



Research Article

The association of physical activity duration and intensity on emotional intelligence in 10–13 year-old Children

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ABSTRACT

Previous studies have shown that Physical Activity (PA) has a positive association with emotional health and intelligence in adolescents but none have focused on the relationship of PA duration and intensity on Emotional Intelligence (EI). The purpose of this study was to cross-sectionally assess the association of PA measures on overall EI and its domains in a cohort of 2 029 adolescents aged 10–13 years of age in the National Longitudinal Survey for Children and Youth (NLSCY) from Canada. Multivariable linear regression analysis of EI was adjusted for age, sex, annual household income, and health status. One-way analysis of variance (ANOVA) was used to relate PA duration measured in minutes, frequency, and intensity categories with continuous GEI scores and also the corresponding scores for domains of GEI. The mean GEI scores were (28.3 ± 6.6) for 0–30 minute (min) PA duration, (30.0 ± 6.5) for 30 to < 60 min, (30.8 ± 6.7) for 60–120 min, and (30.1 ± 6.5) for ≥ 121 min. There was a statistically significant linear trend across PA duration categories, $p = 0.0004$. Post-hoc pairwise comparison revealed that compared to the referent category (< 30 min PA category) was statistically significantly lower GEI than each of the other two PA categories (30–59 min; and 60–120 min), both p -values < 0.01. Meeting World Health Organization (WHO) guidelines for duration and vigorous intensity were positively associated with the higher overall EI and its domains except for Stress Management.

1. Introduction

In observational studies, PA has been positively associated with numerous health benefits in humans. According to the World Health Organization (WHO), these health benefits vary from physical to psychological.¹ The current WHO Guidelines for PA require that an individual engage daily in at least 1 hour (h) of aerobic exercise, and at least three of those days should include vigorous aerobic activity, and three times a week of bone and strengthening activities.¹ While PA is clinically beneficial for adolescents during this critical phase of their growth and development, about 80% of adolescents do not meet the current WHO recommended guidelines for PA.¹ Globally, 85% of adolescent females and 78% of adolescent males are not meeting the guidelines.¹

Scientific evidence suggests that PA can influence an adolescent's emotional health.¹ The emotional dimension of an individual's health, referred to as Emotional Intelligence (EI), is measured using Emotional Quotient comprising of five domains, General Mood, Adaptability, Intrapersonal, Interpersonal and Adaptability. EI is defined as “The

ability to engage in sophisticated information processing about one's own and others' emotions, and the ability to use this information as a guide to thinking and behavior”.² While EI is a major indicator of health, it is a notion of both cognitive and non-cognitive abilities and skills that affect an individual's capability to thrive in dealing with both environmental demands and pressures.^{3,4}

A higher EI has been shown to be positively associated with life satisfaction, occupational satisfaction, general health, and is inversely proportional with the propensity for an individual to engage in risky behaviors.^{5–9} Additionally a higher EI has been shown to be positively associated with increased cognitive function, higher academic performance, and psychological security and lower tendency for impulsivity.^{10–12} EI has a positive relationship with coping with stress and the perception that exercise can regulate one's mood.¹³ Zysberg and colleagues reported a moderate relationship between EI and PA.¹⁴ Lower EI, on the other hand, is strongly associated with excessive alcohol consumption, reduced fruit and vegetable consumption, and engaging in unsafe sex practices.⁹

Multiple studies have reported a positive relationship between total

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Abbreviations

GEI	Global Emotional Intelligence
PA	Physical Activity
VPA	Vigorous Physical Activity
MPA	Moderate Physical Activity
WHO	World Health Organization
NLSCY	Canadian National Longitudinal Survey of Children and Youth
EQ-i:	YV: Emotional Quotient Inventory Youth Version
ANOVA	One-way analysis of variance
PNS	Parasympathetic Nervous System
SNS	Sympathetic Nervous System
MVPA	Moderate and Vigorous Physical Activity

