Preventive Medicine 112 (2018) 168–175

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Outdoor play and nature connectedness as potential correlates of internalized mental health symptoms among Canadian adolescents

Caroline Piccininni[a], Valerie Michaelson[b], Ian Janssen[c], William Pickett[a,*]

[a] Department of Public Health Sciences, Queen's University, Kingston, ON K7L 3N6, Canada
[b] School of Religion and the Department of Public Health Sciences, Queen's University, Kingston, ON K7L 3N6, Canada
[c] School of Kinesiology, and Department of Public Health Sciences, Queen's University, Kingston, ON K7L 3N6, Canada

ARTICLE INFO

Keywords:
Adolescence
Cross-sectional study
Epidemiology
Pediatrics
Mental health
Outdoor play

ABSTRACT

Exposures to outdoor environments have great potential to be protective factors for the mental health of young people. In a national analysis of Canadian adolescents, we explored how such exposures, as well as self-perceptions of connectedness with nature, each related to the prevalence of recurrent psychosomatic symptoms. The data source for this cross-sectional study, consisting of a weighted sample of 29,784 students aged 11–15 years from 377 schools, was the 2013/2014 cycle of the Health Behaviour in School-aged Children (HBSC) study. We modeled reports of exposure to the outdoors and then perceived connection(s) to nature as correlates of reduced psychosomatic symptoms. Associations varied by sex. Among girls, spending on average > 0.5 h/week outdoors was associated with a 24% (95% CI: 5%, 40%) lower prevalence of high psychosomatic symptoms, compared to those who averaged no time playing outdoors. No such relationship was observed among boys. Perception of connection to nature as '*important*' was similarly associated with a 25% (95% CI: 9%, 38%) reduction in the prevalence of high psychosomatic symptoms; this association did not differ by sex or age. Our analysis highlights the potential importance of adolescent engagement with nature as protective for their psychological well-being. It also emphasizes the importance of accounting for differences between boys and girls when researching, planning, and implementing public mental health initiatives that consider exposure to the outdoors.

1. Introduction

Exposures to outdoor environments have great potential to be protective factors for the mental health of young people (McCurdy et al., 2010; Louv, 2005). And yet, many young people spend less time outdoors and feel less connected to nature than ever before (McCurdy et al., 2010; Louv, 2005; Driessnack, 2009). This lack of connection may be harmful to both their physical and mental health, (Louv, 2005; Driessnack, 2009) and at the same time, deny them the potential benefits of engagement with nature as protective of their psychological well-being.

There is growing recognition that the mental health of young people is a critical, contemporary health problem (Merikangas et al., 2011; Patel et al., 2007; Patton et al., 2016; Cyranowski et al., 2000). As is the case in other like nations, the mental health of Canadian children is of particular concern. In the 2013 UNICEF Report Card on health status of children in selected developed nations, Canada had a notably low ranking in terms of "life satisfaction," ranking 24th out of 29 countries; (UNICEF, 2013a; UNICEF, 2013b) this relates strongly to depression, and is a powerful predictor of adverse adult health outcomes (Goldbeck et al., 2007; Koivumaa-Honkanen et al., 2001; Kinnunen et al., 2010). Boys and girls experience different levels of risk, with morbidity patterns tending to favour boys, while mortality patterns favour girls. Illustratively, while across nations suicide ideation and "attempts" are most common among girls, "completed" suicides are far more frequent among boys (Navaneelan, 2012; Canadian Mental Health Associations, n.d.). In terms of psychosomatic symptoms, however, past findings from the Health Behaviour in School-aged Children study see males consistently reporting better mental health and fewer psychosomatic symptoms than females, (Iannotti et al., 2009; Freeman et al., 2011a; Craig and Pepler, 2014) whose diagnoses tend to manifest more often in terms of anxiety, depression and associated physical symptoms (Iannotti et al., 2009; Freeman et al., 2011a). Emotional well-being provides a basis for healthy social and emotional development; hence such declines are important and warrant focused intervention. There is a particular need for interventions to be based upon evidence surrounding factors that protect young people from mental health disorders. Exposures to the outdoors represent one potential public health

* Corresponding Author at: Department of Public Health Sciences, Queen's University, Carruthers Hall, Room 210, Kingston, ON K7L 3N6, Canada.
E-mail addresses: 0cp41@queensu.ca (C. Piccininni), vmichaelson.michaelson@queensu.ca (V. Michaelson), ian.janssen@queensu.ca (I. Janssen), will.pickett@queensu.ca (W. Pickett).

https://doi.org/10.1016/j.ypmed.2018.04.020
Received 7 October 2017; Received in revised form 2 April 2018; Accepted 15 April 2018
Available online 18 April 2018

strategy that may be protective, accessible, and affordable for many adolescent populations.

Despite growing interest in the potential psychological benefits of nature, (Munoz, 2009) few large-scale studies of children have examined this topic. Most existing studies have focused on adult populations and have assessed exposure to natural environments through quantification of natural space in participants' neighborhoods (Huynh et al., 2013; Kytta et al., 2012; Maas et al., 2009a; van den Berg et al., 2015; de Vries et al., 2003; Corraliza et al., 2012). Amounts of public natural space in residential environments have been weakly related to positive emotional well-being after controlling for family, peer, and other contextual factors (Huynh et al., 2013). The potential mental health benefits of contact with and feelings towards nature, which are more proximal variables and take into account youth's own perceptions, have not been quantified on a population basis. Interaction with nature could have unique psychological benefits for young people; specifically, this population may derive additional benefits in terms of opportunities for play, learning about risks, and becoming comfortable with being exposed to natural environments (Munoz, 2009; O'Brien, 2005). Such mechanisms may serve as protective factors for mental health.

We had a unique opportunity to conduct a large and nationally representative cross-sectional epidemiologic study in order to address this gap in the adolescent health literature. Our aims were to explore how outdoor play and perceived importance of nature connectedness related to the prevalence of psychosomatic symptoms, one indicator of poor mental health (Boyce et al., 2008). Based on the potential for interventions involving intentional exposure to nature among boys and girls of various ages, (Barton and Pretty, 2010; Barton et al., 2016) an additional objective was to identify whether these associations differed by sex and age.

2. Methods

2.1. Data source and study sample

Data collected as part of the 2013/2014 cycle of the Canadian Health Behaviour in School-aged Children (HBSC) study were used. HBSC is a cross-sectional survey administered every four years to gather information on the health (physical, social, emotional, and spiritual domains) of adolescents aged 11 to 15 years (Currie et al., 2009). Multistage cluster sampling is used, in which students are nested within classrooms, which in turn are nested within schools, school boards, then provinces and territories. In 2013/2014, the weighted Canadian sample included 29,784 students from 377 schools across the country. This sample was considered representative of public school students (> 93% of the population) (Van Pelt et al., 2015) based on language (English, French, Inuktitut), school board type (public, separate), size of the surrounding community (urban-rural continuum), and geographic location. A 77% participation rate was obtained at the individual student level (Freeman et al., 2016).

2.2. Ethics

The Canadian HBSC study holds ethics approval from the General Research Ethics Board at Queen's University and Public Health Agency of Canada/Health Canada. The plan for this analysis was also approved by the Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board.

