

Original article

# Parents' participation in physical activity predicts maintenance of some, but not all, types of physical activity in offspring during early adolescence: A prospective longitudinal study

Jennifer Brunet<sup>a,b,c,\*</sup>, Jeffrey Gaudet<sup>d</sup>, Erin K. Wing<sup>a</sup>, Mathieu Bélanger<sup>d</sup>

<sup>a</sup> School of Human Kinetics, University of Ottawa, Ottawa, ON K1N 6N5, Canada

<sup>b</sup> Institut du Savoir Montfort (ISM), Hôpital Montfort, Ottawa, ON K1K 0T2, Canada

<sup>c</sup> Cancer Therapeutic Program, Ottawa Hospital Research Institute (OHRI), Ottawa, ON K1H 8L6, Canada

<sup>d</sup> Centre de formation médicale du Nouveau-Brunswick, Université de Moncton, Moncton, NB E1A 3E9, Canada

Received 22 October 2016; revised 17 March 2017; accepted 28 April 2017

Available online 15 June 2017

## Abstract

**Purpose:** We aimed to examine the longitudinal associations between parents' and youth's participation in physical activity (PA).

**Methods:** One hundred and ninety youth completed self-administered questionnaires 3 times per year from 2011 to 2015, and their parents completed an interviewer-administered questionnaire during a telephone interview once in 2011–2012. Data on youth's and parents' activities were classified as interdependent or coactive/independent.

**Results:** Youth with one or both parents who participated in interdependent activities were more likely to maintain participation in interdependent activities (hazard ratio (HR) = 3.63; 95% confidence interval (CI) = 1.30–10.17). Youth's sustained participation in coactive/independent activities was not associated with parents' participation in coactive/independent activities (HR = 0.97; 95%CI = 0.46–2.06).

**Conclusion:** Longitudinal associations between parents' and youth's participation in PA differed across type of PA. Encouraging parents' participation in interdependent activities may promote sustained participation in interdependent activities in youth.

2095-2546/© 2019 Published by Elsevier B.V. on behalf of Shanghai University of Sport. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

**Keywords:** Longitudinal; Maintenance; Parental behavior; Physical activity; Sports; Youth

## 1. Introduction

Regular participation in physical activity (PA) can help reduce the risk of several chronic diseases (e.g., cardiovascular diseases, diabetes, certain cancers, hypertension, osteoporosis) and premature death in youth.<sup>1,2</sup> It can also promote healthy physical (e.g., build muscle, improve flexibility, maintain healthy weight), psychological (e.g., reduce symptoms of stress, anxiety and depression, enhance self-esteem), and social development (e.g., foster supportive relationships, reinforce a sense of belonging) in youth.<sup>3,4</sup> In light of this evidence, guidelines suggesting youth engage in at least 60 min of moderate-to-vigorous intensity PA per day have been issued.<sup>5</sup> However, only 9% of youth age 6–17 years are meeting these PA guide-

lines in Canada.<sup>6</sup> Moreover, participation in PA markedly decreases as youth transition from childhood to adolescence,<sup>7–9</sup> and annual decreases are more pronounced in youth age 12–19 years relative to annual decreases observed in adults.<sup>10,11</sup> These statistics are alarming because physical inactivity during youth predicts inactivity during adulthood.<sup>12</sup> Early interventions may therefore have considerable value for preventing decreases that occur from age 12 years onwards and subsequently offset the risk of physical inactivity and associated health consequences later in life. To support the development of tailored early interventions, a better understanding of factors that contribute to the adoption and maintenance of PA starting at age 12 years is needed.

It is widely believed that parents can influence youth's participation in PA,<sup>13</sup> likely because youth live in close proximity and have daily contact with their parents.<sup>14</sup> Parents can play an important role in supporting their child's participation by providing the resources their child needs to participate in PA,

Peer review under responsibility of Shanghai University of Sport.

\* Corresponding author.

E-mail address: [jennifer.brunet@uottawa.ca](mailto:jennifer.brunet@uottawa.ca) (J. Brunet)

<https://doi.org/10.1016/j.jshs.2017.04.012>

Cite this article: Brunet J, Gaudet J, Wing EK, Bélanger M. Parents' participation in physical activity predicts maintenance of some, but not all, types of physical activity in offspring during early adolescence: a prospective longitudinal study. *J Sport Health Sci* 2019;8:273–9.