PA volume and EI.^{15–17} Few studies, however, found an inverse relationship between EI and PA volume.^{18,19} Few studies have focused on the association between PA and EI in adolescents. The two studies conducted by Hinkley and colleagues and by Kolpakov and colleagues focused more on children than adolescents and found that lower levels of overall PA and sedentary behavior were associated with higher overall EI.^{18,19} It is unclear why, contrary to adults, children who did not exercise exhibited higher EI than children who did.^{18,19}

Adolescence, a crucial period for cognitive, social, emotional, and psychological development, is also a critical period for brain development for acquiring EI. The association of PA duration and PA intensity of EI has not been explored in adolescents. Previous studies focused on PA volume and its relationship on EI; however, the associations of PA duration and intensity with EI and EI domains have not yet been analyzed.¹⁶

The objectives of the study, therefore, were to cross-sectionally assess the relationships between PA duration, moderate, vigorous, and group-based PA and GEI in children 10–13 years of age. Additionally, we also sought to determine the association of PA categories with the five domains of EI. We hypothesized that PA duration, moderate, vigorous, and group PA have a direct association with GEI and its five domains. We further hypothesized that the increased amount of PA would directly correlate to an increased GEI and its domains in an existing cohort of children 10 and 13 years of age. The large number of participants evaluated allowed for greater representation of the population and for broader generalizability of findings.

2. Methods

We conducted a secondary analysis of 2 029 participants of the Canadian National Longitudinal Survey of Children and Youth (NLSCY) focusing on early adolescents 10–13 years of age. The NLSCY was designed to assess overall child development and well-being from birth through early adulthood.^{20,21} The NLSCY provides a unique database suitable for evaluating the association with GEI and domains of EI with measures of PA. Initiated in 1994, the NLSCY systematically collected observational data on education, social, emotional, and behavioral growth and development, education and overall health and well-being in children and youth, in two-year cycles. Structured and systematic assessments covering physical development, learning, various behaviors, and information on their friends, family, school, and overall community were longitudinally collected from across all 10 Canadian provinces.^{20,21} Excluded were residents of Indian Reserves or Crown Lands, Institutions, some remotely located groups, and full-time members of the Canadian Armed Forces.^{20,21}

2.1. Measurement of General Emotional Intelligence scores, scored for the five domains

GEI was measured using the EQ-i: YV brief version (Emotional Quotient Inventory Youth Version, Brief), a validated tool for assessing the five domains of EI derived from the Bar-On Model.^{20–22} Originally developed for adults, the EQ-i: YV brief version assesses levels of both emotional and social functioning in both children and adolescents. The interval scale composite scores for GEI were obtained by summing up the fifteen items of the instruments to yield scores ranging from 0 to 45. A low composite score indicates low GEI level, and a high score indicates high levels. In this study we used GEI to refer to the composite score and EI to refer to emotional intelligence as a general concept. The interval scale composite scores for Intrapersonal, Interpersonal, Adaptability, General Mood, and Stress Management domains ranged from 0 to 9. In the Statistics Canada data files, the only domain that is reverse coded score of the Stress Management domain making 0 the highest and 9 the lowest score.^{20,21} Reliability of the overall EQ-i: YV and the domains had Cronbach's alpha ranging from 0.65–0.87.²² Contrasted with the long version, the validity of the EQ-i: YV tool and the five domains assessed using correlation coefficients ranged from 0.92–1.0.²² GEI was derived by the EQ-i: YV from the NLSCY dataset by totaling up the scores of the fifteen items; the specific domain scores were derived by totaling the scores of the specific questions associated with each domain.

2.2. Measurement of physical activity

Questionnaires for assessing PA and GEI were pilot-tested in focus groups by Human Resources and Skills Development Canada and expert advisory groups.^{20,21} PA was measured using intensity classifications (moderate and vigorous) and duration (minutes). For frequency of PA intensity participants were asked the question: “In the past 12 months, how often have you played sports without a coach or done other physical activities? (e.g. example, biking, skateboarding)”; and, “In the past 12 months, how often have you: ... Played sports or done physical activities with a coach or instructor (for example, swimming lessons, baseball, hockey)?”; and “In the past 12 months, how often have you ... taken part in dance, gymnastics, karate or other groups or lessons?” The possible ordinal category answers were “Never, less than once a week, 1–3 times per week, and 4 or more times per week”. PA duration was measured in minutes. Participants were asked the question: “Thinking of the sport or physical activity that you do the most often, how long do you usually spend being active in one session?” The answers ranged from, “I don't do physical activity” “1–15 min, 16–30 min, 31–59 min, 1–2 hours (h), more than 2 h”.