2.3. Key measures

Outdoor play was assessed using two items. The first asked students: "*On weekdays, how many hours a day do you usually spend time playing outdoors outside school hours?*" The second asked the same about weekends.(Freeman et al., 2016) For both questions, possible responses in hours/day were '*none at all*', '*half an hour*', '*1 h*', '*2 h*', '*3 h*', '*4 h*', '*5 h*', '*6 h*', and '*7 h or more*'. A weighted average of weekday and weekend hours was estimated and converted to hours of exposure per week. Outcome-based spline modeling was used to determine the most optimal cut-points for a posteriori categorization of this variable; (Williams et al., 2006) this supported a cut-off value of "*half an hour per week*" or more vs. "*none at all*", and sensitivity analyses (data not shown) suggested that the use of different cut-offs did not change results or inferences substantially.

Nature connectedness comprised one of four domains of the HBSC spiritual health scale (Gomez and Fisher, 2003; Michaelson et al., 2016). Responses to two items were summed (Michaelson et al., 2016). Participants were asked: "*How important is it for you to feel connected to nature?*" and: "*How important is it for you to care for the natural environment?*" (five response options, ranging from 1 - '*not at all important*' to 5 - '*very important*'). Three categories were derived: not important (2 to 4), somewhat important (5 to 8), and important (8 to 10) (Michaelson et al., 2016).

Psychosomatic symptoms were measured via an eight-item scale that asked participants about the following complaints: *psychological* - feeling low or depressed, irritability or bad temper, feeling nervous, and difficulties in getting to sleep; *somatic* - headache, stomach ache, backache, and feeling dizzy (Hetland et al., 2002). This composite scale has good internal consistency ($\alpha = 0.84$), (Currie et al., 2014) acceptable test-retest reliability as a whole ($r = 0.79$) and for its two subscales ($r = 0.61$ to 0.76) (Haugland and Wold, 2001). For each symptom, respondents indicated how often it occurred in the past six months, with possible responses being '*about every day, 1; more than once a week, 2; about every week, 3; about every month, 4; and rarely or never, 5*'. Responses were summed across the eight items to create a total score (range 8 to 40). A high score for psychosomatic symptoms was defined as having a total score of ≤ 28, as per precedent (Kinnunen et al., 2010).

Potential confounders and effect modifiers were based on literature precedent. Confounders that were considered included: sex (males vs. females), (Simpson et al., 2006; Richardson and Mitchell, 2010) age (11 to 15y), (Rathmann et al., 2016; Astell-Burt et al., 2014a) socioeconomic status (a proxy measure that asked students: "*How well off do you think your family is?*"; 5 response options ranging from '*very well off*' to '*not at all well off*'), (Langton et al., 2011; Kimbro and Schachter, 2011) ethnicity (7 categories), (Pahwa et al., 2012) a school climate scale ($\alpha = 0.78$), (Freeman et al., 2011a; Freeman et al., 2011b; Parsons, 2011) a family support scale ($\alpha = 0.91$), (Levin and Currie, 2003; Levin et al., 2012) a family communication scale ($\alpha = 0.87$), (Simpson et al., 2006; Levin and Currie, 2003) a friend support scale ($\alpha = 0.92$), (Dadvand et al., 2016; Boyce, 2004) the HBSC neighbourhood social capital scale ($\alpha = 0.78$), (Aarts et al., 2012; Leslie and Cerin, 2008; Astell-Burt et al., 2014b) and urban-rural geographic status, assessed via Beale code (Romans et al., 2011; Beale, 2004). Sex and age were additionally tested as effect modifiers because previous work has suggested that the health benefits of nature may differ considerably for males and females and based on developmental stage (Richardson and Mitchell, 2010; Astell-Burt et al., 2014a).

2.4. Statistical analysis

Descriptive analyses were used to profile the full sample, as well as the individuals falling in the high psychosomatic symptoms category, according to each exposure variable and suspected confounder and effect modifier. Standardized weights were applied to ensure representativeness by province/territory, age, and sex. Ninety-five percent confidence intervals that accounted for the clustered nature of the sampling design were estimated for comparisons of proportions.

We then created a series of models to quantify the strength and significance of associations between the key exposures (outdoor play then nature connectedness) and high psychosomatic symptoms. Intraclass correlation coefficients (ICCs) (Merlo et al., 2006) were estimated

to partition the variance at individual and then area (classroom and school) levels, and quantify the degree of clustering in the psychosomatic scale at each level. Next, using data from complete cases, generalized linear regression models were created using the PROC GENMOD procedure with a binomial distribution and log link function. To ensure parsimony, a backwards elimination strategy was used, starting with full models that included all potential confounders. Variables with *P*-values > 0.15 were removed in descending order of significance. A change-in-estimate approach was then used to assess the consequences of variable removal, with any variables causing a change in the main effect estimate by 10% or greater kept in the final model (Greenland, 1989). Effect modification by sex and age was assessed through inclusion of two-way interaction terms.

Finally, we modeled associations between the two exposures and each of the eight individual psychosomatic symptoms, rather than the psychosomatic symptoms scale in full, in order to determine whether one symptom or a group of symptoms was unequally impacting the findings. In addition, in order to assess the impact of excluding those with missing data, sensitivity analyses involving imputation of missing data as the most extreme combinations of values for exposure and outcome variables were performed.

All analyses were conducted using SAS software version 9.4 (Cary, NC: SAS Institute Inc.).

3. Results

3.1. Study sample

Our sample is described in Table 1. After removing all participants with missing data, the final sample for complete case analyses was reduced from 29,784 to 20,697 students. There were no notable differences between those included and excluded with regards to key study variables, including outdoor play, nature connectedness, psychosomatic symptoms, sex, age, ethnicity, and perceived family wealth.

3.2. Outdoor play and connections to nature

Participants reported playing outdoors outside of school hours for a mean of 15.0 (95% CI: 14.9 to 15.9) hours per week. A small portion (8.9%) of participants reported no outdoor play. Average weekly outdoor time was higher among males (16.8 h) than females (13.4 h) and decreased slightly with increasing grade from 15.8 h in Grade 6 to 14.1 h in Grade 10.

Connection to nature was considered '*important*' by 59.2% of participants, with slight differences between males (57.2%) and females (61.0%). This proportion decreased with increasing grade from 72.0% in Grade 6 students to 50.3% in Grade 10 students.

3.3. Psychosomatic symptoms

Approximately 28% of participants (18.9% of males, 37.5% of females) reported having high levels of psychosomatic symptoms. Higher proportions of females and older students reported experiencing each of the eight individual symptoms more often than once a week. We identified associations between having high psychosomatic symptoms and each of: perceived family wealth, ethnicity, urban-rural status, school climate, neighbourhood social capital, family support, family communication, and friend support (Table 1).

3.4. Associations between outdoor play and psychosomatic symptoms

In empty models, the ICCs were 4.2% at the school level and 6.7% at the classroom level, indicating that homogeneity at the area level accounted for up to 10.9% of the observed variance in psychosomatic symptoms. Classrooms were specified as random effects in subsequent regression models.

