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Introduction

Low levels of physical activity (PA) and unhealthy nutrition are the key determinants of overweight and obesity in children and their parents (U.S. Department of Health and Human Services, 2008). Recognizing the evidence for PA as a factor preventing excessive weight gain, the World Health Organization (WHO; 2003) recommended that children should accumulate at least 60 min of moderate-to-vigorous PA per day. Importantly, light-intensity PA is also assumed to protect children from obesity (Kwon et al., 2011).

An investigation of behavioral and cognitive predictors of obesity among children may focus on body mass index or on other indicators of body composition, such as body fat percentage (Laurson et al., 2011). Child body fat may be predicted by child PA, but also by parental PA (for review see Cislak et al., 2012). This is particularly true for children aged 11 years old or younger, whereas significant associations between parental and adolescent weight-related perceptions and PA are less likely to occur (Cislak et al., 2012). There are significant associations between child body fat and child PA (Duncan et al., 2006; Jiménez-Pavón et al., 2010), parental PA and child PA levels (Edwardson & Gorely, 2010), as well as parental and child body fat levels (Cislak et al., 2012). Parental and child overweight indices form moderate-to-strong associations (Mech et al., 2016). Thus, a thorough examination of determinants of child body fat requires accounting for parental and child PA levels, as well as parental obesity indices (e.g., parental body fat percentage). The present study will investigate parental and child predictors of child body fat and PA (among children aged 6-11). The predictors will include behavioral factors such as parental PA and parental body fat. Furthermore, two cognitive factors will be included: perceived accessibility, which refers to the physical PA environment, and
perceived safety, which is a characteristic of the social environment determining PA in childhood (Carroll-Scott et al., 2013).

Several theoretical models attempt to explain PA and obesity. The ecological model of four domains of active living (domains of: active transport, occupation, active recreation, and household; Sallis et al., 2006) assumes that PA is predicted by the perceptions of the physical and social environment. Perceptions of the physical environment refer to accessibility to PA facilities, but also to comfort, convenience, or attractiveness of PA facilities (Sallis et al., 2006). Perceptions of the social environment refer to safety of PA facilities. The model (Sallis et al., 2006) was developed to explain PA among children and adults. In contrast, the ecological model of predictors of child obesity (Davison & Birch, 2001) focuses solely on predictors that operate in childhood. (Davison & Birch, 2001). In line with the model proposed by Sallis et al. (2008), Davison and Birch’s (2001) model includes such predictors of childhood obesity as perceptions of accessibility and safety, but it also accounts for indicators of the socioeconomic status and the built environment. Additionally, the ecological model of predictors of child obesity (Davison & Birch, 2001) highlights the role of parent-related predictors, such as parental PA and parental obesity.

In sum, the ecological model of predictors of child overweight (Davison & Birch, 2001) and the ecological model of four domains of active living (Sallis et al., 2006) have two common cognitive predictors of child overweight: child perceptions of safety and accessibility. Importantly, these two models propose that respective perceptions may be directly associated with child PA (Davison & Birch, 2001; Sallis et al., 2006) and that child perceptions directly predict child overweight (Davison & Birch, 2001). Finally, as suggested in ecological model of predictors of child overweight (Davison & Birch, 2001) parental perceptions and behaviors are
also direct predictors of child body fat. Thus, the present study examined if parental and child PA as well as parental and child perceptions of accessibility and safety of the PA environment were direct predictors of body fat in children.

Evidence for perceptions of environment—PA associations was gathered mostly in cross-sectional studies (Bauer et al., 2011; Bélanger-Gravel et al., 2015; Forthofer et al., 2016). Similarly, the associations between PA and obesity among children and parents were usually tested in cross-sectional studies (for review see: Jiménez-Pavón et al., 2010). Furthermore, research on relationships between child PA and perceptions of accessibility or safety usually accounted for child perceptions only (e.g., Carroll-Scott et al., 2013) or parental perceptions only (e.g. Bauer et al., 2011). Some of these shortcomings were addressed in recent research. For example, perceptions of the environment (measured in parents) correlated with PA and body composition (measured in children) (Bauer et al., 2011) whereas perceptions of support for PA (measured in parents) were associated with child PA (Loprinzi & Trost, 2010). Parental perceptions were associated with child and parental PA, but child and parental BMI did not moderate these associations (Bélanger-Gravel et al., 2015). Unfortunately, joint effects of child and parental perceptions of social and physical PA environment were usually not considered. To date, dyadic research focused on cross-sectional associations (Bauer et al., 2011; Bélanger-Gravel et al., 2015; Forthofer et al., 2016). In sum, there is a lack of dyadic prospective studies explaining how parental and child variables (perceptions, PA, and body fat) operate together.