Computer-assisted telephone interviewing administered by a trained interviewer was used to collect data from the children. Geographic locations in each of the ten provinces in Canada were classified as either urban or rural. The NLSCY samples participants from 56 000 households in the Labour Force Survey.^{20,21,23} Each province was stratified into either rural or urban where a simple random sample was utilized for the rural strata and a two-staged method was used for the urban stratum.^{20,21} Stage 1 included a sample of the geographical area, and Stage 2 consisted of a sample of children within each predetermined selected area.^{20,21}

2.3. Conceptual model

The conceptual model for which PA affects EI is adapted from a schematic of the theoretical approaches across various research.^{24–31} The schematic shows the sequence of stages and pathways through which an individual attains psychosomatic and physical health. An increase in PA (our main predictor of EI) has been shown to be associated with decreased cortisol levels triggering an increase in the Parasympathetic

Nervous System (PNS) activity and neurotransmitters.^{24–31} The activation of the PNS decreases the negative emotions, increased mood, cognition, and stress management, further increasing the ability to regulate, manage, and understand emotions.^{24–31} Ultimately, EI (the dependent variable) is increased, leading to increased psychosomatic, mental, and physical health.

2.4. Institutional review board approval

Institutional Review Board (IRB) approval for the NLSCY Study was approved by the Social Sciences and Humanities Research Council of Canada, from whom permission was sought and obtained before accessing the data for statistical analysis. Protection of human subjects, informed consent, and requirements safeguarding of confidentiality were approved, following the Statistics Act, by the Chief Statistician at Statistics Canada, approval and contract number 19-SSH-MCM-6156. Parents or guardians signed informed consent on behalf for their children prior to participating in the study. Since this was a secondary data analysis of a publicly available dataset our project was exempted from IRB consideration at the University of Massachusetts Boston.

2.5. Statistical methods

Prior to conducting statistical analysis, exploratory data analysis was conducted to eliminate and highlight implausible values and to assess normality in the distributions of composite scores. Descriptive statistics were generated using the mean and standard deviation for continuous measures, and frequencies and percentages for categorical or qualitative variables. One-way analysis of variance (ANOVA) was used to compare group means of GEI scores among PA categories. Simple and multivariable linear regression analyses with GEI as the dependent variable and PA measures were used to determine the association of PA with GEI. In regression models, PA measures were entered as class variables to obtain slopes for each level with the lowest category representing the referent category. Linear trend was assessed using regression models with the PA measures analyzed as an ordinal variable. Effect modification was assessed using an interaction term of covariates with measures of PA. Potential confounding factors were selected from age, annual household income, gender, child health status, hours of television, smoking, self-esteem, friends score, physical aggression, hyperactivity inattention, anxiety/emotional disorder, and indirect aggression. A parsimonious model was selected using stepwise selection procedures with $p < 0.05$ as the criteria for covariate entry in the final model.³² Post-hoc pairwise analysis to determine group differences was conducted when the general model F -test attained statistical significance at the 0.05 level. Results for linear regression analysis were summarized using regression coefficients β (standard error [SE]) for categories of PA variables. Some of the six categories of PA duration had low counts therefore, categories were collapsed to four categories. Statistical analysis was adjusted to account for the complex design and unequal sampling weights. A test for linear trend was used to assess the dose-response associated with ordinal categories of PA and EI scores. A p value of $p < 0.05$ was considered statistically significant. Statistical analysis was conducted using STATA 15.³³

3. Results

Table 1 summarizes baseline (Cycle 5) characteristics of the 2 029 participants. The majority, 51.2%, were female. With respect to age, 19.6%, 22.5%, 29.5%, and 28.3% were 10, 11, 12, 13, and 14 years of age, respectively. A majority, 39.0% had annual household income exceeding 80 000 Canadian dollars. Most of the participants recorded their health status as Excellent. More than 9 out of every 100 children reported current cigarettes smoking at Cycle 5.

