. In both EFA and CFA, we estimated missing data (for participants with $< 50\%$ on barriers items) based on all the available data using an algorithm built into Mplus for WLSMV estimation. The EFA and CFA analyses were estimated by analyzing the polychoric correlation matrix and using WLSMV which is robust to non-normality. We interpreted a combination of goodness-of-fit statistics to determine

the fit of the EFA and CFA models: Comparatives Fit Index (CFI; values close to or above .95 indicate good fit), Tucker Lewis Index (TLI; values close to or above .95 indicate good fit), and Root Mean Square Error of Approximation (RMSEA; values close to or below .06 indicate good fit; 22). Composite reliability was calculated based on the results of the CFA.

Next, given that the remainder of the analyses were conducted in SPSS where there is no correction for non-normality, we analyzed the factor scores obtained from the CFA alongside MVPA scores to detect multivariate outliers based on Mahalanobis distance criteria. In total, we removed 12 multivariate outliers to reduce the impact of non-normality on the estimated parameters for the remainder of the analyses. Once multivariate outliers were removed, we employed a multiple linear regression analysis to examine the relationships between perceived barriers and MVPA to determine the associations between the perceived barriers categories derived from the factor analyses (independent variable) and the continuous MVPA scores (dependent variable). We computed regression coefficients for the association between each barrier and MVPA and calculated the R^2 to estimate the total explained variance in MVPA. To examine validity evidence based on known-group differences we examined if boys and girls differed on their mean level of reported barriers using an analysis of variance (ANOVA). Perceived barriers factor scores served as the dependent variable whereas sex was entered as the independent variable. Cohen's d values were calculated to provide estimates of the magnitude of differences in perceived barriers across sex and MVPA, and interpreted based on benchmarks introduced by Cohen (10) where values close to .20, .50 and $> .80$ equate to small, medium and large effects, respectively.

Results

Non-participation in survey cycle 6 and data cleaning procedures are outlined in Figure 1. Based on participants who provided data on age and sex from the full dataset, there were no statistically significant differences on age ($t_{(752)} = -1.40, p = .16$) or sex ($\chi^2_{(1)} = .003, p = .95$) between participants who were excluded from analyses ($n = 339$) and those who were retained ($n = 507$). Also, there were no statistically significant differences in days of MVPA based on sex ($t_{(456.363)} = -1.07, p = .29$; see Table 2). On average, the analytical sample reported engaging in 4.85 days ($SD = 1.77$) of MVPA per week.

Validity Evidence Based on Internal Structure

EFA results revealed that a two-factor model fit the data well ($\chi^2_{(118)} = 187.83, p < .001$, CFI = .95, TLI = .93, RMSEA = .03 [90% CI = .02 - .04]) and presented an interpretable solution. The correlation between the two factors was .36 ($p < .05$). Examination of the scree plot indicated that there was one strong factor (Eigen value = 5.49) and a second factor (Eigen value = 1.95). After the second factor, interpretation of the scree plot indicated that the remaining factors (4 with Eigen values > 1) were small and did not create a large bend in the plot. Inter-item polychoric correlations ranged from |.01 to .80|. Based on the constellation of items and previous research (3), we labelled the two factors as perceived *internal* and *external* barriers. As shown in Table 1, four items loaded onto the perceived internal barriers latent factor, whereas 10 items loaded onto the perceived external barriers latent factor. Four items were problematic (i.e., they had high cross-loadings or low loadings on both factors).

Therefore, two CFAs were conducted to determine the best measurement model. In the first CFA which retained the four items that were problematic in the EFA, we specified the items “I don’t have enough energy” and “I am not good enough” to load onto the internal barriers item, and specified “I have too much homework” and “my friends tease me” to load onto the external

barrier factor based on their conceptual content. Results of this CFA indicated that the model fell slightly below good fit criteria, yet still fell within acceptable ranges ($\chi^2_{(134)} = 232.93, p < .001$, CFI = .92, TLI = .91, RMSEA = .04 [90% CI = .03 – .05]) (9). Standardized factor loadings ranged from .38 to .87 ($p < .001$), residual variances ranged from .24 to .86, and item R^2 ranged from .15 to .68. The correlation between internal and external factors was .64 ($p < .001$). Composite reliability scores derived from the CFA were .84 for both perceived internal and external barriers subscales.