participating in PA together, exposing their child to a variety of activities, developing their child's feelings of competence for PA, and transmitting positive attitudes toward PA to their child.<sup>15,16</sup> In addition, parents can promote youth's participation in PA by showing their child that PA is an important part of their own life. They might do so by participating in PA themselves or by sharing their personal experiences and the benefits it has offered them (e.g., develop competencies, gain confidence, connect with others, build character). Accordingly, several researchers have investigated the association between parents' and youth's participation in PA.<sup>17-21</sup> Evidence supporting this association is inconsistent. There are data in support of similar PA patterns between parents and youth,<sup>18,19</sup> but other reports have not demonstrated such associations.<sup>22,23</sup> The inconsistencies observed in the literature could be related, in part, to researchers having focused on parents' and youth's participation in PA generally, by either using a single item to assess PA or by combining all fields of activity into a total measure of PA, instead of considering participation in different types of activities separately.<sup>24,25</sup>

There is consensus that PA includes many different types of activities that may have different correlates.<sup>26-28</sup> Classifying activities based on relative amount of task interdependence required to achieve the activity's goal would allow researchers to examine the associations between parents' and youth's participation in different types of PA. According to Carron et al.,<sup>29</sup> interdependent activities are those whereby members of a group are mutually dependent on one another, task interactions are inherently variable, and greater success in such tasks relies on the coordination and cooperation within the group. In contrast, the success of coactive/independent activities depends solely on the actions of 1 individual or the synchronized responses of 2 individuals.<sup>29</sup> The social nature of this categorization makes it particularly relevant for investigating associations between parents' and youth's participation in different types of PA, especially during the transition from childhood to adolescence, which has been viewed as a period when the influence of parents decreases.<sup>16,30</sup> Though the timing and nature of the decline in parental influence remains unclear, it is possible that parents influence youth's participation in PA differently based on the social nature of the activity.

Furthermore, although several researchers have investigated the association between parents' and youth's participation in PA, most have used cross-sectional study designs.<sup>18,20,21</sup> Such designs do not allow for the examination of whether parents' participation in PA is associated with youth's sustained participation over time. With PA initiation and maintenance having different determinants,<sup>7,31</sup> a longitudinal study is necessary to determine whether parents' participation in interdependent activities and coactive/independent activities is associated with youth's sustained participation in interdependent activities and coactive/independent activities, respectively. This type of study would provide evidence for the importance of involving parents when implementing interventions to maintain participation in different types of PA among youth. Therefore, we examined the associations between parents' participation in interdependent activities and coactive/independent activities with youth's sus-

tained participation in interdependent activities and coactive/independent activities in this longitudinal study. Whereas findings regarding the association between parents' and youth's participation in PA have been conflicting,<sup>18,19,22,23</sup> theoretical perspectives demonstrate the importance of parents' influence on youth's health behaviors.<sup>16</sup> Thus, we hypothesized that parents' participation in interdependent activities would be associated with youth's continued participation in these respective activities, and that parents' participation in coactive/independent activities would be associated with youth's continued participation in these respective activities.

## 2. Methods

### 2.1. Participants and procedures

We analyzed data from the Monitoring Activities of Teenagers to Comprehend their Habits (MATCH) study,<sup>32</sup> an ongoing prospective longitudinal study designed to investigate patterns of participation in PA in a sample of youth recruited from Grade 5 and Grade 6 classes in 17 schools across the province of New Brunswick, Canada. The MATCH study was approved by the Centre Hospitalier de l'Université de Sherbrooke Ethics Committee. Complete study description and protocol are published elsewhere.<sup>32</sup> In brief, 802 youth (51% of those eligible) provided written informed parent or legal guardian consent and assented to participate in the MATCH study in the fall of 2011. We collected data from youth through self-report questionnaires administered 3 times during the school year. At the time of analysis, data were available for 12 time points spanning a 4-year period.

In addition, we collected data from parents during a telephone interview once in 2011–2012, corresponding to the first year of the MATCH study, using a standardized questionnaire. Contact information was available for 490 parents whom we attempted to contact on at least 3 occasions at various times throughout the day. We were able to reach, obtain informed consent, and collect data from 190 of these parents. In each household, we interviewed one parent (mother 72.9% of the time), and obtained data on the other parent's participation in PA via the interviewed parent. The results we report are limited to the 190 families (i.e., mother or father and 1 offspring (49% girls;  $10.50 \pm 0.68$  years at the start of the study)) who provided complete data.

### 2.2. Measures

#### 2.2.1. Youth's participation in PA

Every 4 months during the school year, we collected data on youth's participation in PA using a self-administered questionnaire in which we asked youth how often they participated in 36 common activities in the past 4 months outside of their physical education class. The list of activities included all activities represented in the Kowalski et al.<sup>33</sup> PA checklist for adolescents, and an additional 14 activities to reflect other commonly practiced activities by youth in Atlantic Canada.<sup>34</sup> Pilot testing of the questionnaire with Grade 5 and Grade 6 students ( $n = 12$ ) showed it had acceptable readability and good comprehension. For each activity, we asked youth to indicate whether they

engaged in it never, once per month or less, 2–3 times per month, once per week, 2–3 times per week, 4–5 times per week, or almost every day.