Results for ANOVA shown on Table 2 revealed that for mean GEI scores were statistically significantly different across PA duration categories i.e., 28.3 (6.6) for the < 30 min category, 30.0 (6.5) for the 31–60

Table 1
Baseline participant characteristics ($n = 2\ 029$).

Characteristic	Categories	%
Gender	Male	48.7
	Female	51.2
Age (years)	10	19.6
	11	22.5
	12	29.5
	13	28.3
Annual Household income in Canadian Dollars (%)	< \$50 000	30.3
	\$50 000–59 999	7.7
	\$60 000–69 999	11.5
	\$70 000–79 999	11.5
	≥ \$80 000	39.0
Child health status (%)	Excellent	55.9
	Below Excellent	44.1
Current smoking status (%)	Yes	9.4
	No	90.6
Daily hours watching TV (%)	< 1 h	63.4
	> 1 h	36.6
Scales (Mean ± SD)		
Physical aggression		1.16 ± 1.8
Indirect aggression		1.45 ± 1.7
Anxiety emotional disorder		3.37 ± 2.6
Hyperactivity inattention		3.88 ± 2.8
Self-esteem		13.34 ± 2.5
Friends score		13.05 ± 2.7

Values are presented as percentages for categorical and ordinal variables, and as Mean ± Standard Deviation (SD) for quantitative variables. Hours: h.

min category, 30.8 (6.7) for the 60–120 min category, and 30.1 (6.5) for the ≥ 121 min category, ANOVA General F -test $p < 0.001$. For domain analysis, similar patterns were observed with Adaptability ($p < 0.001$), General Mood ($p < 0.001$), and Stress Management ($p < 0.001$) domains. ANOVA comparisons of GEI means across VPA weekly frequency categories revealed statistically significant GEI means ranging from 29.0 (6.4) for the Never VPA category, 29.1 (6.8) for the < 1 time per week, 29.7 (6.7) for the 1–3 times per week, and 31.6 (6.6) for the > 4 times category ($p < 0.001$). Post-hoc category pairwise comparisons revealed statistically significant differences in means for Intrapersonal, Interpersonal, Adaptability, General Mood domains with the highest mean GEI in the > 4 times VPA category and lowest in the Never VPA category. Generally similar results were seen in the comparison of GEI in categories of means for MPA weekly frequency categories with the highest mean GEI similarly in the > 4 times VPA category and lowest in the Never VPA category suggesting a dose response relationship between increasing PA duration and increasing GEI.

Table 3 shows results of the analysis of the association of PA duration categories with GEI at Cycle 5 as the response variable using linear regression models. In this analysis GEI is the dependent variable. Model 1 represents the crude analysis without any statistical adjustment for confounding. Model 2 represents a parsimonious multivariable-adjusted linear regression analysis adjusted for covariates selected in stepwise selection, i.e., annual household income, sex, and child health status. In this analysis, the < 30 min PA duration was used as the referent category. A linear trend analysis was conducted by entering the PA duration category variable as an ordinal variable. Results are summarized using regression coefficients (slopes) and standard error, i.e., β (SE). Slopes. Compared to the referent category of < 30 min PA duration, the multivariable-adjusted slopes (Model 2) were 1.80 (0.73), 2.50 (0.60), 2.12 (0.68) for 31–< 60, 60–120, and ≥ 121 min of PA duration categories, respectively with all p -values < 0.014. The test for linear trend was statistically significant, $p < 0.001$. When analyzed separately for each GEI domain, Intrapersonal, Interpersonal, Adaptability, General Mood domains had qualitatively similar results to the results of the GEI. However, the Stress Management domain did not attain statistical significance. In the analysis of domains, all slopes for PA duration greater than 60 min were statistically significantly greater than zero except for Stress Management domain. Analysis of linear trend revealed that all the

Table 2

Mean Emotional Intelligence (EI) scores by PA duration, weekly vigorous PA (VPA) Intensity and weekly moderate PA (MPA) at Cycle 5.