Models examining relationships between outdoor play and psychosomatic symptoms suggested effect modification by sex but not by age (Table 2). After adjustment for confounding factors, outdoor play averaging > 0.5 h weekly was associated with a 24% (95% CI: 5%, 40%) reduction in the prevalence of high psychosomatic symptoms among females, while no statistically significant relationship was observed among males. Findings from spline models indicated a threshold effect whereby the prevalence of high psychosomatic symptoms decreased from 0.5 h of weekly outdoor play to 14 h weekly, while levels past this did not result in further benefit.

When examined for individual psychosomatic symptoms, outdoor play for > 0.5 h weekly was most strongly related to psychosomatic symptoms among females: feeling low or depressed (RR: 0.73; 95% CI: 0.56, 0.91), irritability or bad temper (RR: 0.72; 95% CI: 0.57, 0.91), feeling nervous (RR: 0.76; 95% CI: 0.62, 0.92), and difficulties in getting to sleep (RR: 0.75; 95% CI: 0.60, 0.92). Relationships between outdoor play and the four somatic symptoms were less consistent and not statistically significant (Table 3).

3.5. Associations between nature connectedness and psychosomatic symptoms

Identifying connection to nature as '*somewhat important*' or '*important*' was associated with lower prevalence levels of psychosomatic symptoms, after adjusting for confounders (Table 4). This finding was observed consistently in groups defined by sex and age.

With respect to individual psychosomatic symptoms, nature connectedness was most strongly related to psychological symptoms: feeling low or depressed (RR: 0.72; 95% CI: 0.58, 0.88), irritability or bad temper (RR: 0.62; 95% CI: 0.52, 0.74), feeling nervous (RR: 0.84; 95% CI: 0.71, 0.99), and difficulties in getting to sleep (RR: 0.78; 95% CI: 0.66, 0.94) (Table 5).

4. Discussion

Using data from a nationally representative sample of Canadian adolescents, we found that engagement in outdoor play (even half hour per week, on average) was associated with decreased prevalence levels of psychological symptoms reported by females. We also found that an appreciation of the importance of feeling connected to nature was associated with decreased prevalence of psychosomatic symptoms in both males and females. The strongest relationships existed for the four items that make up the psychological dimension of a psychosomatic symptoms scale. Our findings therefore suggest a potential protective role of engagement with natural environments against symptoms of poor mental health among Canadian adolescents.

Our study contributes to an emergent body of literature on the potential importance of nature in the mental health of young people. Based on geographic information system analyses, weak and inconsistent relationships have been identified previously in Canadian analyses (Huynh et al., 2013). The more consistent relationships identified in our study may be attributable to our application of more direct measures of usage and self-perceptions of the importance of natural space in the lives of children. Although proximity to and availability of natural space are determinants of its usage, mental health benefits derived from nature are more closely related to individual perceptions and usage patterns (McMahan and Estes, 2015; Sturm and Cohen, 2014). Having participants report on subjective feelings of the importance of connectedness to nature captures such perceptions at a more personalized, and perhaps in terms of measures – more sensitive level. Analogous findings have been identified for a number of well-being indicators in samples of Canadian university students (Nisbet et al., 2011).

It remains uncertain how much outdoor play is sufficient to affect the prevalence of poor mental health outcomes among adolescents. However, our findings are consistent with those of two other recent studies, both of which focused on adult samples, and which have

Table 1
Description of exposure variables and potential confounders and effect modifiers for full study sample and for students reporting high psychosomatic symptoms; Canadian 2013/2014 HBSC study.

	Complete case sample (n = 20,697)		High psychosomatic symptoms (*n* = 5928)	
	n	Column % (95% CI)	n	Row % (95% CI)
Outdoor play				
0 h weekly	1775	8.5 (8.2,8.8)	712	40.1 (37.1,43.2)
0.5–6.5 h weekly	5767	27.8 (27.3,28.3)	1753	30.4 (28.7,32.1)
7–13.5 h weekly	4593	22.1 (21.7,22.6)	1231	26.8 (24.9,28.6)
14–34.5 h weekly	7018	33.8 (33.3,34.3)	1783	25.4 (23.9,26.8)
≥35 h weekly	1610	7.8 (7.5,8.1)	449	27.9 (24.8,31.0)
Connection to nature				
Not important	1885	9.1 (8.8,9.4)	829	44.0 (40.8,47.2)
Somewhat important	6682	32.2 (31.7,32.7)	2112	31.6 (30.0,33.3)
Important	12,196	58.7 (58.2,59.2)	2964	24.3 (32.2,25.3)
Sex				
Female	9821	47.3 (46.8,47.8)	3683	37.5 (36.3,38.7)
Male	10,942	52.7 (52.2,53.2)	2068	18.9 (17.7,19.8)
Grade				
6	2903	14.0 (13.7,14.4)	537	18.5 (16.7,20.2)
7	3995	19.2 (18.8,19.6)	919	23.0 (21.3,24.6)
8	4206	20.3 (19.9,20.7)	1140	27.1 (25.4,28.9)
9	5060	24.4 (23.9,24.8)	1665	32.9 (31.1,34.7)
10	4600	22.2 (21.7,22.7)	1628	35.4 (33.4,37.4)
Perceived family wealth (SES)				
Below average	1904	9.2 (8.7,9.5)	918	48.2 (46.0,52.0)
Average	7130	34.4 (33.9,34.9)	2396	33.6 (32.1,35.1)
Above average	11,732	56.7 (56.2,57.1)	2628	22.4 (21.3,23.4)
Ethnicity				
Canadian dominant culture	16,574	79.8 (79.4,81.2)	4939	29.8 (28.8,30.7)
African	643	3.1 (2.9,3.3)	125	19.4 (15.7,23.0)
Arab & West Asian	359	1.7 (1.6,1.8)	97	27.0 (21.0,32.9)
East & Southeast Asian	1473	7.1 (8.8,7.4)	379	25.7 (22.6,28.8)
Latin American	212	1.0 (0.9,1.1)	6	29.0 (20.6,37.5)
South Asian & East Indian	816	3.9 (3.7,4.1)	161	19.7 (16.2,23.2)
Other	687	3.3 (3.1,3.5)	161	23.5 (19.0,27.8)
Urban-rural status				
1 (most rural)	825	4.0 (3.7,4.3)	215	26.1 (23.4,28.8)
2	7536	36.4 (35.9,36.9)	2246	29.8 (28.3,31.2)
3	4013	19.4 (18.9,19.9)	1112	27.7 (25.7,29.7)
4	5233	25.3 (25.0,25.6)	1491	28.5 (26.9,30.1)
5 (most urban)	3157	15.3 (14.9,15.7)	833	26.4 (24.6,28.2)
School climate				
Low	6650	32.0 (31.5,32.5)	3066	46.1 (44.5,47.8)
Medium	7368	35.2 (34.7,35.7)	1798	24.4 (23.0,25.7)
High	7089	32.8 (32.5,33.5)	1035	14.6 (13.5,15.7)
Neighbourhood social capital				
Low	6307	30.4 (29.9,30.9)	2523	40.0 (38.3,41.7)
Medium	7368	35.5 (35.0,36.0)	1894	25.7 (24.4,27.1)
High	7089	34.1 (33.6,34.6)	1460	20.6 (19.3,21.9)
Family support				
Low	7055	34.0 (33.5,34.5)	3203	45.4 (43.8,47.1)
Medium	6963	33.5 (33.0,34.0)	1532	22.0 (20.7,23.3)
High	6746	32.5 (32.0,33.0)	1113	16.5 (15.3,17.8)
Family communication				
Low	6399	30.8 (30.3,31.3)	2988	46.7 (45.0,48.3)
Medium	7827	37.7 (37.2,38)	1863	23.8 (22.5,25.1)
High	6538	31.5 (31.0,32.0)	1059	16.2 (15.0,17.4)
Friend support				
Low	6961	33.5 (33.0,34.0)	2325	33.4 (31.9,34.9)
Medium	7253	34.9 (34.4,35.4)	1857	25.6 (24.2,27.0)
High	6550	31.5 (31.0,32.0)	1683	25.7 (24.3,27.2)