In the second CFA, we removed the four problematic items identified in the EFA analysis (9). Results of this CFA using the shortened scale provided a good fit to the data ($\chi^2_{(76)} = 101.46, p = .03$, CFI = .97, TLI = .97, RMSEA = .03 [90% CI = .01 – .04]). Standardized factor loadings ranged from .36 to .90 ($p < .001$), residual variances ranged from .19 to .87, and item R^2 ranged from .13 to .81. Composite reliability scores derived from the second CFA analysis were .84 and .81 for perceived internal and external barriers subscales, respectively. Both factors were significantly correlated with each other ($r = .52, p < .001$). Our comparison of the goodness-of-fit indices between both models indicated that the 14-item model was a superior fit to the data compared to the measurement model with all items included (see endnote 2). Although factor loading ranges and composite reliability were slightly higher in the first model, the second trimmed model had lower item residuals, higher item R^2 , and a lower correlation between internal and external factors. Consequently, we proceeded with the subsequent analyses by saving the factor scores derived from the second CFA conducted with the 14-item version to reduce the impact of measurement error on the results (25).

Validity Evidence Based on Relations to Other Variables

Results of the regression analysis indicated that perceived internal and external barriers collectively accounted for 9% of the variance in MVPA ($F(2, 504) = 24.22, p < .001$; see endnote 3 and 4). Perceived internal barriers were negatively associated with MVPA (unstandardized beta = -1.02, standard error = .24, standardized beta = -.32, $p < .05$), whereas perceived external barriers were not statistically associated with MVPA (unstandardized beta = -0.07, standard error = .18, standardized beta = .03, $p = .69$). Results of the ANOVA indicated that there were no statistically significant difference between girls and boys on perceived internal ($F(1, 505) = 0.39, p = .26$) or external barriers ($F(1, 505) = 1.78, p = .07$; see Table 3).

Discussion

The current study addressed a lack of validation work in relation to how perceived barriers are measured and provides initial evidence that adolescents' perceived barriers are best operationalized by two factors representing perceived internal and external barriers. When we examined perceived barriers relationship with MVPA, we found that perceived internal barriers, but not external barriers, were inversely associated with MVPA. Known-group differences analysis demonstrated that girls did not differ significantly from boys on perceived internal or external barriers. Taken together, the findings highlight the value of examining perceived barriers to MVPA as a construct consisting of two dimensions, and suggest that responses to the PB-MVPA scale demonstrated good psychometric properties, although caution is warranted because we did not have a cross-validation sample to confirm these results.

Results of the EFA and CFA supported the idea that scores from the PB-MVPA scale can be dichotomized into internal and external barriers (4, 7). However, it is important to note that these two types of barriers are entwined because some barriers that were classified as perceived external barriers may overlap with internal barriers and vice versa. For example, not wanting to

sweat and holding beliefs that physical activity can impair one's appearance are considered perceived external barriers in this study in as much as they reflect a desire to avoid negative evaluations by external people. Indeed, it is commonly accepted that one's fear of negative evaluation is a type of external barrier because of its controlling nature and undermining effect on intrinsic motivation for physical activity (44). Nonetheless, these concerns and beliefs could also reflect internal barriers as they reflect some inner thoughts and feelings about MVPA. Another example is that feeling that one is too overweight to participate in physical activity can be classified as an internal barrier as it encompasses internal thoughts that people identify as reasons hindering physical activity participation. Yet, it could also reflect an external barrier because it could reflect a fear of negative evaluation. These examples highlight the complexity of studying barriers to MVPA and the need to pay more attention to the way items are worded to ensure items associated with internal and external barriers are truly associated with these types of barriers. In doing so, think aloud protocols (i.e., validity evidence of response processes) where adolescents verbalize why they are answering items the way they are could be used to gain further insight about the nature of perceived internal and external barriers (1).

A main contribution of the current study was the examination of psychometric characteristics of responses from an existing perceived barriers scale (i.e., the PB-MVPA) for adolescents that can easily be integrated into large studies needing relatively brief measures. Based on the findings from this investigation and particularly the results of the supplementary analyses presented in endnote 2, it seems reasonable to suggest that researchers interested in studying perceived barriers to MVPA in adolescents use the full 18-item version of the scale with the intention of examining evidence of score reliability and validity to determine if the items load onto either internal or external factors as demonstrated in this investigation (albeit

with the removal of 4 items). Until cross-validation research is conducted, it is premature to recommend only using the 14 items that emerged as clear indicators of internal and external perceived barriers in this investigation. That said, the results herein support the factor structure of responses as representing internal and external facets. Moreover, the finding that perceived internal barriers scores were negatively associated with MVPA provides validity evidence based on relations to other variables. In line with current validity theory (1), validation is an ongoing process and the results from this study corroborate Allison and colleagues' (3) findings and contribute to the accumulation of validity evidence for the more general classification of perceived barriers into internal and external factors (21). Finally, the findings showed evidence of subscale score reliability, and thus show promise for researchers using this self-report PB-MVPA scale to understand which types of perceived barriers hinder MVPA.