PA duration category (min)	Referent 0-30	Group 1 31 -< 60	Group 2 60-120	Group 3 ≥ 120	p-value ^a	Post-Hoc Pairwise Comparisons
Global Emotional Intelligence	28.3 ± 6.6	30.0 ± 6.5	30.8 ± 6.7	30.1 ± 6.5	13.9/< 0.001	2 > 3 > 1
Domains						
Intrapersonal	4.5 ± 2.4	4.4 ± 2.5	4.8 ± 2.5	4.9 ± 2.6	4.6/< 0.01	ns
Interpersonal	6.5 ± 2.0	6.5 ± 1.9	6.7 ± 1.9	6.6 ± 1.8	2.3/0.077	ns
Adaptability	5.0 ± 2.0	6.0 ± 1.8	6.0 ± 2.0	6.2 ± 2.1	35.9/< 0.001	3 > 2 > 1
General Mood	6.9 ± 1.9	7.2 ± 1.7	7.4 ± 1.8	7.2 ± 1.7	9.2/< 0.001	2 > 3 > 1
Stress Management	5.5 ± 2.2	5.8 ± 2.1	5.8 ± 2.2	5.0 ± 2.5	10.6/< 0.001	3 > 2 > 1
GEI VPA weekly frequency	Referent Never	Group 1 < 1 time	Group 2 1–3 times	Group 3 ≥ 4 times	ANOVA General F/p-value	Post-Hoc Pairwise Comparisons
GEI	29.0 ± 6.4	29.1 ± 6.8	29.7 ± 6.7	31.6 ± 6.6	14.27/< 0.001	3 > 2 > 1
Domains						
Intrapersonal	4.3 ± 2.5	4.7 ± 2.1	4.6 ± 2.5	5.2 ± 2.4	10.67/< 0.001	3 > 2 > 1
Interpersonal	6.4 ± 2.2	6.3 ± 1.9	6.6 ± 1.9	7.0 ± 1.8	11.95/< 0.001	3 > 2 > 1
Adaptability	5.8 ± 2.0	5.3 ± 2.0	5.6 ± 2.0	6.4 ± 1.9	23.19/< 0.001	3 > 2 > 1
General Mood	7.0 ± 1.8	7.1 ± 2.0	7.2 ± 1.7	7.5 ± 1.8	8.25/< 0.001	3 > 2 > 1
Stress Management	5.5 ± 2.3	5.6 ± 2.1	5.8 ± 2.1	5.4 ± 2.5	3.09/0.026	ns
GEI MPA weekly frequency	Never Referent	< 1 Group 1	1-3 Group 2	≥ 4 Group 3	ANOVA General F/p-value	Post-Hoc Pairwise Comparisons
GEI	29.4 ± 7.2	28.1 ± 6.8	30.5 ± 6.4	30.3 ± 6.8	11.80/< 0.001	2 > 3 > 1
Domains						
Intrapersonal	4.8 ± 2.6	4.3 ± 2.2	4.7 ± 2.5	4.8 ± 2.6	3.73/0.011	ns
Interpersonal	6.9 ± 2.2	6.1 ± 2.1	6.7 ± 1.8	6.7 ± 1.9	11.06/< 0.001	3 > 2 > 1
Adaptability	5.4 ± 2.3	5.3 ± 2.0	5.8 ± 1.9	6.0 ± 2.1	11.04/< 0.001	3 > 2 > 1
General Mood	7.2 ± 2.0	6.8 ± 1.8	7.3 ± 1.7	7.4 ± 1.8	9.23/< 0.001	ns
Stress Management	5.0 ± 2.7	5.6 ± 2.2	5.9 ± 2.1	5.4 ± 2.3	7.33/0.001	2 > 3 > 1

Values are presented as Mean ± SD.

Ns = not statistically significant.

MPA = Moderate Physical Activity.

VPA = Vigorous Physical Activity.

PA = Physical Activity.

SD = Standard Deviation.

Min = minutes.

^a General F from Analysis of variance.

domains except Stress Management domain had statistically significant linear trend. These results suggest a dose response relationship between increasing PA duration and increasing GEI.