suggested as little as 30 min weekly may be protective (Shanahan et al., 2016; Kerr et al., 2012). The majority (91.1%) of adolescents in our sample met this 30 min/week threshold. Scottish researchers similarly have concluded that being active in a natural environment even once per week may be sufficient for positive benefits (Mitchell, 2013). It also remains uncertain whether the apparent benefits of outdoor play were attributable to physical activity that occurs when outdoors, the benefits of increased social interaction that occur outdoors, or some other effect

Table 2
Results of multivariate log-binomial regression models for the association between weekly outdoor play and having high psychosomatic symptoms stratified by sex; Canadian 2013/2014 HBSC study.

Outdoor play	High psychosomatic symptoms % (95% CI)	Unadjusted model RR (95% CI)	Adjusted model[a] RR (95% CI)
Males (n = 10,438)			
0 h/week	26.7 (22.5,30.9)	1.00 (ref)	1.00 (ref)
≥0.5 h/week	18.8 (17.0,19.2)	0.62 (0.48,0.79)	0.99 (0.72,1.36)
0.5–6.5 h/week	19.0 (16.8,21.2)	0.65 (0.49,0.88)	1.07 (0.74,1.53)
7–13.5 h/week	18.4 (16.0,20.7)	0.63 (0.48,0.81)	1.01 (0.72,1.40)
14–34.5 h/week	17.0 (15.3,18.7)	0.57 (0.43,0.76)	0.92 (0.65,1.29)
≥35 h/week	19.8 (16.3,23.3)	0.68 (0.49,0.96)	1.04 (0.70,1.56)
Females (n = 11,401)			
0 h/week	51.5 (47.4,55.6)	1.00 (ref)	1.00 (ref)
≥0.5 h/week	36.1 (34.8,37.8)	0.56 (0.47,0.67)	0.76 (0.60,0.95)
0.5–6.5 h/week	37.7 (35.4,39.9)	0.59 (0.49,0.72)	0.78 (0.61,0.99)
7–13.5 h/week	33.8 (31.1,36.5)	0.50 (0.41,0.62)	0.69 (0.53,0.89)
14–34.5 h/week	35.2 (32.9,37.5)	0.54 (0.45,0.65)	0.76 (0.59,0.98)
≥35 h/week	40.9 (35.4,46.3)	0.69 (0.52,0.91)	0.92 (0.64,1.33)

[a] Models adjusted for age, ethnicity, SES, school climate, family support, family communication, neighbourhood social capital, urban-rural status, and classroom-level clustering.

Table 3
Results of adjusted log-binomial regression models for the association between weekly outdoor play (≥0.5 h/week compared to 0 h/week) and having individual psychosomatic symptoms greater than once a week stratified by sex[a]; Canadian 2013/2014 HBSC study.

Symptom	Females (n = 11,401) RR (95% CI)	Males (n = 10,438) RR (95% CI)
	1.00 (ref)	1.00 (ref)
Psychological		
Feeling low/depressed	0.72 (0.58,0.91)	0.60 (0.42,0.86)
Irritability/bad temper	0.72 (0.57,0.91)	0.91 (0.66,1.24)
Feeling nervous	0.76 (0.62,0.92)	0.83 (0.62,1.13)
Difficulties in getting to sleep	0.75 (0.60,0.92)	0.85 (0.67,1.09)
Somatic		
Headache	0.95 (0.76,1.17)	0.83 (0.57,1.20)
Stomach ache	0.81 (0.62,1.07)	0.93 (0.61,1.40)
Backache	0.98 (0.76,1.25)	0.90 (0.64,1.26)
Feeling dizzy	0.91 (0.72,1.16)	0.93 (0.63,1.38)

[a] Models adjusted for age, ethnicity, SES, school climate, family support, family communication, neighbourhood social capital, urban-rural status, and classroom-level clustering.

of being in outdoor environments. The survey question that focused on amounts of outdoor play was placed following a series of analogous questions quantifying physical activity, increasing the likelihood that respondents may have interpreted this questionnaire item as active play. This interpretation was also confirmed in initial focus group testing conducted as part of the HBSC survey protocol. Further, there is evidence that young people are more active during time spent outdoors compared to indoors, suggesting that physical activity remains the most likely explanation for any observed effects (Leech et al., 2002).

Most of the benefits of these exposures to nature may be realized as improvements in the psychological rather than somatic dimensions of emotional health. Past work with the HBSC psychosomatic scale has established that the two dimensions may have unique etiologies requiring differentiated intervention (Currie et al., 2014). It is also thought that the two dimensions may differ in timing, with psychological symptoms being the initial expression of perceived stress, with the potential to develop into somatic symptoms in later stages of perceived stress (Haugland et al., 2001). In this regard, exposures to nature may be more beneficial for adolescents with milder symptoms, and who are in the earlier stages of this etiological process. One important consideration is that the relationships studied may occur at ages younger than those included in the HBSC sample. Unfortunately, data pertaining to younger children were not available to our group, and therefore, conclusions about the earliest possible etiological stages cannot be drawn in the present study.

Differences in associations between outdoor play and psychosomatic symptoms observed for boys and girls are consistent with precedent (Annerstedt et al., 2012; Triguero-Mas et al., 2015; Wiens et al., 2016; Faber Taylor et al., 2002). Sex differences in the expression of poor mental health are another likely explanation of this finding. In general, females tend to report and be diagnosed with higher rates of mood and anxiety disorders while males show higher rates of antisocial disorders (Eaton et al., 2012). Among other influences, the attribution of these sex differences to different average standings on internalizing and externalizing dimensions of emotional expression has garnered

Table 5
Results of adjusted log-binomial regression models for the association between perceived importance of nature connectedness ('*important*' compared to '*not important*') and having individual psychosomatic symptoms greater than once a week[a] (*n* = 20,697); Canadian 2013/2014 HBSC study.

Symptom	Complete case sample RR (95% CI)
	1.00 (ref)
Psychological	
Feeling low/depressed	0.72 (0.58,0.88)
Irritability/bad temper	0.62 (0.52,0.74)
Feeling nervous	0.84 (0.71,1.00)
Difficulties in getting to sleep	0.78 (0.66,0.94)
Somatic	
Headache	0.99 (0.81,1.21)
Stomach ache	0.98 (0.76,1.26)
Backache	0.85 (0.69,1.04)
Feeling dizzy	0.84 (0.67,1.06)

[a] Models adjusted for age, ethnicity, SES, school climate, family support, family communication, neighbourhood social capital, urban-rural status, and classroom-level clustering.