We classified activities into 1 of 2 categories, interdependent or coactive/independent, on the basis of the relative amount of task interdependence required to achieve the activity's goal. Following the classification of activities put forth by Carron et al.,<sup>29</sup> 10 activities were classified as interdependent: street or floor hockey; ice hockey; ringette; baseball or softball; basketball; football; volleyball; soccer; handball or mini handball; and ball playing. The remaining activities were classified as coactive/independent: ice skating; in-line skating; skateboarding; bicycling; walking for exercise; track and field; jogging or running; golfing; swimming; gymnastics; aerobics, yoga, or exercise class; home exercises; weight training; tennis; badminton; dance; skipping rope; downhill skiing or snowboarding; cross-country skiing; karate, Judo, Tai Chi, Taekwondo; trampoline; boxing and wrestling; and kayaking and canoeing. Activities specified as "other" were determined on a case-by-case basis. Three activities listed in the questionnaire (i.e., indoor chores; outdoor chores; and games, tag, or hide-and-seek) were excluded because we were unable to determine degree task interdependence. Initial participation in each category was defined as "yes" if youth reported taking part in 1 activity or more within the respective category at least once per week at each time point during the first year of this study. Sustained participation in each category was assessed by verifying that youth reported taking part in 1 activity or more within the respective category at least once per week at each time point during the second, third, and fourth year of the MATCH study.

### 2.2.2. Parents' participation in PA

During the first year of the MATCH study, we collected data on parents' participation in PA by asking responding parents if they participated in 21 activities in the past 12 months. The list of activities was drawn from the Minnesota Leisure-Time Physical Activity Questionnaire, a widely used and validated interviewer-administered questionnaire.<sup>35–37</sup> For each activity they said they participated in, they were asked to report the months in which they did the activity (response options: January, February, March, April, May, June, July, August, September, October, November, and December), the average number of times per month they performed the activity (response options: never, once per month or less, 2–3 times per month, once per week, 2–3 times per week, 4–5 times per week, and almost every day), and how much time they spent on each occasion (response options: 1–15 min, 16–30 min, 31–60 min, and more than 1 h). As with the data from youth, the frequency to which parents participated in interdependent activities (i.e., ice hockey; baseball or softball; basketball; volleyball; and soccer) and coactive/independent activities (i.e., walking for exercise; swimming; tennis; bicycling; popular or social dance; home exercises; ice skating; in-line staking or roller blading; jogging and running; golfing; exercise classes and aerobics; downhill skiing or snowboarding; weight training; fishing; and bowling) was tabulated. Additionally, as was the case for youth's participation in PA, activities listed in a category speci-

fied as "other" were determined on a case-by-case basis. Participation in interdependent activities was defined as "yes" if parents reported taking part in 1 or more of these activities at least once per week for 4 months in the past year. A threshold of 4 months was set for interdependent activities to capture seasonal participation, as the opportunity to participate in many of the activities may depend on the seasonal availability of recreational teams and leagues (e.g., ice hockey; baseball; softball; basketball; and soccer).<sup>35</sup> No such limit was set on the coactive/independent category as many of the activities do not rely on seasonal availability, and furthermore, walking which was the most commonly reported activity in our sample, has been shown to remain consistent from season to season.<sup>38</sup> Thus, participation in coactive/independent activities was defined "yes" if parents reported taking part in 1 or more of these activities at least once per week for the past 12 months. If applicable, the responding parent also reported on the activities participated in by the other parent living in the household.

### 2.2.3. Potential covariates

We collected sociodemographic data pertaining to youth's age, sex, postal code, and proximity to PA infrastructures from youth in the questionnaire administered at the first time point. We determined neighborhood status by entering youth's self-reported postal code into the "address finder" function on the Post Canada website. We considered municipality of residence as "rural" if it was populated with less than 10,000 residents or "suburban or urban" if it included 10,000 residents or more according to Statistics Canada's classification system. We collected information on proximity to PA infrastructures using the Proximity to Recreation Facilities subscale of the Neighborhood Environmental Walkability Scale for Youth.<sup>39</sup> Proximity scores ranged from 14 to 70 and were divided into tertiles. We considered participants with scores of 14–28 to be living nearest to PA infrastructures, those with score of 29–40 to be living in mid-range distance to PA infrastructures, and those reporting scores higher than 40 as living farthest from PA infrastructures. Aside from data on potential covariates collected from youth, we collected data pertaining to household income (i.e., <CAD30,000; CAD30,000–80,000; or >CAD80,000) and parents' educational status (i.e., "neither parent completed a university degree" or "at least one parent completed a university degree") during the telephone interview with the responding parent. Given evidence of collinearity between household income and parents' educational status, and similarity in results with either variable, we only present results including parents' educational status as a covariate.