In addition to these methodological contributions, the current paper has implications for research and practice. Given the negative association between perceived internal barriers and MVPA in adolescents, which substantiates previous research (2, 12, 47) and an early review (34), it may be helpful to develop strategies to help adolescents overcome perceived internal barriers. It is possible that it is easier for adolescents to find ways to overcome perceived external barriers and remain engaged in MVPA. Using social cognitive theory (4), it seems reasonable to argue that self-efficacy or barrier self-efficacy – the confidence an individual has to overcome a perceived barrier to MVPA – could play a role in the relationship between perceived internal barriers and MVPA. Indeed, barrier self-efficacy has been linked to MVPA (3), therefore it is possible that individuals who have less general or barrier self-efficacy perceive internal barriers as more threatening and consequently, engage in less MVPA. Researchers should explore more complex models that examine the role of self-efficacy as a possible mechanism linking internal

perceived barriers to MVPA. To extend the current findings, researchers should also examine factors that buffer the negative association between perceived internal barriers and MVPA.

Contrary to previous research among adolescents in high school (3, 39) and our hypotheses, an examination of perceived internal and external barriers across sex in the current study showed that girls did not differ significantly compared to boys in perceived internal or external barriers. However, another investigation among adolescents of similar age to the current study (32) found no sex differences when examining an overall perceived barrier score. Coupled with the findings from Robbins and colleagues (32) and the findings presented herein, it appears as though interventions aimed at increasing MVPA through reducing perceived barriers could target both boys and girls. That is, because no sex differences were found, sex tailored interventions may not be needed. Notwithstanding, more research is needed to understand if the scores from the PB-MVPA scale are invariant across sex because some items may carry different meaning between males and females (e.g., “I don’t want to get too strong or muscular”).

While this study adds to our understanding of adolescents’ perceived barriers for physical activity and their association with MVPA, there are limitations to consider. One is that there were fewer perceived internal barrier items ($n = 4$) compared to perceived external barrier items ($n = 10$). Although the number of items per subscale met recommendations to have at least three items per subscale (9), the perceived internal barriers represented in the current scale may not capture all relevant internal barriers experienced by adolescents. As such, researchers may wish to examine alternative internal barriers to MVPA to determine if the perceived barriers captured in the PB-MVPA scale truly reflect the conceptual range of perceived barriers. Another limitation concerns the item response anchors. In their current form, the anchors are unbalance because there are more variations of ‘true’ responses than ‘false’, and the options vary in

reference to time (e.g., sometimes, usually) or amount (e.g., very). Researchers may wish to change and test the response options to ensure they are balanced and present a consistent reference point. Similarly, the stem for the PB-MVPA scale was negatively worded and may have caused interpretation problems. Researchers have used other stems that ask adolescents the factors that prevent them from doing MVPA (3). In the future, researchers may wish to alter the instructional stem such that it is not negatively worded. Finally, while the presence of univariate outliers is not substantial enough to raise concern based on the large sample size, there were a number of univariate outliers. Researchers should report the frequency of outliers in their investigations to determine if this finding was sample specific or if the response options provided for the perceived barrier items were causing abnormal responses.

Other limitations are that the cross-sectional analyses preclude the ability to establish temporal or causal associations. Also, our analyses were conducted on primarily Caucasian adolescents from one province in Canada and therefore, may not generalize to other adolescents. It is also possible that adolescents' perceived external barriers shift across seasons (e.g., bad weather), whereby assessment of perceived barriers during winter could have increased the magnitude of the association between perceived external barriers and MVPA. Researchers should examine seasonal fluctuations of perceived barriers. Our EFA and CFA examination of the factor structure of perceived barriers scores were conducted on the same participants. Although some researchers have argued for the appropriateness of using the same sample to conduct EFA and CFA (e.g., 43), further research should cross-validate the EFA results in different samples. Last, data were collected with self-report scales which are susceptible to recall and reporting bias. Similarly, MVPA was measured with a self-report scale comprised of only two items. Although these items yielded scores that correlate with accelerometer data (30) and

received support from experts (see 6), researchers in the future may wish to use alternative measures of MVPA.

Conclusion

This study provided empirical evidence that adolescents' perceived barriers to physical activity can be categorized into internal and external dimensions using items from the PB-MVPA scale. Basing our validation efforts on validity theory (1), we demonstrated evidence of reliability and validity for scores of an 18-item perceived barriers to MVPA scale in adolescents reduced to 14-items. Our results suggested that perceived barriers to MVPA are best represented as two dimensions representing internal and external barriers, and levels are consistent for boys and girls. We also provided evidence of the relationships between perceived barriers and MVPA. Overall, this study showed promise for the PB-MVPA scale for use by researchers interested in studying the associations between perceived barriers and MVPA in adolescents. Nonetheless, given the ongoing nature of score validation, other types of validity evidence (e.g., replication, predictive evidence, response processes) should be investigated in the future.