Table 4
Results of multivariate log-binomial regression models for the association between perceived importance of nature connectedness and having high psychosomatic symptoms (n = 20,697); Canadian 2013/2014 HBSC study.

Nature connectedness	High psychosomatic symptoms % (95% CI)	Unadjusted model RR (95% CI)	Adjusted model[a] RR (95% CI)	Females (n = 11,041)[a] RR (95% CI)	Males (n = 10,438)[a] RR (95% CI)
Not important	44.0 (40.8,47.2)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Somewhat	31.6 (30.0,33.3)	0.59 (0.51,0.69)	0.79 (0.66,0.95)	0.77 (0.59,0.98)	0.78 (0.57,0.98)
Important	24.3 (32.2,25.3)	0.42 (0.36,0.49)	0.75 (0.62,0.91)	0.71 (0.55,0.93)	0.77 (0.55,0.97)

[a] Model adjusted for sex (overall adjusted model only) and age, ethnicity, SES, school climate, family support, family communication, neighbourhood social capital, urban-rural status, and classroom-level clustering.

substantial support (Eaton et al., 2012). Thus, it is possible that the findings would have been different if an externalizing measure such as antisocial or risky behaviour had been used, as this type of measure may provide a better indication of poor mental health among male adolescents. In addition to a tendency to internalize, excesses in symptoms among females have also been attributed to a stronger female disposition to attend to bodily cues and a greater willingness to report perceived symptoms to others (Gijsbers Van Wijk and Kolk, 1997; Barsky et al., 2001). Past research has also suggested that certain aspects of males' tendency to externalize may actually protect adolescent boys against developing some of the symptoms included in the psychological dimension of the scale (Chaplin and Aldao, 2013). For these reasons, the use of different cut-off values for males and females to be classified as having high psychosomatic symptoms may be warranted.

Strengths and limitations of our analysis warrant comment. We considered both the usage of outdoor space and subjective feelings of connectedness to nature in a series of novel analyses. Many past studies (Huynh et al., 2013; Kytta et al., 2012; Maas et al., 2009a; van den Berg et al., 2015; de Vries et al., 2003; Corraliza et al., 2012) have used geographic measures to indicate the amount of natural space in the area surrounding participants' homes or schools, which does not take usage of and self-perceptions of the importance of nature into account. Measures used in this study are more likely sensitive to the lived experiences of young people, who use and perceive nature differently from adults and who may be subject to parental control of their decision making on where, when, and how they interact with the outdoors, regardless of the amount of natural space in the surrounding area. Because of its large sample size, the study also had sufficient power to identify existing associations in a robust and national analysis. In terms of limitations, since outdoor activity or connections to nature may be considered socially desirable, respondents may have overestimated their participation. This may have resulted in bias in the form of underestimation of observed effect estimates, assuming social desirability was non-differential according to the presence of psychosomatic symptoms. Second, recalled measures are prone to error, which can alter the likelihood of identifying associations. Third, because cross-sectional designs measure both the exposure and outcome at a single time point, these designs do not allow for confirmation of temporality, and therefore, causality. It is plausible that poor emotional health among adolescents may impact their usage of and feelings towards the outdoors, resulting in reverse causality. Further, the outcome of high psychosomatic symptoms may also have preceded engagement in outdoor activities. However, in studies of nature and health, the most common, cited theoretical frameworks (Mitchell, 2013; Ulrich, 1979; Kaplan and Kaplan, 1989; Pretty et al., 2007; Thompson Coon et al., 2011; Richardson et al., 2013; Sugiyama et al., 2008; Maas et al., 2009b; Townsend and Weerasuriya, 2010; Wilson, 1984) do state that measures of mood, stress and other components of mental health should be considered as outcomes. In addition, both experimental and longitudinal designs also have their own inherent methodological challenges, including cost and challenges in following large groups of children over time. Experimental study designs are challenged by the need to randomize children to exposure to the outdoors, which can be impractical. Finally, measuring and controlling for important covariates have been identified as a methodological gap in past research on nature and mental health. Though we attempted to control for most potential confounders, there are likely other factors that contribute to the risk of poor mental health, such as having a history of mental illness, which were not measured on the HBSC (Howren and Suls, 2011).

This is not the first study to conclude that exposure to nature may constitute an effective strategy for preventing poor mental health at the population level; (Shanahan et al., 2016; Gill, 2014; Chawla, 2015) nonetheless, this study adds evidence on the unique experiences of young people. Increased participation in outdoor activities during childhood and adolescence has been found to increase the likelihood of making longer and more frequent visits to green spaces in adulthood (Pretty et al., 2009; Wells and Lekies, 2006; Snell et al., 2016; Collado et al., 2013). In contrast, low levels of contact with nature during this critical developmental window have been shown to track across the life course, and have a detrimental effect on future health and well-being (Pretty et al., 2007; Pretty et al., 2009; Wells and Lekies, 2006; Snell et al., 2016). For female adolescents, spending time outdoors may constitute an affordable and widely accessible way to promote mental well-being and provide a buffer against developing poor mental health. For all adolescents, nature contact may promote mental well-being through its positive effect on nature connectedness (Collado et al., 2013; Kamitsis and Francis, 2013; Mayer et al., 2009). Strategies that aim to foster this intricate link, while addressing barriers to outdoor play and nature connectedness, may prove particularly beneficial.

Acknowledgments

We thank members of the international and national HBSC team. International coordinator of the HBSC survey is Dr. Jo Inchley, University of St. Andrews, Scotland. The international databank manager is Dr. Oddrun Samdal, University of Bergen, Norway. The Canadian principal investigators of the 2014 HBSC were Drs. John Freeman and William Pickett, Queen's University, and its national coordinator was Matthew King.

Funding

The Public Health Agency of Canada funded Cycle 7 of the Health Behaviour in School-aged Children Survey in Canada (Contract CD016-123017). Additional support for this analysis included operating grants from the Canadian Institutes of Health Research (CIHR; Grants MOP 97962; MOP 341188) and CIHR with the Heart and Stroke Foundation of Canada (PCR 101415). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript. Caroline Piccininni was supported by a Canadian Institutes of Health Research Frederick Banting and Charles Best Canada Graduate Scholarship Masters Award.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

Aarts, M.-J., de Vries, S.I., van Oers, H.A.M., Schuit, A.J., 2012. Outdoor play among children in relation to neighborhood characteristics: a cross-sectional neighborhood observation study. Int. J. Behav. Nutr. Phys. Act. 9, 98. http://dx.doi.org/10.1186/2046-1682-4-13.

Annerstedt, M., Östergren, P.-O., Björk, J., Grahn, P., Skärbäck, E., Währborg, P., 2012. Green qualities in the neighbourhood and mental health – results from a longitudinal cohort study in Southern Sweden. BMC Public Health 12 (337). http://dx.doi.org/10.1186/1471-2458-12-337.