### 2.3. Data analysis

Cox proportional hazard models were used for both univariate and multivariate analyses. Univariate analyses were performed to assess bivariate associations between youth's sustained participation in interdependent activities and coactive/independent activities (separately) and the following variables: parents' participation in interdependent activities, parents' participation in coactive/independent activities, youth's sex, neighborhood status, parents' educational status,

and proximity to PA infrastructures. Multivariate models were then used to assess the associations between youth's sustained participation in interdependent activities and coactive/independent activities (separately) and parents' participation in these respective activities while accounting for potential covariates (i.e., youth's sex, neighborhood status, parents' educational status, proximity to PA infrastructures). Such models provide hazard ratios (HR) with 95% confidence intervals (CI) for the main effect of parents' participation in interdependent activities and coactive/independent activities. HR greater than 1.0 for the main effect indicates that youth with one or both parents who participated in a particular type of PA were more likely to sustain participation in the given type of activity than youth whose parents did not participate in that type of PA. Because boys' and girls' participation in PA may be influenced differently by parents,<sup>13</sup> we conducted additional analyses to investigate the associations for boys and girls separately. However, we could not test for sex interactions formally because of the small samples in some strata. Results yielding a  $p$  value  $< 0.05$  were considered statistically significant. All analyses were computed using SAS Version 9.4 (SAS Institute Inc., Cary, NC, USA).

### 3. Results

Of the 190 youth retained for analysis, 110 (58%) reported participating in interdependent activities and 175 (92%) in coactive/independent activities at each time point during the first year of the MATCH study (Table 1), with 52% ( $n = 99$ ) participating in both types. Parents also reported greater participation in coactive/independent activities ( $n = 160$ , 84%) than in interdependent activities ( $n = 39$ , 21%) when interviewed during the first year of the MATCH study, with 12% ( $n = 23$ ) participating in both types. Of these families, 33% of fathers and 42% of mothers attended university, and just over half (51%) had annual incomes greater than CAD80,000. Of note, youth included in the analyses reported similar average weekly participation in PA as those not included in the analyses ( $t$  test  $p > 0.05$  for Years 1, 2, 3, and 4, respectively).

Table 2

Univariate and multivariate associations between study variables and likelihood of youth having sustained participation in interdependent ( $n = 110$ ) and coactive/independent activities ( $n = 175$ ).

Reference group	Comparison group(s)	Univariate				Multivariate			
		Interdependent activities		Coactive/independent activities		Interdependent activities		Coactive/independent activities	
		HR (95%CI)	$p$	HR (95%CI)	$p$	HR (95%CI)	$p$	HR (95%CI)	$p$
No parent participating in same activities	≥1 parent participating in same activities	3.63 (1.30–10.17)	0.02	0.97 (0.46–2.06)	0.94	4.24 (1.48–12.18)	0.01	1.06 (0.49–2.26)	0.89
Female	Male	0.82 (0.43–1.56)	0.54	0.55 (0.32–0.94)	0.03	0.97 (0.49–1.91)	0.93	0.54 (0.31–0.93)	0.03
Rural neighborhood	Suburban or urban neighborhood	1.74 (0.92–3.30)	0.09	1.04 (0.60–1.80)	0.89	1.11 (0.48–2.54)	0.81	1.11 (0.59–2.09)	0.75
No university degree	≥1 parent with a university degree	2.96 (1.51–5.80)	0.01	1.15 (0.67–1.98)	0.61	2.89 (1.34–6.23)	0.01	1.23 (0.71–2.33)	0.40
Living shortest distance to PA infrastructures	Living mid-distance to PA infrastructures	1.84 (0.85–3.92)	0.12	0.66 (0.34–1.31)	0.24	1.52 (0.69–3.30)	0.29	0.56 (0.28–1.15)	0.20
	Living farthest distance to PA infrastructures	1.52 (0.76–3.06)	0.24	0.68 (0.35–1.33)	0.27	0.86 (0.37–1.99)	0.73	0.62 (0.30–1.29)	0.77

Abbreviations: CI = confidence intervals; HR = hazard ratios derived from cox proportional hazard models; PA = physical activity.

Table 1

Description of participants from the Monitoring Activities of Teenagers to Comprehend their Habits (MATCH) study retained for analysis ( $n = 190$ ).