Identifying modifiable psychological variables which predict PA among children with overweight is crucial for developing effective psychological interventions. Furthermore, it is relevant to evaluate if the same effects may be observed among children with overweight/obesity and in those with normal body weight, because this would allow to combine prevention and
treatment efforts into one intervention, targeting general population (Cislak et al., 2012). To our knowledge, only one study (Bélanger-Gravel et al., 2015) tested if the associations between child and parental perceptions and PA are similar across two types of dyads, that is dyads with overweight children and in those with children with normal body weight.

In sum, we aimed at explaining child body fat and PA in a prospective study accounting for data from parent-child dyads. In particular, we hypothesized that perceptions of accessibility and safety of PA facilities for children (measured in children and parents at Time 1) as well as PA and body fat (measured in children and parents at Time 1) would directly predict child PA and body fat, measured at the follow-up (Time 2). This hypothesis was tested for the total sample of the participants. Next, using a two-group model we explored if the time-lagged associations assumed in the model would be similar across two subgroups: (1) dyads with a child with overweight/obesity and (2) dyads with a child with normal body weight.

Method

Participants

Dyads of children and their parents (or legal guardians in case there was no parent) were invited to participate. At Time 1 (T1) 922 dyads (1844 individuals) were enrolled. At Time 2 (T2), which took place 7-8 months later, data from 525 (57%) full parent-child dyads were collected. Participants were enrolled in schools or general practitioners’ offices in 26 villages, towns and cities of 6 administrative regions of Poland. In each location, the research team visited primary schools providing education for children aged 6-11 years old. The team also visited nurse/general practitioners’ offices (conducting check-ups for all children, registered with a respective general practitioner) and discussed the possibility of data collection in a respective location. Two schools (out of 27) and two practitioners’ offices (out of 12) did not agree to data
collection. Among potential respondents one in ten dyads declined to participate (either parent or child did not provide their consent).

Children \((N = 922)\) were 52.2% girls and 47.8% boys. They were 6-11 years old \((M = 8.42, SD = 1.26)\). At T1 23.8% \((n = 219)\) of children had their body mass percentile above 85, indicating overweight/obesity. The remaining children had normal body weight (percentiles from 5 to 85; 76.2%). None of children had body mass percentile values below 5.

Parents\(^1\) \((N = 922, 16.1\% \text{ men}, 83.9\% \text{ women})\) were 23 to 69 years old \((M = 35.97, SD = 5.56)\) at T1. Among parents, 11.3% had a body mass index (BMI) below 19, 50.1% had a normal body weight, 38.7% were overweight/obese (BMI > 25).

**Procedure**

Data were collected from 2011 through 2015. Study personnel \((N = 13; \text{ women with MA in psychology or MD degree})\) participated in a data collection training. Children and parents were given information about the research schedule one week before the study began and were asked to confirm participation and provide their consent. In each family, the parent who was the main caretaker (in terms of time spent with a child and co-organizing child PA) was invited to

\(^1\)Collected data also indicated that the majority of parents (56%) evaluated their economic situation as similar to the economic situation of the average family in Poland, with 25% and 8% indicating that their economic situation was slightly better or better than the average, respectively. The remaining participants indicated that their economic situation was slightly worse (8%) or worse (3%) than the average. Forty-one percent had secondary education; 39% had a higher education degree, 20% reported primary education. The majority declared that they were employed full-time (61%) or part time (16%), with the remaining 23% indicating no current employment or being retired. The majority of participants lived in cities and towns (69%, including 26% living in large cities with > 500,000 inhabitants) and 31% lived in rural areas. To represent economic diversity, data collection was conducted in the regions characterized with lower economic development (23% of locations from the region with GDP of 68.5% of Polish GDP per capita), medium economic development (50 % of locations from the region with GDP of 103.4%), and higher economic development (27% of locations from the region with GDP of 151.6%; cf. Demographic Yearbook of Poland, 2015). All participants were white (98% of Poland’s population is white, see Demographic Yearbook of Poland, 2015).
participate in the study. All participants were informed about the aims of the study and ensured about anonymity by the study personnel.