Astell-Burt, T., Mitchell, R., Hartig, T., 2014a. The association between green space and mental health varies across the lifecourse. A longitudinal study. J. Epidemiol. Community Health 68, 578–583. http://dx.doi.org/10.1136/jech-2013-203767.

Astell-Burt, T., Feng, X., Mavoa, S., Badland, H.M., Giles-Corti, B., 2014b. Do low-income neighbourhoods have the least green space? A cross-sectional study of Australia's most populous cities. BMC Public Health 14 (292). http://dx.doi.org/10.1186/1471-2458-14-292.

Barsky, A.J., Peekna, H.M., Borus, J.F., 2001. Somatic symptom reporting in men and women. J. Gen. Intern. Med. 16 (4), 266–275.

Barton, J., Pretty, J., 2010. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. Environ. Sci. Technol. 44, 3947–3955. http://dx.doi.org/10.1021/es903183r.

Barton, J., Bragg, R., Pretty, J., Roberts, J., Wood, C., 2016. The wilderness expedition: an effective life course intervention to improve young people's well-being and connectedness to nature. J. Exp. Educ. 39 (391), 59–72. http://dx.doi.org/10.1177/1053825915626933.

Beale, C., 2004. Measuring rurality: Rural-urban continuum codes. United States Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/briefing/Rurality/RuralUrbCon.

Boyce, W.F., 2004. Young People in Canada: Their Health and Well-Being. http://www.