Variable	$n$ (%)
<b>Youth participation in PA during Year 1</b>	
Interdependent activities	110 (58)
Coactive/independent activities	175 (92)
<b>Parents participation in PA during Year 1</b>	
Interdependent activities	39 (21)
Coactive/independent activities	160 (84)
<b>Proximity to PA infrastructures</b>	
First tertile representing shortest distance (scores: 14–28)	65 (34)
Second tertile representing mid-distance (scores: 29–40)	61 (32)
Third tertile representing farthest distance (scores: 41–68)	64 (34)
<b>Youth's sex</b>	
Female	94 (49)
Male	96 (51)
<b>Neighborhood status</b>	
Rural	113 (59)
Suburban or urban	77 (41)
<b>Parents' education</b>	
No university degree	105 (55)
≥1 parent with a university degree	85 (45)

Abbreviation: PA = physical activity.

Compared with youth whose parents did not participate in interdependent activities, those with at least one parent who participated in this type of PA in the first year of this study were over 3 times more likely to sustain participation in interdependent activities over the next 3 years. Conversely, the likelihood of youth sustaining participation in coactive/independent activities was not associated with parents' participation in this type of PA (Table 2). Similar results were observed in fully adjusted models (Table 2), such that parents' participation in interdependent activities remained statistically significantly associated with youth's sustained participation in interdependent activities. In regards to the covariates, youth with at least one parent who had completed a university degree were more likely to sustain participation in interdependent activities, and girls were more likely to sustain participation in coactive/independent

activities than boys (Table 2). In an analysis not presented herein, when a combined score reflecting parents and youth's overall participation in PA (i.e., when participation in interdependent activities and coactive/independent activities was combined), parents' participation in PA was not statistically significantly associated with youth's sustained participation in PA.

Although some strata were too small to test interactions by youth's sex, sex-specific analyses showed that the association between girls' and boys' sustained participation in interdependent activities was statistically significantly associated with parents' participation in this type of PA, but that the association was greater in girls. Specifically, girls with at least one parent who participated in interdependent activities sustained participation for longer (i.e.,  $42.67 \pm 12.17$  months) than boys (i.e.,  $31.76 \pm 15.13$  months); however, there was no apparent difference between boys and girls whose parents did not participate in this type of PA (i.e.,  $29.67 \pm 13.57$  months for boys;  $28.00 \pm 13.94$  months for girls). Also, there was no apparent sex difference in the association between youth's sustained participation in coactive/independent activities and parents' participation in this type of PA. Boys and girls with at least one parent who participated in coactive/independent activities sustained participation for  $31.57 \pm 12.74$  months and  $35.95 \pm 12.79$  months, respectively, and those whose parents did not participate in this type of PA sustained participation for  $34.00 \pm 15.11$  months (boys) and  $35.73 \pm 10.63$  months (girls), respectively.

#### 4. Discussion

In this study, we aimed to extend past research by distinguishing between types of PA and examining the degree to which youth's sustained participation in interdependent activities and coactive/independent activities over a 4-year period is associated with their parents' participation in these respective activities in the first year. We observed a significant association for interdependent activities. Conversely, parents' participation in coactive/independent activities was not significantly associated with youth's sustained participation in this type of PA, which suggests parents' influence on youth's participation in PA may be limited to certain types of activities. This observation may help to explain the inconsistent findings previously reported by researchers examining the association between parents' and youth's participation in PA.<sup>18,19,22,23</sup> By suggesting that participation in some activities, but not all, are passed on to youth, this study underscores the importance of distinguishing between interdependent activities and coactive/independent activities to gain insight into the longitudinal associations between parents' and youth's participation in PA.

Although previous research has shown that different types of PA may have different correlates,<sup>26–28</sup> our study is the first to investigate how parents' participation in interdependent activities and coactive/independent activities is associated with youth's continued participation in these types of PA. Notably, we found that youth with one or both parents who reported participating in interdependent activities at the start of the MATCH study were more than 3 times more likely to sustain their participation in interdependent activities over the next 3

years. Although not directly assessed herein, it is possible that youth engaged in interdependent activities because they were exposed to those types of activities via their parents through role modeling, observational learning, and parental transmission of attitudes and values.<sup>14,16,26</sup> This would support Bandura's<sup>40</sup> contention that youth learn behaviors by observing and imitating their parents' behavior. Interdependent activities also often require a greater commitment on part of the parents,<sup>41</sup> including transportation, purchasing equipment, paying registration costs, and time spent during games and practices, compared to more independent activities such as walking or jogging. Accordingly, the influence from parents may be complex: youth's participation in interdependent PA may be the effect of having one or both parents participating in interdependent activities, but may also depend on the type of support youth receive from their parents and the attitudes and values espoused by their parents. Therefore, the moderating effects of role modeling, observational learning, and transmission of attitudes and values should be investigated when examining the association between parents' and youth's participation in interdependent activities.