Collection of child and parent data took place at schools or in offices of general practitioners. These locations were proposed for data collection as parents were personally collecting children from schools or accompanying children at general practitioners’ offices. If parents indicated that data collection at their home would be more feasible, the measurement was conducted at the location of their choice. Children age 6-8 were interviewed using self-report items. Older children (9-11) were invited to read and write down their responses unless they indicated a preference for being interviewed. In all cases, the interviewers asked children to signal when they were not sure if they understood the words used in the interviews. If children signaled a lack of clarity, the interviewer discussed the term with the child. Parents responded to questionnaires. Data collection lasted between 20 and 30 minutes depending on child age. Data from parents and children were collected in separate rooms. After the questionnaires/interviews had been completed, body weight and height were measured with certified body weight scales.

At T2 the study personnel revisited the schools after contacting parents by phone. The attempts to contact parents were repeated 3-5 times during a three-week period. The time gap between the measurement points was designed to include one school year (from the beginning of the school year to its end) and avoid additional dropout due to school change after the completion of the school year. In cases where participants had been recruited at general practitioners’ offices, parents were contacted by phone and invited for T2 assessment.

To partially control for the accessibility of at least some PA facilities for children, the present study was conducted in locations that had at least one built PA facility accessible and safe for children, located within 15-20 minutes (walking) from their schools/homes. In particular,
all neighborhoods where data were collected had at least one newly built outdoor facility for child PA, such as soccer, basketball, and volleyball, with respective equipment and facilities available (nets, locker rooms, lighting, fencing, sitting areas, and adult supervision). Those facilities were built between 2008 and 2012 in Poland during the implementation of a nationwide policy ‘Eagle 2012: My Playing Field’ which resulted in building 2,700 outdoor team sports facilities near schools (mostly primary schools for children aged 6-12 years old), funded by the state, accessible to children for free from 07:00 a.m. to 10:00 p.m.. All facilities were fenced and provided supervised training in team sports. The facilities had similar terms of accessibility and safety for children, and the overall quality of the facilities, and available equipment. The presence of facilities was checked by searching Google maps and governmental websites (e.g., https://www.orlik2012.pl/index.php/mapa) to identify whether facilities providing physical activity opportunities were available in the neighborhood.

The study was approved by the Institutional Review Board at SWPS University of Social Sciences and Humanities, Wroclaw, Poland. Informed consents were collected from parents (about their own and child participation) and from children. Personal codes were used to secure anonymity.

**Measures**

Descriptive statistics are reported in Supplement 1. The same measures (or measures as similar as possible) were applied in both members of the dyad. The use of the same measures is the optimal solution as the association between the parental and child activity may be influenced by the differences in assessment format (Kenny, Kashy, & Cook, 2006). The feasibility of item-wording of child variables was tested in a pilot study with \( n = 18 \) children aged 5-10 years old. If the pilot participants indicated that the wording was unclear, respective terms used in the original
measures (Giles-Corti & Donovan, 2002; Wilcox et al., 2000) were replaced, e.g. ‘traffic’ was replaced with ‘cars driving near my house and school’. All items presented below are translations from Polish. Unless otherwise noted, responses were given on 4-point response scales ranging from 1 (‘definitely not’) to 4 (‘exactly true’).

Parental perceptions of accessibility of PA facilities for children were assessed at T1 with two items ‘My child has easy access to facilities where she/he can play sports, such as indoor courts, outdoor pitches, swimming pools, etc.’ and ‘My child has easy access to facilities where she/he can exercise, such as parks, recreational playgrounds’. The items were based on a measure developed by Wilcox et al.’s (2000). The items used by Wilcox et al. (2000) were adjusted to the aims of the present study (e.g., the phrase ‘I have easy access’ was replaced with ‘my child has easy access’). Easy access was defined as ‘close to your home or that you can get to easily’ (Carroll-Scott et al., 2013). The reliability of the measure was acceptable with Spearman-Brown ρ = .64, p < .001.

Child perceptions of accessibility of PA facilities for children were measured at T1 with two items based on Wilcox et al. (2000), ‘It is easy for me to get to and use places where I can play sports, such as sport pitches or arenas (e.g. football or basketball pitch), swimming pools, etc.’ and ‘It is easy for me to get to and use places where I can exercise and play, such as parks, playgrounds’. The reliability was acceptable with Spearman-Brown ρ = .54, p < .001.

Parental perceptions of neighborhood safety were evaluated at T1 with two items, ‘The neighborhood is safe (and crime-free) for my child to play sports and engage in physical activity’ and ‘There is a lot of traffic in the neighborhood and therefore it is not safe for my child to cycle, play or be physically active’ based on items used by Giles-Corti and Donovan (2002). The phrase ‘safe for walking’ used by Giles-Corti and Donovan (2002) was replaced with ‘safe for
my child to play sports and engage in physical activity’. The reliability of the measure was acceptable with Spearman-Brown $\rho = .53, p < .001$.