phac-aspc.gc.ca/hp-ps/dca-dea/publications/hbsc-2004/index-eng.php.
Boyce, W.F., King, M.A., Roche, J., 2008. Healthy Settings for Young People in Canada.
Canadian Mental Health Associations http://www.cmha.ca/media/fast-facts-about-mental-illness/#.WZgu6a2ZPVo, Accessed date: 12 March 2018.
Chaplin, T.M., Aldao, A., 2013. Gender differences in emotion expression in children: a meta-analytic review. Psychol. Bull. 139 (4), 735–765. http://dx.doi.org/10.1037/a0030737.
Chawla, L., 2015. Benefits of nature contact for children. J. Plan. Lit. 30 (4), 433–452. http://dx.doi.org/10.1177/0885412215595441.
Collado, S., Staats, H., Corraliza, J.A., 2013. Experiencing nature in children's summer camps: affective, cognitive and behavioural consequences. J. Environ. Psychol. 33, 37–44. http://dx.doi.org/10.1016/j.jenvp.2012.08.002.
Corraliza, J., Collado, S., Bethelmy, L., 2012. Nature as a moderator of stress in urban children. Procedia. Soc. Behav. Sci. 38, 253–263. http://dx.doi.org/10.1016/j.sbspro.2012.03.347.
Craig, W., Pepler, D., 2014. Trends in Healthy Development and Healthy Relationships: Trends Analysis of Canadian Data from the Health Behaviour in School- Aged Children (HBSC).
Currie, C., Gabhainn, S.N., Godeau, E., International HBSC Network Coordinating Committee, 2009. The health behaviour in school-aged children: WHO collaborative cross-national (HBSC) study: origins, concept, history and development 1982–2008. Int. J. Public Health 54, S131–S139. http://dx.doi.org/10.1007/s00038-009-5404-x.
Currie, C., Inchley, J., Molcho, M., Lenzi, M., Weselska, Z., Wild, F., 2014. Health Behaviour in School-Aged Children (HBSC) Study Protocol: Background, Methodology, and Mandatory Items for the 2013/2014 Survey. St Andrews University, Scotland. http://www.hbsc.org.
Cyranowski, J.M., Frank, E., Young, E., Shear, M.K., 2000. Adolescent onset of the gender difference in lifetime rates of major depression: a theoretical model. Arch. Gen. Psychiatry 57 (1), 21–27.
Dadvand, P., Bartoll, X., Basagaña, X., et al., 2016. Green spaces and general health: roles of mental health status, social support, and physical activity. Environ. Int. 91, 161–167. http://dx.doi.org/10.1016/j.envint.2016.02.029.
de Vries, S., Verheij, R.A., Groenewegen, P.P., Spreeuwenberg, P., 2003. Natural environments — healthy environments? An exploratory analysis of the relationship between greenspace and health. Environ. Plan. A 35, 1717–1731. http://dx.doi.org/10.1068/a35111.
Driessnack, Martha A., 2009. Children and nature-deficit disorder. J. Spec. Pediatr. Nurs. 14 (1), 73–75.
Eaton, N.R., Keyes, K.M., Krueger, R.F., et al., 2012. An invariant dimensional liability model of gender differences in mental disorder prevalence: evidence from a national sample. J. Abnorm. Psychol. 121 (1), 282–288. http://dx.doi.org/10.1037/a0024780.An.
Faber Taylor, A., Kuo, F.E., Sullivan, W.C., 2002. Views of nature and self-discipline: evidence from inner city children. J. Environ. Psychol. 22, 49–63. http://dx.doi.org/10.1006/jevp.2001.0241.
Freeman, J.G., King, M., Pickett, W., 2011a. The health of Canada's young people: a mental health. Focus 1–194. http://site.ebrary.com/lib/queen/reader.action?docID=10545263.
Freeman, J., King, M., Pickett, W., 2011b. Protective roles of home and school environments for the health of young Canadians. J. Epidemiol. Community Health 65, 438–444.
Freeman, J.G., King, M., Pickett, W., 2016. Health behaviour in school-aged children (HBSC) in Canada: focus on relationships. http://healthycanadians.gc.ca/publications/science-research-sciences-recherches/health-behaviour-children-canada-2015-comportements-sante-jeunes/index-eng.php#c15.
Gijsbers Van Wijk, C.M.T., Kolk, A.M., 1997. Sex differences in physical symptoms: the contribution of symptom perception theory. Soc. Sci. Med. 45 (2), 231–246. http://dx.doi.org/10.1016/S0277-9536(96)00340-1.
Gill, T., 2014. The benefits of children's engagement with nature: a systematic literature review. Child Youth Environ. 24 (2), 10–34. http://dx.doi.org/10.7721/chilyoutenvi.24.2.0010.
Goldbeck, L., Schmitz, T.G., Besier, T., Herschbach, P., Henrich, G., 2007. Life satisfaction decreases during adolescence. Qual. Life Res. 16 (6), 969–979.
Gomez, R., Fisher, J.W., 2003. Domains of spiritual well-being and development and validation of the spiritual well-being questionnaire. Personal. Individ. Differ. 35 (8), 1975–1991. http://dx.doi.org/10.1016/S0191-8869(03)00045-X.
Greenland, S., 1989. Commentary modeling and variable selection in epidemiologic analysis. Am. J. Public Health 79, 340–349. http://www.medicine.mcgill.ca/epidemiology/hanley/c678/greenlan.pdf, Accessed date: 19 April 2017.
Haugland, S., Wold, B., 2001. Subjective health complaints in adolescence— reliability and validity of survey methods. J. Adolesc. 24, 611–624. http://dx.doi.org/10.1006/jado.2000.0393.
Haugland, S., Wold, B., Stevenson, J., Aaro, L.E., Woynarowska, B., 2001. Subjective health complaints in adolescence. A cross-national comparison of prevalence and dimensionality. Eur. J. Pub. Health 11 (1), 4–10.
Hetland, J., Torsheim, T.T., Aaro, L.E.A., 2002. Subjective health complaints in adolescence: dimensional structure and variation across gender and age. Scand. J Public Health 30 (14), 223–230.
Howren, M.B., Suls, J., 2011. The symptom perception hypothesis revised: depression and anxiety play different roles in concurrent and retrospective physical symptom reporting. J. Pers. Soc. Psychol. 100 (1), 182–195. http://dx.doi.org/10.1037/a0021715.
Huynh, Q., Craig, W., Janssen, I., Pickett, W., 2013 Apr 29. Exposure to public natural space as a protective factor for emotional well-being among young people in Canada. BMC Public Health 13, 407. http://dx.doi.org/10.1186/1471-2458-13-407.
Iannotti, R.J., Janssen, I., Haug, E., Kololo, H., Annaheim, B., Borraccino, A., 2009 Sep. HBSC physical activity focus group. Interrelationships of adolescent physical activity, screen-based sedentary behaviour, and social and psychological health. Int. J. Public Health 54 (Suppl. 2), 191–198. http://dx.doi.org/10.1007/s00038-009-5410-z.
Kamitsis, I., Francis, A.J.P., 2013. Spirituality mediates the relationship between engagement with nature and psychological well-being. J. Environ. Psychol. 36, 136–143.
Kaplan, R., Kaplan, S., 1989. The experience of nature: a psychological. Perspective. http://dx.doi.org/10.1177/030913259201600333.
Kerr, J., Marshall, S., Godbole, S., et al., 2012. The relationship between outdoor activity and health in older adults using GPS. Int. J. Environ. Res. Public Health 9, 4615–4625. http://dx.doi.org/10.3390/ijerph9124615.
Kimbro, R.T., Schachter, A., 2011. Neighborhood poverty and maternal fears of children's outdoor play. Fam. Relat. 60 (4), 461–475. http://dx.doi.org/10.1111/j.1741-3729.2011.00660.x.
Kinnunen, P., Laukkanen, E., Kylmä, J., 2010. Associations between psychosomatic symptoms in adolescence and mental health symptoms in early adulthood. Int. J. Nurs. Pract. 16, 43–50. http://dx.doi.org/10.1111/j.1440-172X.2009.01782.x.
Koivumaa-Honkanen, H., Honkanen, R., Viinamaeki, H., Heikkilae, K., Kaprio, J., Koskenvuo, M., 2001. Life satisfaction and suicide: a 20-year follow-up study. Am. J. Psychiatr. 158 (3), 433–439.
Kytta, A.M., Broberg, A.K., Kahila, M.H., 2012. Urban environment and children's active lifestyle: SoftGIS revealing children's behavioral patterns and meaningful places. Am. J. Health Promot. 26 (5), e137–e149. http://dx.doi.org/10.4278/ajhp.100914-QUAN-310.
Langton, E.G., Collishaw, S., Goodman, R., Pickles, A., Maughan, B., 2011. An emerging income differential for adolescent emotional problems. J. Child Psychol. Psychiatry Allied Discip. 52 (10), 1081–1088. http://dx.doi.org/10.1111/j.1469-7610.2011.02447.x.
Leech, J.A., Nelson, W.C., Burnett, R.T., Aaron, S., Raizenne, M.E., 2002. It's about time: a comparison of Canadian and American time-activity patterns. J. Expo. Anal. Environ. Epidemiol. 12, 427–432. http://dx.doi.org/10.1038/sj.jea.7500244.
Leslie, E., Cerin, E., 2008. Are perceptions of the local environment related to neighbourhood satisfaction and mental health in adults? Prev. Med. 47, 273–278. http://dx.doi.org/10.1016/j.ypmed.2008.01.014.
Levin, K.A., Currie, C., 2003. Family structure, mother-child communication, father-child communication, and adolescent life satisfaction: a cross-sectional multilevel analysis. Health Educ. Young Consum. J. Child Serv. Iss. Health Educ. 110 (3), 152–168. http://dx.doi.org/10.1108/09654281011038831. (Accessed May 24, 2016).
Levin, K.A., Dallago, L., Currie, C., 2012. The association between adolescent life satisfaction, family structure, family affluence and gender differences in parent–child communication. Soc. Indic. Res. 106, 287–305. http://dx.doi.org/10.1007/s11205-011-9804-y.
Louv, R., 2005. Last Child in the Woods. Richard Louv.
Maas, J., Verheij, R.A., de Vries, S., Spreeuwenberg, P., Schellevis, F.G., Groenewegen, P.P., 2009a. Morbidity is related to a green living environment. J. Epidemiol. Community Health 63 (12), 967–973. http://dx.doi.org/10.1136/jech.2008.079038.
Maas, J., van Dillen, S.M.E., Verheij, R.A., Groenewegen, P.P., 2009b. Social contacts as a possible mechanism behind the relation between green space and health. Health Place 15, 586–595. http://dx.doi.org/10.1016/j.healthplace.2008.09.006.
Mayer, F.S., McPherson Frantz, C., Bruehlman-Senecal, E., Dolliver, K., 2009. Why is nature beneficial? The role of connectedness to nature. Environ. Behav. 41 (5), 607–643. http://dx.doi.org/10.1177/0013916508319745.
McCurdy, L.E., Winterbottom, K.E., Mehta, S.S., Roberts, J.R., 2010. Using nature and outdoor activity to improve children's health. Curr. Probl. Pediatr. Adolesc. Health Care. 40, 102–117. http://dx.doi.org/10.1016/j.cppeds.2010.02.003.
McMahan, E.A., Estes, D., 2015. The effect of contact with natural environments on positive and negative affect: a meta-analysis. J. Posit. Psychol. 10 (6), 507–519. http://dx.doi.org/10.1080/17439760.2014.994224.
Merikangas, K., He, J., Burstein, M., et al., 2011. Lifetime prevalence of mental disorders in US adolescents: results from the National Comorbidity Study-adolescent supplement. J. Am. Acad. Child Adolesc. Psychiatry 49 (10), 980–989. http://dx.doi.org/10.1016/j.jaac.2010.05.017.Lifetime.
Merlo, J., Chaix, B., Ohlsson, H., et al., 2006. A brief conceptual tutorial of multilevel analysis in social epidemiology: using measures of clustering in multilevel logistic regression to investigate contextual phenomena. J. Epidemiol. Community Health 60, 290–297. http://dx.doi.org/10.1136/jech.2004.029454.
Michaelson, V., Brooks, F., Jirásek, I., et al., 2016. Developmental patterns of adolescent spiritual health in six countries. SSM – Popul. Heal. 2, 294–303. http://dx.doi.org/10.1016/j.ssmph.2016.03.006.
Mitchell, R., 2013. Is physical activity in natural environments better for mental health than physical activity in other environments? Soc. Sci. Med. 91, 130–134. http://dx.doi.org/10.1016/j.socscimed.2012.04.012.
Munoz, S.-A., 2009. Children in the Outdoors: a Literature Review. Australian Camps Association, Forres, Scotland.
Navaneelan, T., 2012. Suicide rates: an overview. In: Health at a Glance, Statistics Canada Catalogue No. 82-624-X, . http://www.statcan.gc.ca/pub/82-624-x/2012001/article/11696-eng.htm, Accessed date: 12 March 2018.
Nisbet, E.K., Zelenski, J.M., Murphy, S.A., 2011. Happiness is in our nature: exploring nature relatedness as a contributor to subjective well-being. J. Happiness Stud. 12, 303–322. http://dx.doi.org/10.1007/s10902-010-9197-7.
O'Brien, L., 2005. Trees and Woodlands: Nature's Health Service (Farnham, Surrey). .
Pahwa, P., Karunanayake, C.P., McCrosky, J., Thorpe, L., 2012. Longitudinal trends in mental health among ethnic groups in Canada. Chronic Dis. Inj. Can. 32 (3), 164–176.
Parsons, A., 2011. Young Children and Nature: Outdoor Play and Development, Experiences Fostering Environmental Consciousness, and the Implications on