We found that youth's sustained participation in coactive/independent activities was not significantly associated with parents' participation in this type of PA. Considering that youth participated more in coactive/independent activities than interdependent activities, this may point toward the influence of sources other than parents that are important in determining youth's participation in different types of PA as youth transitioned from childhood to adolescence—a critical period in which the influence of parents has been found to decrease.<sup>16,30</sup> These sources may include peers<sup>42,43</sup> or siblings.<sup>44</sup> It may be that peers or siblings could have been responsible for prompting youth to participate in coactive/independent activities. From this standpoint, youth who saw their siblings or peers engage in coactive/independent activities may have been more likely to participate in these activities, regardless of their parents' participation. Thus, future studies should examine the relative influence of parents, peers, and siblings on youth's participation in PA. Additionally, it may be that parents and youth differed in their interests and motivation for different types of PA,<sup>45</sup> which could have led them to select different activities. Parents may also have put a strong emphasis on the importance of coactive/independent activities based on the notion that these activities foster autonomy and self-development<sup>23,46</sup> and thus provided support to youth that nurtured participation in these activities regardless of their own participation. Lastly, it may be that participation in coactive/independent activities are more self-selected by youth rather than influenced by parents' participation because activities such as walking, jogging, skateboarding, and bicycling typically require less organization by adults.

A final noteworthy finding is that parents' participation in coactive/independent activities seemed to affect boys' and girls' participation in this type of PA similarly. Although these sex-specific associations need to be tested in larger samples, our results generally suggest there are no sex-specific associations and are in line with results reported by others.<sup>16,21,47</sup> That said, we found sex differences in participation in interdependent

activities, whereby girls sustained their participation in this type of PA for longer than boys if one or both parents participated in interdependent activities. This is a noteworthy finding because participation in PA decreases more drastically for girls than for boys throughout adolescence,<sup>6</sup> which emphasizes the need to create opportunities for parents and girls to continue participating in interdependent activities.

Whereas our findings help in the understanding of the longitudinal associations between parents' and youth's participation in specific types of PA, our study has limitations that should be considered when interpreting these findings. First, we assessed PA using self-report measures. Although needed to collect information on the specific types of PA, they are subject to reporting biases. Second, both parents' participation in PA in the past year was reported by one parent during a telephone interview conducted during the first year of the MATCH study, preventing the analysis of parents' sustained participation in PA. Third, though parents' and youth's participation in PA may differ based on their unique characteristics and contexts (e.g., family structure, resource constraints, life events, parents' age, attitudes, values toward PA), it was not possible to consider these variables in our analyses (as these data were not collected). Fourth, there may be stronger associations between parents' and youth's participation in certain activities (rather than broad categories); however, it was not possible to investigate these associations due to parents' or youth's low involvement in certain activities. Lastly, our sample consisted of a convenience sample which may limit the generalizability of our results.

## 5. Conclusion

In the present study, we showed that parents' participation in interdependent activities was associated with youth's participation in this type of PA over a 4-year period. Determining that parents can influence youth's participation in interdependent activities may help parents realize that their behavior can impact their child now and in the future. Having this information may encourage parents to participate in interdependent activities themselves. As such, it is important to ensure parents have opportunities to do so. In addition, it suggests that more research is needed to understand how being involved in interdependent activities allows parents to influence youth. Thus, investigating potential mechanisms (e.g., role modeling, involvement, transmission of attitudes and values) that could possibly be driving the association between parents' and youth's participation in interdependent activities would be informative. Furthermore, although we did not find that parents' participation in coactive/independent activities was associated with youth's participation in this type of PA, it is possible that parents can still be supportive of their child's PA endeavors. Indeed, regardless of parents' participation in coactive/independent activities, those who have positive attitudes toward coactive/independent activities, believe in their child's competence to undertake them, encourage their child to find interest in or see value in coactive/independent activities, and encourage persistence can help their child develop an intrinsic motivation to participate in PA. This possibility calls

for a more comprehensive examination of the ways parents can support or thwart youth's participation in PA in future studies.

## Acknowledgments

The authors are grateful to the school administrators and teachers, as well as parents and youth who participated in the MATCH study. The MATCH study is supported by the New Brunswick Health Research Foundation and by a joint Sport Participation Research Initiative grant obtain from the Social Sciences and Humanities Research Council of Canada (SSHRC) and Sports Canada. This manuscript was prepared while the first author was supported by a Canadian Cancer Society Career Development Award in Prevention.