Child perceptions of neighborhood safety were measured at T1 with two items, ‘It is safe for me to play sports and exercise near my house and school’ and ‘There is a lot of cars driving near my house and school so it is not safe for me to cycle, play or exercise outdoors’. The items were based on a measure by Giles-Corti and Donovan (2002). The reliability of the measure was acceptable with Spearman-Brown $\rho = .57, p < .001$.

Physical activity of parents and children was assessed at T1 and T2 with a self-report physical activity questionnaire developed by Godin and Shephard (1985). Validity and reliability of this measure was found to be acceptable in studies involving children aged 7-15 (Koo & Rohan, 1999) and adults (Godin & Shephard, 1985). Participants were told to report any exercise session that lasted at least 15 minutes (one bout) and was enacted outside of the physical education class at school. The obtained PA index accounts for bouts of PA and the metabolic values of PA per week. The index was calculated with a formula: total exercise score = 9 x [strenuous bouts per week] + 5 x [moderate bouts per week] + 3 x [mild bouts per week] (Godin & Shephard, 1985). Reliability for this 3-item measure was moderate with $\alpha$ of .53 (T1) and .51 (T2) in children and $\alpha$ of .55 (T1) and .51 (T2) in parents.

Total body fat (T1 and T2) was measured with the bioimpedance (BIA) method (Kyle et al., 2004) which determines the electrical impedance of an electric current through body tissues. Body fat percentage was estimated with the Schaefer equation for BIA which is considered a reliable index of body fat in youth from primarily white backgrounds (Cleary et al., 2008). A body weight scale evaluating total body fat with BIA method was used (BF-100 and BF-25; Beurer, Germany). BF-100 and BF-25 manufacturer declares a measurement error of 1%.
Overweight and obesity in parents and children (T1 and T2) was determined with certified body weight floor scales (BF-100 and BF-25; Beurer, Germany) and medically approved telescopic height measuring rods. Using WHO Anthro calculator (WHO, 2011) child body mass indicators (Z scores and percentiles) were calculated, adjusting for child age and sex. Percentile indicators with values above 85 indicate overweight or obesity (WHO, 2011). Body weight index (BMI) was calculated for parents, using their body weight and height.

**Data Analysis**

The sample size was determined using the GPower calculator. Assuming small effect sizes of variables in the model predicting child body fat and considering that analyses should account for potential confounders (such as age and gender of children and parents) we estimated that the sample should include at least 919 dyads at T1. It was assumed that any missing data (including data missing due to dropouts at T2) would be accounted for using the full information maximum likelihood (FIML, Byrne, 2010). Therefore, we aimed at enrolling approximately 920 dyads at T1.

Path analyses (Byrne, 2010) were conducted with IBM AMOS 24, maximum likelihood estimation. Due to assumed small effects on the main outcome, we estimated that analysis of the one-group model should account for < 90 parameters (i.e. 10 persons per parameter) or a two-group model should include <180 parameters (Wolf et al., 2013). To limit the critical number of parameters in the models we refrained from fitting latent variables and used manifest variables. Several fit indices were applied to assess model-data fit. We used a cutoff point < .08 for root mean square error of approximation (RMSEA) and standardized root mean residual (SRMR) and a cutoff point > .90 for comparative fit index (CFI) and Tucker Lewis index (TLI) (Byrne, 2010).
The first path analysis was conducted to test the associations in the total sample, whereas the second analysis was conducted for the two-group model, including a subsample of dyads with children of normal body weight (< 85 percentile for body weight) and a subsample of dyads with children with overweight/obesity (≥ 85 percentile). The unconstrained two-group model was compared with a nested model assuming that regression paths were equal across two subsamples. A lack of significant differences between the unconstrained and nested models indicates that the constrained model should be accepted (Byrne, 2010).

As suggested in the actor-partner interdependence model (APIM, Cook & Kenny, 2005) the effects of parental and child predictors on parental and child outcomes were assumed in the hypothesized model. To account for non-independence, the respective predictors measured in both dyad members (e.g., parental and child PA) as well as their respective outcome residuals were allowed to covary. In line APIM (Cook & Kenny, 2005) the hypothesized model accounted for covariations between respective child and parent variables at respective measurement points (e.g., child perceptions of accessibility and child PA at Time 1 were assumed to covary; child and parental perceptions of safety at Time 1 were assumed to covary).