Playground Design. https://theses.lib.vt.edu/theses/available/etd-05062011-114155/unrestricted/Parsons_AE_T_2011.pdf, Accessed date: 5 July 2016.
Patel, V., Flisher, A.J., Hetrick, S., McGorry, P., 2007. Mental health of young people: a global public-health challenge. Lancet 369, 1302–1313. http://dx.doi.org/10.1016/S0140-6736(07)60368-7.
Patton, G.C., Sawyer, S.M., Santelli, J.S., Ross, D.A., Afifi, R., Allen, N.B., Arora, M., Azzopardi, P., Baldin, W., Bonell, Kakuma, R., Kennedy, E., Mahon, J., McGovern, T., Mokdad, A., Patel, V., Petroni, S., Reavley, N., Taiwo, K., Waldfogel, J., Wickremarathne, D., Barroso, C., Bhutta, Z., Fatusi, A., Mattoo, A., Diers, J., Fang, J., Ferguson, J., Ssewamala, F., Viner, R., 2016. Our future: a Lancet commission on adolescent health and wellbeing. Lancet 387 (10036), 2423–2478.
Pretty, J., Peacock, J., Hine, R., Sellens, M., South, N., Griffin, M., 2007. Green exercise in the UK countryside: effects on health and psychological well-being, and implications for policy and planning. J. Environ. Plan. Manag. 50 (2), 211–231. http://dx.doi.org/10.1080/09640560601156466.
Pretty, J., Angus, C., Bain, M., et al., 2009. Nature, Childhood, Health and Life. In: Pathways. University of Essex: interdisciplinary Centre for Environment and Society (iCES) Occasional Paper 2009-2.
Rathmann, K., Pförtner, T.K., Hurrelmann, K., Osorio, A.M., Bosakova, L., Elgar, F.J., Richter, M., 2016. The great recession, youth unemployment and inequalities in psychological health complaints in adolescents: a multilevel study in 31 countries. Int. J. Public Health. 61 (7), 809–819. http://dx.doi.org/10.1007/s00038-016-0866-0.
Richardson, E.A., Mitchell, R., 2010. Gender differences in relationships between urban green space and health in the United Kingdom. Soc. Sci. Med. 71, 568–575. http://dx.doi.org/10.1016/j.socscimed.2010.04.015.
Richardson, E.A., Pearce, J.R., Mitchell, R., Kingham, S., 2013. Role of physical activity in the relationship between urban green space and health. Public Health 127, 318–324. http://dx.doi.org/10.1016/j.puhe.2013.01.004.
Romans, S., Cohen, M., Forte, T., 2011. Rates of depression and anxiety in urban and rural Canada. Soc. Psychiatry Psychiatr. Epidemiol. 46, 567–575. http://dx.doi.org/10.1007/s00127-010-0222-2.
Shanahan, D.F., Bush, R., Gaston, K.J., et al., 2016. Health benefits from nature experiences depend on dose. Sci. Rep. 6 (February), 28551. http://dx.doi.org/10.1038/srep28551.
Simpson, K., Janssen, I., Boyce, W.F., Pickett, W., 2006. Risk-taking and recurrent health symptoms among young Canadians. Prev. Med. 43 (1), 46–51.
Snell, T.L., Lam, J.C.S., Lau, W.W., et al., 2016. Contact with nature in childhood and adult depression. Child Youth Environ. 26 (1), 111–124. http://dx.doi.org/10.7721/chilyoutenvi.26.1.0111.
Sturm, R., Cohen, D., 2014. Proximity to urban parks and mental health. J. Ment. Health Policy Econ. 17 (1), 19–24.
Sugiyama, T., Leslie, E., Giles-Corti, B., Owen, N., 2008. Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? J. Epidemiol. Community Health 62, e9. http://dx.doi.org/10.1136/jech.2007.064287.
Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., Depledge, M.H., 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ. Sci. Technol. 45, 1761–1772. http://dx.doi.org/10.1021/es102947t.
Townsend, M., Weerasuriya, R., 2010. Beyond Blue to Green: the Benefits of Contact with Nature for Mental Health and Well-being. Beyond Blue Limited, Melbourne, Australia.
Triguero-Mas, M., Dadvand, P., Cirach, M., et al., 2015. Natural outdoor environments and mental and physical health: relationships and mechanisms. Environ. Int. 77, 35–41. http://dx.doi.org/10.1016/j.envint.2015.01.012.
Ulrich, R.S., 1979. Visual landscapes and psychological well-being. Landsc. Res. 4 (1), 17–23. http://dx.doi.org/10.1080/01426397908705892.
UNICEF, 2013a. Stuck in the middle report card 11. In: Child Well-Being in Rich Countries: a Comparative Overview, (International Version).
UNICEF, 2013b. Stuck in the middle report card 11. In: Child Well-Being in Rich Countries: a Comparative Overview, (Canadian Companion).
van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., Maas, J., 2015. Health benefits of green spaces in the living environment: a systematic review of epidemiological studies. Urban For. Urban Green. 14, 806–816. http://dx.doi.org/10.1016/j.ufug.2015.07.008.
Van Pelt, D., Clemens, J., Brown, B., Palacios, M., 2015. Where Our Students Are Educated: Measuring Student Enrollment in Canada (Vancouver). .
Wells, N.M., Lekies, K.S., 2006. Nature and the life course: pathways from childhood nature experiences to adult environmentalism. Child Youth Environ. 16 (1), 1–24. http://www.colorado.edu/journals/cye/.
Wiens, V., Kyngäs, H., Pölkki, T., 2016. The meaning of seasonal changes, nature, and animals for adolescent girls' wellbeing in northern Finland: a qualitative descriptive study. Int. J. Qual. Stud. Health Well-Being. 11, 30160. http://dx.doi.org/10.3402/qhw.v11.30160.
Williams, B.A., Mandrekar, J.N., Mandrekar, S.J., Cha, S.S., Furth, A.F., 2006. Finding optimal cutpoints for continuous covariates with binary and time-to-event outcomes. Tech. Rep. Ser. June (79), 1–26. http://www.mayo.edu/research/documents/biostat-79pdf/doc-10027230.
Wilson, E.O., 1984. Biophilia. Harvard University Press.