## Authors' contributions

JB made substantial contributions to the study conception and design, analysis and interpretation of data, and drafting of the manuscript; JG made substantial contributions to the analysis and interpretation of data analysis and revised the manuscript critically for important intellectual content; EKW revised the manuscript critically for important intellectual content; MB contributed to the study conception and design, acquisition and analysis of data, and revised the manuscript critically for important intellectual content; and MB also designed the MATCH study from which data for this study were drawn, obtained funding for the MATCH study, and supervised the MATCH research group. All authors have read and approved the final version of the manuscript, and agree with the order of the presentation of the authors.

## Competing interests

The authors declare that they have no competing interests.

## References

1. Boreham C, Riddoch C. The physical activity, fitness and health of children. *J Sports Sci* 2001;**19**:915–29.
2. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 2010;**7**:40. doi:10.1186/1479-5868-7-40.
3. Eime RM, Young JA, Harvey JT, Charity MJ, Payne WR. A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. *Int J Behav Nutr Phys Act* 2013;**10**:98. doi:10.1186/1479-5868-10-98.
4. Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al. Evidence based physical activity for school-age youth. *J Pediatr* 2005;**146**:732–7.
5. Tremblay MS, Warburton DE, Janssen I, Paterson DH, Latimer AE, Rhodes RE, et al. New Canadian physical activity guidelines. *App Physiol Nutr Metab* 2011;**36**:36–46.
6. ParticipACTION. *The biggest risk is keeping kids indoors. The 2015 ParticipACTION Report Card on Physical Activity for Children and Youth*. Toronto: ParticipACTION; 2015.
7. Kahn JA, Huang B, Gillman MW, Field AE, Austin SB, Colditz GA, et al. Patterns and determinants of physical activity in U.S. adolescents. *J Adolesc Health* 2008;**42**:369–77.
8. Telama R, Yang X. Decline of physical activity from youth to young adulthood in Finland. *Med Sci Sports Exerc* 2000;**32**:1617–22.
9. Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA* 2008;**300**:295–305.