The hypothesized associations are presented in Figure 1 (see also Table 1). In particular, perceptions of accessibility and safety of PA facilities for children, measured both in parents (T1) and in children (T1), were assumed to directly predict child PA (T2) and body fat (T2). Furthermore, child PA (T1) was assumed to predict child body fat and PA at T2. Parental PA (T1) was assumed to predict child and parental PA (T2) and parental body fat (T2). The hypothetical model controlled for effects of T1 PA and body fat in parents and children on T2 indicators of respective variables. The four indices of parental and child perceptions of accessibility and safety (T1) were assumed to covary. Four indices of PA and body fat at T1
were assumed to covary. T2 residuals of parental and child body fat and PA were also assumed to covary. Finally, the hypothesized model controlled for potential effects of parental age and gender (T1) on parental and child PA and body fat (T2). For clarity, Figure 1 does not display assumed covariances between T1 variables, covariances between T2 residuals, or effects of age and gender.

**Results**

Those who completed both T1 and T2 did not differ from dropouts in perceptions, PA, body fat, gender, age, education, or socioeconomic status, all $F$s < 1.37, all $p$s > .242. Correlations between study variables are presented in Supplement 1. All indices of perceptions of accessibility at T1 were related to lower body fat among children (T2).

**Parental and Child Perceptions (T1) Predicting Child Physical Activity and Total Body Fat (T2): Results of Path Analysis in the Total Sample**

The hypothesized model calculated for the total sample ($N = 922$ dyads) presented an acceptable fit with $\chi^2 (73) = 327.21, p < .001, \chi^2/df = 4.48, \text{GFI} = .958, \text{NFI} = .920, \text{TLI} = .904, \text{CFI} = .936, \text{RMSEA} = .061 \ (90\% \text{ CI:} \ .055, .068), \text{SRMR} = .059$. The unstandardized solution is presented in Table 1. Figure 1 shows assumed associations with solid lines representing significant effects. Overall, the variables in the hypothesized model explained 79% and 77% body fat (T2) in children and parents, respectively; 10% of PA (T2) variance in children and 44% of PA (T2) variance in parents was explained.

In accordance with our main hypotheses, parental perceptions of accessibility of PA facilities for children (T1) were related to lower body fat and higher PA in children (T2) (Table 1; Figure 1). Child PA (T1) predicted lower body fat and higher PA in children (T2). Parental PA (T1) predicted child PA (T2) but not child body fat (T2). Child perceptions of accessibility and
safety at T1 were unrelated to body fat or PA indicators among children (T2; Table 1; Figure 1). Parental perceptions of safety (T1) were also unrelated with child body fat and PA (T2). Parental PA and body fat (T2) were explained only by respective T1 variables (Table 1; Figure 1).

Results of Path Analysis with a Two Group Model: Children with Normal Body Weight and those with Overweight/Obesity

The two-group model analyses aimed at exploring if the patterns of associations were similar across the two groups. The first group consisted of dyads with children with body mass < 85 percentiles; the second included dyads with children with body mass ≥ 85 percentiles. The model-data fit for the two-group unconstrained model was acceptable with $\chi^2 (126) = 414.87, p < .001, \chi^2/df = 2.84, \text{GFI} = .950, \text{TLI} = .932, \text{CFI} = .930, \text{RMSEA} = .045 \text{ (90\% CI: .040, .050), SRMR = .045.}$ The unconstrained two-group model did not differ significantly from the two-group models which had structural covariances and residuals constrained to be equal ($\Delta \text{TLI of - .015 and - .018, respectively}$). The model assuming the paths being equal across both groups did not differ from the unconstrained two-group model, $\chi^2 (32) = 39.70, p = .164, \Delta \text{TLI} = -.018$. Thus, the model assuming that the regression (path) coefficients were equal across the two groups may be accepted.

The unstandardized path coefficients for the unconstrained model are reported in Table 1. Across the two groups, the path coefficients which were significant for the total sample remained significant in the subgroup with children with normal body weight and in the subgroup with children with overweight/obesity. Parental perceptions of higher accessibility of PA facilities for children (T1) were related to higher levels of PA (T2) and lower levels of body fat (T2) among dyads with children with normal body weight and among dyads with children with overweight and obesity (Table 1). Parental and child PA (T1) predicted child PA (T2) in the two groups.
Additionally, higher parental PA (T1) was related to lower body fat in children (T2) in a subsample of dyads with children with overweight or obesity.

Among dyads with children with normal body weight, variables in the equation explained 71% and 79% variance of body fat (T2) in children and parents respectively, whereas 13% and 42% variance of PA (T2) measured in children and parents was explained. In the subgroup of dyads with children with overweight/obesity, respectively 80% and 75% variance of child body fat (T2) and 12% and 50% of child PA (T2) were explained.