4. Discussion

4.1. Association of PA duration with GEI score and its domains

Our findings suggest that adolescents who reported engaging in PA between 1 and 2 h duration had a higher overall GEI score compared to the referent group (0 to < 30 min). The statistically significant linear trend suggests a dose response relationship between increasing PA duration and increasing GEI. This finding is consistent with previous analyses of the association of higher PA volume and overall EI in adults yet it contradicts the findings of Kolpakov and colleagues who reported a negative association of EI and PA volume in adolescents.^{3,15,18,32,34} This discrepancy may be due to the constant hormonal changes and transitions that adolescents experience as opposed to adults. Decreased propensity for depression, anxiety, an increase in self-esteem, confidence, well-being, and cognition are among the known psychological advantages of PA.³⁵ The majority of the five domains of GEI were statistically significantly associated with PA duration. Intrapersonal, Interpersonal, Adaptability and Stress Management domains exhibited a positive association wherein > 2 h of PA duration category had higher domain scores. General Mood scores tracked the pattern of GEI score and PA duration in which the 1–2 h of PA duration category had the largest General Mood score. Adolescents should strive to meet the PA guidelines to help regulate the constant hormonal changes associated with puberty. While we observed a positive association between PA and EI, this may translate to positively influencing different aspects of adolescent well-being and

development. As EI is a strong indicator of health, PA may strengthen such psychological aspects related to EI.^{3,4}

Overall, we observed a steady positive association and dose-response relationship suggesting that as PA duration categories increased, so did GEI scores and its domains. This finding is consistent with the findings of other studies but at odds with both Hinkley and colleagues and Kolpakov and colleagues who reported a negative correlation of PA and EI and that sedentary behavior was associated with a higher emotional quotient.^{3,17–19,32} The positive tracking of domain scores with increasing levels of PA duration categories could be explained by the resultant increase in psychological well-being attributed to PA.³⁶ Notably, for the Intrapersonal domain of EI, engaging in PA has been associated with an increased perception self-image and self-esteem.^{36–38} The association of Interpersonal domain of is congruent with previous studies showing an increase in emotional stability and social support.^{36,39} A 2009 systematic review found that engaging in physical exercise has been shown across numerous interventions to increase some neurotransmitters such as serotonin, dopamine, acetylcholine, norepinephrine, and increases the receptors of these neurotransmitters affecting both the cortical and subcortical activity of the brain.⁴⁰ Mechanistically, these neurotransmitters can in turn promote the relief of feeling under pressure, and result in increased balance of an individual's mental state, which could explain the increase in Stress Management scores over PA duration categories we found in our study.⁴¹ As one engages in PA for an extended duration, the more they become able to deal with stressful situations and adapt to new changes, reflective of the Adaptability domain. PA has been associated with the General Mood domain scores while inversely proportional with depressive symptom and anxiety scores, hostility and psychotic behavior, and an increase in well-being.^{36,42} It was noted that those who reported engaging in PA for > 2 h was associated with a lower General Mood

Table 3
Associations of Physical Activity duration categories with Global Emotional Intelligence at Cycle 5.