Endnotes

1. As recognized in the Standards, there no longer exist different ‘types’ of validity. Rather, validity *evidence* is based on various sources of information. Validity evidence based on internal structure refers to examining if scores on items conform to the hypothesized construct (e.g., through factor analysis examining factor structure). Validity evidence based on relations to other variables involves examining relationships between variables from external scales and the scale under investigation. For example, researchers can examine correlations or regressions between the scale scores and an external scale to provide evidence of relations to other variables. A second example of relations to other variables would be known-group difference testing, which occurs when a researcher tests the scale scores to see if there are group differences (e.g., sex) (1, 17).

2. It is possible that the results of our CFA between the 18- and 14-item versions of the PB-MVPA may represent sample specific variations in our data. As such, our main analyses were repeated using the full 18-item PB-MVPA scale to determine if conclusions would differ based on how many items were in the analyses. To this end, factor scores were saved from the CFA including all 18 items and the multiple linear regression analysis and ANOVA were re-run using these scores. Results using the 18- and 14-items were similar, with the exception that boys reported fewer perceived external barriers compared to girls ($F_{(1, 512)} = 5.47, p = .02$) when the 18-item version was used. However, the effect sizes were similar for both versions ($d_{18\text{-items}} = .20$ compared to $d_{14\text{-items}} = .17$).

3. The analyses were repeated including the 93 univariate and multivariate outliers to ascertain the impact of outliers. Similar results were obtained for the relationship between PB-MVPA scores and MVPA, and known-group differences. Based on the assumption of normality for the

analyses used in this investigation, results are presented excluding outliers to ensure the distributions approached normality and prevent biases in the ANOVA and regression estimates (38).

4. Sex by barriers (i.e., internal, external) interactions were tested in preliminary regression analyses. No significant interactions were found. Consequently, results are presented for the combined sample.

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Table 1. Results of the exploratory factor analysis on PB-MVPA responses

Items		Internal (SE)	z-score	External (SE)	z-score	h^2
1.	I am not interested in physical activity	.93* (.06)	15.50	-.02 (.07)	0.29	.85
2.	I don't enjoy physical activity	.84* (.05)	16.80	.00 (.02)	0.00	.71
3.	It's too boring	.72* (.07)	10.30	.15 (.09)	1.67	.64
4.	I am too overweight	.44* (.14)	3.14	.08 (.12)	.67	.23
5.	I don't have enough time	-.06 (.16)	-.38	.79* (.08)	9.88	.59
6.	I don't have anyone to do physical activities with	.08 (.15)	.53	.68* (.08)	8.50	.50
7.	I need equipment I don't have	-.03 (.14)	-.21	.60* (.09)	6.67	.34
8.	My friends don't like to exercise	.01 (.03)	.33	.52* (.09)	5.78	.28
9.	I don't like to sweat	.14 (.15)	.93	.43* (.10)	4.30	.25
10.	There's no place to do physical activity	.23 (.12)	1.92	.43* (.09)	4.78	.31
11.	Weather is too bad	.07 (.12)	.58	.43* (.08)	5.38	.21
12.	I'm always chosen last for teams	.18 (.13)	1.38	.40* (.10)	4.00	.25

13.	Physical activity messes up my appearance	.18 (.25)	.72	.39* (.18)	2.17	.23
14.	I don't want to get too strong or muscular	.20 (.14)	1.43	.31* (.11)	2.81	.18
15.	I don't have enough energy	.37* (.09)	4.11	.35* (.08)	4.34	.35
16.	I have too much homework	-.29* (.13)	-2.23	.67* (.09)	7.44	.39
17.	I am not good enough	.49* (.16)	3.06	.32* (.09)	3.55	.46
18.	My friends tease me	.26 (.15)	1.73	.10 (.12)	.83	.14

Notes. Bolded factor loadings represent which subscale the items uniquely loaded onto. Items 1-14 were used for the main analyses. SE = Standard Error, h^2 = communalities.

Table 2. Mean MVPA level and mean internal and external barrier scores across sex

Dependent variables	Girls		Boys		
	<i>(n = 282)</i>		<i>(n = 225)</i>		
	<i>M</i>	<i>(SD)</i>	<i>M</i>	<i>(SD)</i>	<i>d</i>
MVPA	4.78	1.69	4.95	1.87	0.09
Internal Barriers	0.11	0.54	0.06	0.57	0.09
External Barriers	0.13	0.72	0.01	0.72	0.17

Note: *M* = mean, *SD* = standard deviation, MVPA = moderate-to-vigorous physical activity, *d* = Cohen's *d*. MVPA = days, Internal/External = factor scores. * $p < .05$

Figure 1. Flow chart outlining number of participants included and excluded through data cleaning