**Discussion**

To our knowledge this is the first prospective study providing an insight into dyadic associations among parental and child perceptions of PA environment, PA, and body fat. Dyadic data indicated that parental, not child perceptions of accessibility of PA facilities predicted body fat percentage among children. The effect of parental perceptions of accessibility seems to be robust, as it was observed for self-reported PA among children and for child body composition (an objective measure of body fat). These effects were observed in the total sample, in the subsample of dyads with children with overweight/obesity, and in the subsample of dyads with children with normal body weight. Although associations between perceived accessibility or safety and PA were often studied (Humpel et al., 2002; Pocock et al., 2010; Sallis et al., 2006) the research so far investigated these processes in parents only or children only, or accounted for parental perceptions but child behaviors only (Bauer et al., 2011; Carroll-Scott et al., 2013). Our study went two steps further: first, it accounted for the associations between perception and behavior in parent-child dyads, and second, the objective indicator of body fat composition was applied. In sum, our dyadic study explains how parental and child variables (perceptions, PA,
and body fat) operate together and therefore it offers an insight into dyadic mechanisms which may lead to a reduction of body fat among children.

This study showed no effects of safety perceptions on child PA and body fat at follow-ups. Systematic reviews showed significant, but weaker associations between perceived safety and PA, compared to associations found for perceived accessibility and PA (Humpel et al., 2002). In sum, our findings tend to be in line with those weaker effects of safety perceptions, which seem to be non-significant in predicting obesity of younger children.

In line with our findings, Forthofer et al. (2016) recently discovered that maternal, but not child perceptions of parental support for PA were associated with child PA levels. The significant role of parental, but not child perceptions may be specific for this developmental period (children aged 0-11 years old) and become less salient in adolescence (cf. Safron et al., 2011).

Because parental variables were found to predict child PA and body fat, our findings have some implications for the development of theoretical models explaining PA and its health outcomes, such as body fat. So far, the vast majority of behavior change theories and research focused on an individual as a unit of analysis (cf. Conner & Norman, 2015). This study suggests that instead of focusing on how individual’s perception predicts his/her behavior and obesity, theoretical approaches explaining childhood obesity should account for dyadic associations. Including parental and child perceptions as well as parental and child behaviors may provide the fuller picture of the determinants of childhood obesity.

The findings may have implications for childhood obesity prevention. Parental participation in childhood obesity treatment and prevention is a well-established determinant of effectiveness of such programs (for review see Cislak et al., 2012). The authors of childhood
obesity treatment and prevention programs may consider investing more effort to help parents recognize the accessible PA facilities in their neighborhood. Childhood obesity prevention and treatment should prompt parents to engage in PA, which would be beneficial for their own body composition (WHO, 2003) but most of all for reducing childhood obesity.

In line with socio-ecological models (Davison & Birch, 2001; Sallis et al., 2006) the present study assumed that the perceptions of PA environment are direct predictors of PA and body fat. An alternative approach would be to assume indirect effects in the perception—behavior—body fat relationship. Future studies may compare these two approaches to improve our understanding of the processes in which respective perceptions, behavior, and overweight indices operate together.

The present study has several limitations. Due to a large sample size (922 parent-child dyads) we decided that the use of accelerometer-based measurement of PA was not feasible. The applied measure of PA has its limitations. The reliability and validity of applied measure may be considered acceptable (but not high) in samples consisting of children (Koo & Rohan, 1999). The time gap between the measurement points was relatively short (7-8 months). This approach contributed to limited variability of body fat percentage, which was rather stable over this relatively short time period. The process of selection of parents for the parent-child dyad relied on identifying the parent who was spending more time with the child and was co-organizing child PA. It is possible, however, that in some dyads one parent was the main caretaker but the other parent (who did not participate in the study) was the main organizer of child PA. The ideal design would account for a more thorough investigation of the objective environment, that is the presence and the distance to the PA facilities. Objective indicators of the built environment may explain PA of children, over and above perceptions of the built PA environment (Scott et al.,
2007). Future research should consider a more thorough test of the ecological model of four domains of active living (Sallis et al., 2006) and account for other perceptions of the PA environment, such as attractiveness, comfort, and convenience (Sallis et al., 2006). The protocol of our study accounted for measuring accessibility of PA facilities for adults. As it was not possible to assess this variable reliably in both parents and children, it was dropped from the hypothesized model. Furthermore, the inclusion of modifiable self-regulatory variables, such as self-efficacy could further help to explain PA and body fat in children (Luszczynska et al., 2016). Other factors which may determine the perceptions of accessibility or PA levels, such as the use of sports facilities and the characteristics of PA facilities were not accounted for, but should be also considered in future research. Additionally, research should use multiple measurement points to investigate if perceptions of accessibility and safety of PA facilities, PA, and body fat may form a specific chain of the associations, with PA acting as a mediator. The associations between parental perceptions and child obesity indicators may depend on child’s age. For example, Timperio et al. (2005) indicated that parental perceptions of safety were correlated with obesity of children, however the associations were significant only for 10-12-years-old children but not for those 5-6-years-old. Therefore, the conclusions of our study cannot be generalized across age groups.