	PA Duration (min)	Model 1* β (SE)	p-value	Model 2** β (SE)	p-value*
Global Emotional Intelligence	0–30	Referent		Referent	–
	31-< 60	1.62 (0.74)	0.028	1.80 (0.73)	0.014
	60–120	2.48 (0.59)	<	2.50 (0.60)	<
	≥ 121	1.75 (0.65)	0.001	2.12 (0.68)	0.001
	<i>p</i> for linear trend	< 0.001		< 0.001	
Intrapersonal	0–30	Referent		Referent	–
	31-< 60	–0.04 (0.29)	0.887	0.05 (0.27)	0.863
	60–120	0.36 (0.21)	0.090	0.42 (0.22)	0.052
	≥ 121	0.45 (0.27)	0.091	0.60 (0.27)	0.033
	<i>p</i> for linear trend	0.027		0.010	
Interpersonal	0–30	Referent		Referent	–
	31-< 60	0.06 (0.24)	0.784	0.15 (0.22)	0.499
	60–120	0.27 (0.18)	0.128	0.36 (0.18)	0.046
	≥ 121	0.16 (0.21)	0.438	0.40 (0.20)	0.040
	<i>p</i> for linear trend	0.196		0.020	
Adaptability	0–30	Referent		Referent	–
	31-< 60	0.97 (0.19)	<	0.94 (0.19)	<
	60–120	1.05 (0.19)	<	0.97 (0.18)	<
	≥ 121	1.29 (0.24)	<	1.22 (0.25)	<
	<i>p</i> for linear trend	< 0.001		< 0.001	
General Mood	0–30	Referent		Referent	–
	31-< 60	0.36 (0.20)	0.067	0.37 (0.20)	0.064
	60–120	0.54 (0.17)	0.001	0.52 (0.17)	0.002
	≥ 121	0.37 (0.18)	0.042	0.41 (0.19)	0.026
	<i>P</i> for linear trend	0.007		0.006	
Stress Management	0–30	Referent		Referent	–
	31-< 60	0.27 (0.23)	0.243	0.28 (0.23)	0.218
	60–120	0.26 (0.20)	0.200	0.22 (0.20)	0.270
	≥ 121	–0.53 (0.27)	0.050	–0.50 (0.28)	0.081
	<i>p</i> for linear trend	0.221		0.239	

*Model 1 *p*-value from is unadjusted simple linear regression analysis.
 **Model 2 *p*-value from is multivariable-adjusted linear regression analysis adjusted for annual household income, sex, and child health status.
 **Post-hoc pairwise comparisons revealed that compared to the referent category (< 30 min PA) was statistically significantly lower GEI than each of the other two PA categories (60–120 min and ≥ 121 min), both *p*-values < 0.01.
 PA = Physical Activity.
 EI = Emotional Intelligence.

score. Extra PA may accompany attributes such as compulsiveness, escaping or avoiding problems, being overcompetitive, and being self-centered.³⁶

4.2. Associations of PA intensity with GEI score and its domains

While the association between PA intensity or PA frequency with GEI has not been reported or observed in previous studies, our study is the first to find positive linear trends with PA intensity or PA frequency with GEI. However, the observed linear trends did not extend to the Stress Management domain. This finding suggests a dose response relationship between GEI and frequency of PA. This finding assimilates to those of previous studies that reported a positive linear correlation between PA volume and EI and its domains but at odds with the findings of Kolpakov and colleagues.^{3,15,18,32,34} It is known that self-esteem decreases as individuals transition to become youths; and VPA could potentially augment in the maintenance of self-esteem among adolescents.³⁷ Consistent with our results for PA duration and frequency, our findings indicate statistically significant positive linear trend between weekly frequency of VPA with GEI score and its domains except the Stress Management domain. While PA is generally associated with reduced perceived stress, this may not be the case for adolescents as they are in a growth phase of experiencing both the physical and mental adjustments to puberty.^{40,43–47}

Our finding of a robust overall positive linear trend across group PA duration, frequency, intensity categories could potentially be attributed to increased participation by children in physical sports at school. Previous studies assessing EI and team sports found a positive relationship between increased extroversion and increased use of emotions, and a higher score on the Interpersonal domain.^{42,48} Higher team EI, which is the average of each team member's EI scores, likely increases awareness to the repercussions of negative emotions and how those emotions may affect the individual's performance in sports.⁴⁹ This awareness may be associated with better managing emotions and mood potentially influencing managing stress.

4.3. Neurobiological perspective for the association between PA and GEI

The primary psychological effect of being physically active has been strongly associated with maintaining mental health.⁵⁰ There could be a biological mechanism that may explain the pathway of PA leading to a higher overall EI. Exercise has been found to increase certain neurotransmitters such as serotonin, dopamine, acetylcholine, norepinephrine, and increases the receptors of these neurotransmitters affecting both the cortical and subcortical activity of the brain which can in turn aid in the relief of feeling pressure, and result in increased balance of one's mental state.^{40,41} More time spent exercising enables the individual to deal with stressful situations and adapt to new changes. For adolescents, studies have shown that PA incorporated in the classrooms have positive effects on intellectual capabilities.^{51,52} As cognitive functioning is a major component to EI and PA has a positive impact on mental, physical, and psychosomatic health, PA is within this pathway to promote both health and well-being.^{4,14,29} Athletes with a higher EI viewed stressful situations as challenges and felt they could self-control their stress.²⁶ Decreased stress levels likely result in a better mood, and an increase in flexibility to challenges, thus leading to increased ability to manage, control, regulate, and understand one's and other's emotions, likely resulting in the individual having a higher overall GEI score.