10. Caspersen CJ, Pereira MA, Curran KM. Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Med Sci Sports Exerc* 2000;**32**:1601–9.
11. Sallis JF. Age-related decline in physical activity: a synthesis of human and animal studies. *Med Sci Sports Exerc* 2000;**32**:1598–600.
12. Paavola M, Vartiainen E, Haukkala A. Smoking, alcohol use, and physical activity: a 13-year longitudinal study ranging from adolescence into adulthood. *J Adolesc Health* 2004;**35**:238–44.
13. Beets MW, Cardinal BJ, Alderman BL. Parental social support and the physical activity-related behaviors of youth: a review. *Health Educ Behav* 2010;**37**:621–44.
14. Gustafson SL, Rhodes RE. Parental correlates of physical activity in children and early adolescents. *Sports Med* 2006;**36**:79–97.
15. Bois JE, Sarrazin PG, Brustad RJ, Trouilloud DO, Cury F. Elementary schoolchildren's perceived competence and physical activity involvement: the influence of parents' role modelling behaviours and perceptions of their child's competence. *Psychol Sport Exerc* 2005;**6**:381–97.
16. Pugliese J, Tinsley B. Parental socialization of child and adolescent physical activity: a meta-analysis. *J Fam Psychol* 2007;**21**:331–43.
17. Ammouri AA, Kaur H, Neuberger GB, Gajewski B, Choi WS. Correlates of exercise participation in adolescents. *Public Health Nurs* 2007;**24**:111–20.
18. Fuemmeler BF, Anderson CB, Mâsse LC. Parent-child relationship of directly measured physical activity. *Int J Behav Nutr Phys Act* 2011;**8**:17. doi:10.1186/1479-5868-8-17.
19. Kalakanis LE, Goldfield GS, Paluch RA, Epstein LH. Parental activity as a determinant of activity level and patterns of activity in obese children. *Res Q Exerc Sport* 2001;**72**:202–9.
20. King KA, Tergerson JL, Wilson BR. Effect of social support on adolescents' perceptions of and engagement in physical activity. *J Phys Act Health* 2008;**5**:374–84.
21. Sabiston CM, Crocker PR. Exploring self-perceptions and social influences as correlates of adolescent leisure-time physical activity. *J Sport Exerc Psychol* 2008;**30**:3–22.
22. Aarnio M, Winter T, Kujala UM, Kaprio J. Familial aggregation of leisure-time physical activity – a three generation study. *Int J Sports Med* 1997;**18**:549–56.
23. Trost SG, Sallis JF, Pate RR, Freedson PS, Taylor WC, Dowda M. Evaluating a model of parental influence on youth physical activity. *Am J Prev Med* 2003;**25**:277–82.
24. Edwardson CL, Gorely T. Parental influences on different types and intensities of physical activity in youth: a systematic review. *Psychol Sport Exerc* 2010;**11**:522–35.
25. Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth – a review and update. *Obes Rev* 2007;**8**:129–54.
26. Andersen CB, Hughes SO, Fuemmeler BF. Parent-child attitude congruence on type and intensity of physical activity: testing multiple mediators of sedentary behavior in older children. *Health Psychol* 2009;**28**:428–38.
27. Strauss RS, Rodzilsky G, Burack G, Colin M. Psychosocial correlates of physical activity in healthy children. *Arch Pediatr Adolesc Med* 2001;**155**:897–902.
28. van der Horst K, Paw MJ, Twisk JW, van Mechelen W. A brief review on correlates of physical activity and sedentariness in youth. *Med Sci Sports Exerc* 2007;**39**:1241–50.
29. Carron AV, Brawley LR, Eys MA, Bray S. Do individual perceptions of group cohesion reflect shared beliefs? An empirical analysis. *Small Group Res* 2003;**34**:468–96.
30. Alderman BL, Benham-Deal TB, Jenkins JM. Change in parental influence on children's physical activity over time. *J Phys Act Health* 2010;**7**:60–7.
31. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW, et al. Correlates of physical activity: why are some people physically active and others not? *The Lancet* 2012;**380**:258–71.
32. Bélanger M, Caissie I, Beauchamp J, O'Loughlin J, Sabiston C, Mancuso M. Monitoring activities of teenagers to comprehend their habits: study protocol for a mixed-methods cohort study. *BMC Pub Health* 2013;**13**:649. doi:10.1186/1471-2458-13-649.
33. Kowalski KC, Crocker PRE, Kowalski NP. Convergent validity of the physical activity questionnaire for adolescents. *Pediatr Exerc Sci* 1997;**9**:342–52.
34. Craig C, Cameron C, Russell S, Beaulieu A. *Increasing physical activity participation: supporting children's participation*. Ottawa, ON: Canadian Fitness and Lifestyle Research Institute; 2001.
35. Matthews CE, Freedson PS, Hebert JR, Stanek 3rd EJ, Merriam PA, Rosal MC, et al. Seasonal variation in household, occupational, and leisure time physical activity: longitudinal analyses from the seasonal variation of blood cholesterol study. *Am J Epidemiol* 2001;**153**:172–83.
36. Richardson MT, Leon AS, Jacobs DR, Ainsworth BE, Serfass R. Comprehensive evaluation of the Minnesota leisure time physical activity questionnaire. *J Clin Epidemiol* 1994;**47**:271–81.
37. Steffen LM, Arnett DK, Blackburn H, Shah G, Armstrong C, Luepker RV, et al. Population trends in leisure-time physical activity: Minnesota heart survey, 1980–2000. *Med Sci Sports Exerc* 2006;**38**:1716–23.
38. Williams SL, French DP. Theory of planned behaviour variables and objective walking behaviour do not show seasonal variation in a randomised controlled trial. *BMC Public Health* 2014;**14**:120. doi:10.1186/1471-2458-14-120.
39. Rosenberg D, Ding D, Sallis JF, Kerr J, Norman GJ, Durant N, et al. Neighborhood Environment Walkability Scale for Youth (NEWS-Y): reliability and relationship with physical activity. *Prev Med* 2009;**49**:213–8.
40. Bandura A. *Social learning theory*. Oxford, England: Prentice-Hall; 1977.
41. Vilhjalmsdottir R, Kristjansdottir G. Gender differences in physical activity in older children and adolescents: the central role of organized sport. *Soc Sci Med* 2003;**56**:363–74.
42. Davison KK, Jago R. Change in parent and peer support across ages 9 to 15 yr and adolescent girls' physical activity. *Med Sci Sports Exerc* 2009;**41**:1816–25.
43. Prochaska JJ, Rodgers MW, Sallis JF. Association of parent and peer support with adolescent physical activity. *Res Q Exerc Sport* 2002;**73**:206–10.
44. Duncan SC, Duncan TE, Strycker LA. Sources and types of social support in youth physical activity. *Health Psychol* 2005;**24**:3–10.
45. Allender S, Cowburn G, Foster C. Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. *Health Educ Res* 2006;**21**:826–35.
46. Welk GJ. The youth physical activity promotion model: a conceptual bridge between theory and practice. *Quest* 1999;**51**:5–23.
47. Carson V, Stearns J, Janssen I. The relationship between parental physical activity and screen time behaviors and the behaviors of their young children. *Pediatr Exerc Sci* 2015;**27**:390–5.