Conclusions

Our research supports the notion of parental and child predictors explaining child PA and body fat. In line with the ecological model of predictors of child obesity (Davison & Birch, 2001) our study provides solid evidence for the use of dyadic approach in research explaining childhood obesity. In particular, we found that after controlling for baseline body fat and PA,
perceptions of accessibility still predicted PA and body fat in children, measured at a follow-up. Importantly, parental not child perceptions mattered.

References


Cleary, J., Daniells, S., Okely, A. D., Batterham, M., & Nicholls, J. (2008). Predictive validity of four bioelectrical impedance equations in determining percent fat mass in overweight and

Doi: 10.1016/j.ada.2007.10.004


Figure caption
Figure 1. Results of path analysis for the hypothesized model: parental and child physical activity and perceptions of accessibility and safety of physical activity facilities as predictors of child physical activity and body fat at a 7-8 month follow-up.

Figure notes
Figure 1. For clarity, the covariances were not displayed. Solid lines represent path coefficients which were significant ($p < .05$) in the total sample (as well as in the subsample of children with body mass $< 85$ and the subsample of children with body mass $\geq 85$ centiles). Dashed lines represent path coefficients which were not significant. Path and covariance coefficients are presented in Table 1.
Table 1

Regression coefficients and covariances for the study variables in the total sample, the subsample of dyads with children with normal body weight, the subsample of dyads with children with overweight and obesity

<table>
<thead>
<tr>
<th>Variable</th>
<th>The total sample</th>
<th>Children with normal weight</th>
<th>Children with overweight/obesity</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Path coefficients/covariance coefficients</td>
<td>Estimate</td>
<td>S.E.</td>
</tr>
<tr>
<td>Predictors of child body fat (T2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility (P, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>-0.57</td>
<td>0.12</td>
</tr>
<tr>
<td>Accessibility (Ch, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>-0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Safety (P, T1) → Body fat (Ch, T2)</td>
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<td>0.19</td>
<td>0.15</td>
</tr>
<tr>
<td>Safety (Ch, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>0.28</td>
<td>0.15</td>
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<tr>
<td>PA (P, T1) → Body fat (Ch, T2)</td>
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<td>&lt;.01</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>PA (Ch, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>-0.02</td>
<td>0.01</td>
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<tr>
<td>Body fat (Ch, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>0.86</td>
<td>0.02</td>
</tr>
<tr>
<td>Body fat (P, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>0.04</td>
<td>0.02</td>
</tr>
<tr>
<td>Safety (P, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>0.09</td>
<td>0.21</td>
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<tr>
<td>Safety (Ch, T1) → Body fat (Ch, T2)</td>
<td></td>
<td>0.53</td>
<td>0.09</td>
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<tr>
<td>Predictors of child PA (T2)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Accessibility (P, T1) → PA (Ch, T2)</td>
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<tr>
<td>Accessibility (Ch, T1) → PA (Ch, T2)</td>
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<td>0.85</td>
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<tr>
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<td>1.02</td>
<td>1.20</td>
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<tr>
<td>Safety (Ch, T1) → PA (Ch, T2)</td>
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<td>1.94</td>
<td>1.09</td>
</tr>
<tr>
<td>PA (P, T1) → PA (Ch, T2)</td>
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<td>0.04</td>
<td>0.02</td>
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<tr>
<td>PA (Ch, T1) → PA (Ch, T2)</td>
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<td>0.22</td>
<td>0.03</td>
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<tr>
<td>Body fat (P, T1) → PA (Ch, T2)</td>
<td></td>
<td>0.12</td>
<td>0.16</td>
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<td>0.12</td>
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<td></td>
<td>1.54</td>
<td>0.66</td>
</tr>
<tr>
<td>Predictors of parental body fat (T2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA (P, T1) → Body fat (P, T2)</td>
<td></td>
<td>&lt;.01</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>PA (Ch, T1) → Body fat (P, T2)</td>
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<td>&lt;.01</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Body fat (P, T1) → Body fat (P, T2)</td>
<td></td>
<td>0.89</td>
<td>0.02</td>
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</table>
### Predictors of parental PA (T2)