5. Strengths

This study had many strengths. The large sample size of 2 029 participants included in the cross-sectional analysis, allowed for more precise large-scale estimation of the association of various measures of PA with GEI. Previous studies did not assess the frequency of intensity or the duration of exercise. We analyzed both moderate and vigorous PA in addition to the association of group PA, which has previously not been

analyzed, for its association with GEI. Our findings could be beneficial in further adding benefits of PA and EI in addition to the many already known benefits of engaging in PA.

6. Limitations

Despite the strengths of this study our analysis had some limitations. This study only assessed adolescents 10–13 years of age. Both GEI score and PA variables were measured subjectively. With subjective reporting, recall bias may have occurred. PA variables were pre-coded into categories; therefore, we did not have the raw continuous variables to be able to use different cut-points or conduct Pearson or Spearman linear correlation coefficient analysis or generate scatterplots with GEI. The questionnaire questions required participants to recall their PA habits over a period of the previous twelve months potentially causing recall bias in their responses. Another limitation is that we assessed the association of GEI and PA adjusting for potential confounding factors due to age, gender, child health status, and total household income but we did not account for additional important sociodemographic factors such as race, parent health status, neighborhood safety, religion and body mass index. The observational nature of NLSCY precludes us from inferring causality.

7. Future research

Physical exercises for strengthening, conditioning, and Moderate and Vigorous Physical Activity (MVPA) should be assessed in all ages to better understand the association of strengthening and conditioning with EI. Future studies should measure PA more objectively and more accurately using accelerometers. While there is no known way to biochemically measure EI score, cortisol levels should be used as proxy for Stress Management domain of EI. Interventions should be developed to determine the association of High Intensity Interval Training, walking, running with EI and results contrasted with interventions using PA duration, frequency, intensity, and group PA. While in our study the Intrapersonal, Interpersonal, and Stress Management domains of GEI score were associated with group PA, future studies should longitudinally assess group exercise interventions to determine whether the effect of group exercise persists or wanes over time.

8. Conclusion

Our findings suggest that PA duration and VPA are associated with statistically significant increase overall GEI score. In addition to the several health benefits derived from meeting PA guidelines, our study, even though observational, adds to the body of evidence that PA Duration and vigorous PA are beneficial to GEI in adolescents. Future longitudinal intervention studies are warranted to assess for temporal trends and durability between PA and EI amongst various age-groups.

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Submission statement

All authors have read and agree with the manuscript content. While this manuscript is being reviewed for the Journal of Sports Medicine and Health Science, the manuscript will not be submitted elsewhere for review and publication.

Ethical approval statement

Parents or guardians signed informed consent on behalf before their children prior to participating in the study. Institutional Review Board

(IRB) approval for the NLSCY Study was approved by the Social Sciences and Humanities Research Council of Canada, from whom permission was sought and obtained before accessing the data for statistical analysis. The procedure including consent and confidentiality requirements were approved by the Chief Statistician at Statistics Canada and were conducted according to the Statistics Act. The approval and contract number was: 19-SSH-MCM-6156. Since this was a secondary data analysis of a publicly available dataset our project was exempted from IRB consideration at the University of Massachusetts Boston.

Conflict of interest

We have no direct or indirect interests that are in direct conflict with the conduction of the study.

CRediT authorship contribution statement

Marie C. Gabour: Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Tongjian You:** Writing – review & editing, Resources. **Richard Fleming:** Writing – review & editing. **Paul D. McNicholas:** Writing – review & editing, Resources, Methodology, Investigation, Data curation. **Philimon N. Gona:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis.

Conflict of interest

Tongjian You is an editorial board member for Sports Medicine and Health Science and was not involved in the editorial review or the decision to publish this article. The authors have no Conflict of Interest to declare.

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