<table>
<thead>
<tr>
<th>Predictor 1</th>
<th>Predictor 2</th>
<th>Beta 1</th>
<th>Beta 2</th>
<th>Beta 3</th>
<th>Beta 4</th>
<th>Beta 5</th>
<th>Beta 6</th>
<th>Beta 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA (P, T1) → PA (P, T2)</td>
<td>.59</td>
<td>.02</td>
<td>&lt;.001</td>
<td>.59</td>
<td>&lt;.001</td>
<td>.58</td>
<td>.04</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>PA (Ch, T1) → PA (P, T2)</td>
<td>.02</td>
<td>.02</td>
<td>.202</td>
<td>.03</td>
<td>.02</td>
<td>.104</td>
<td>.02</td>
<td>.04</td>
</tr>
<tr>
<td>Body fat (P, T1) → PA (P, T2)</td>
<td>-.04</td>
<td>.09</td>
<td>.638</td>
<td>-.15</td>
<td>.11</td>
<td>.181</td>
<td>.18</td>
<td>.300</td>
</tr>
<tr>
<td>Body fat (Ch, T1) → PA (P, T2)</td>
<td>.06</td>
<td>.07</td>
<td>.424</td>
<td>-.02</td>
<td>.09</td>
<td>.842</td>
<td>.09</td>
<td>.14</td>
</tr>
<tr>
<td>Gender (P, T1) → PA (P, T2)</td>
<td>.50</td>
<td>1.35</td>
<td>.712</td>
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<td>1.57</td>
<td>.779</td>
<td>1.54</td>
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<tr>
<td>Age (P, T1) → PA (P, T2)</td>
<td>-.20</td>
<td>.09</td>
<td>.024</td>
<td>-.24</td>
<td>.11</td>
<td>.026</td>
<td>-.11</td>
<td>.16</td>
</tr>
</tbody>
</table>

### Note

PA – physical activity, P – parent, Ch – child, T1 - Time 1, T2- Time 2 (7-8 month follow-up). Significant coefficients are marked in bold.
Accessibility of PA facilities for children (reported by parents), T1

Accessibility of PA facilities for children (reported by children), T1

Safety of PA facilities for children (reported by children), T1

Safety of PA facilities for children (reported by parents), T1

Child body fat, T1

Child body fat, T2

Child physical activity, T1

Child physical activity, T2

Parental physical activity, T1

Parental physical activity, T2

Parental body fat, T1

Parental body fat, T2
Research highlights:

- We attempted to explain physical activity and body fat among 5-10 year old children
- The role of perceptions of the environment (its accessibility and safety) was tested
- Longitudinal data (with 7-8-month follow-up) were collected in 922 child-parent dyads
- Parental perceptions of accessibility of exercise facilities affected child outcomes
- Child perceptions were unrelated to child physical activity or body fat the follow-up
Abstract

Objectives: Research explaining childhood obesity has been usually focused on cognitive and behavioral predictors assessed in parents only or in children only. In contrast, the dyadic approach allows to evaluate how parental and child predictors operate together to explain child physical activity (PA) and body fat. This study investigated relationships among: (1) parental and child perceptions of accessibility and safety of exercise facilities for children, (2) parental and child PA, and (3) parental and child body fat percentage.

Design: A prospective and dyadic study with two measurement points was conducted. The follow up (Time 2) took place at 7-8-month after the baseline (Time 1).

Methods: Data were collected among 922 dyads of parents (mean age 35.97 years old; 83.9% women) and children (aged 6-11; $M = 8.42$, 52% girls). Parents and children reported safety and accessibility perceptions (Time 1) and PA (Time 1 and 2). Parental and child body fat were measured objectively (Time 1 and 2).

Results: Path analysis showed that parental perceptions of accessibility of PA facilities for children (Time 1) predicted child body fat and PA (Time 2). The associations were significant in a model accounting for longitudinal and cross-sectional associations between parental and child body fat and PA, controlling for age and gender of parents and children. Similar patterns of associations were found in the subsamples of dyads with children with normal body weight and with children with overweight/obesity.

Conclusions: Parental, not child perceptions of accessibility of PA facilities predicted child PA and body fat.

Keywords: obesity; body fat; physical activity; parent; child; perceived environment