SSM - Population Health 14 (2021) 100805

Contents lists available at ScienceDirect

SSM - Population Health

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

A quasi-experimental examination of how changes in school-level intramurals are associated with physical activity among a sample of Canadian secondary school students from the COMPASS study

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ARTICLE INFO

Keywords:
Youth
Physical activity
Intramurals
School-based programs

ABSTRACT

Introduction: Intramurals in schools may encourage physical activity among youth. Schools are continuously making changes to these intramurals, yet it is not well understood how these changes impact youth physical activity. The main objective of this research was to examine if changes in the number of intramurals were associated with youth physical activity over time with a secondary objective to explore the association between sport participation and physical activity among youth over time.

Methods: This study used three years of linked longitudinal school- and student-level data from Ontario schools in year 5 (Y5: 2016–2017), year 6 (Y6: 2017–2018) and year 7 (Y7: 2018–2019) of the COMPASS study. Data on intramurals from 55 schools were collected from the School Programs and Policies questionnaire to determine intramural changes that were made from Y5 to Y6. Using the COMPASS Student Questionnaire, baseline demographics were collected and data on physical activity and sport participation were measured at Y5, Y6 and Y7 on 4417 students. Hierarchical linear mixed regression models were used to estimate how changes in intramurals were associated with youth physical activity over time.

Results: Changes in school-specific intramurals were not significantly associated with physical activity over time. Intramural, varsity and community sport participation were all positively and significantly associated with youth physical activity among female and males.

Conclusions: Intramural, varsity and community sport participation are important opportunities for youth physical activity. Schools should offer a variety of intramural and varsity sports to encourage physical activity. Although adding intramurals may not be effective at increasing youth physical activity, they may be effective when used in combination with other strategies to increase physical activity.

1. Introduction

Moderate-to vigorous-intensity physical activity (MVPA) is associated with numerous short- and long-term physical and mental health benefits for youth. Specific to physical benefits, MVPA is positively associated with healthy development by promoting healthy musculoskeletal and cardiovascular development among youth (U.S. Department of Health and Human Services, 2018; World Health Organization, n. d.) and helps reduce the risk of future diseases such as heart disease, cancer and type 2 diabetes (Janssen & LeBlanc, 2010; U.S. Department of Health and Human Services, 2018). Relating to mental health, among youth, MVPA is associated with higher academic performance (Centers for Disease Control and Prevention, 2010; Álvarez-Bueno et al., 2017) and social development, (World Health Organization, n. d.) and may reduce symptoms of anxiety and depression (Janssen & LeBlanc, 2010; U.S. Department of Health and Human Services, 2018). Higher intensity physical activities are more strongly associated with these health benefits compared to lower intensity activities (Poitras et al., 2016) however all physical activity of various intensities, durations and patterns (sporadic and continuous) are associated with health benefits (Poitras et al., 2016). This highlights that modest changes in physical activity behaviours among youth could result in the short- and long-term physical and mental health benefits.

The Canadian 24-Hour Movement Guidelines for Children and Youth

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https://doi.org/10.1016/j.ssmph.2021.100805
Received 5 February 2021; Received in revised form 5 April 2021; Accepted 16 April 2021
Available online 24 April 2021

recommend that youth aged 5–17 accumulate at least 60 min of MVPA per day, however only about one-third of Canadian youth are meeting these MVPA recommendations (Colley et al., 2017; Janssen et al., 2017; ParticipACTION, 2018; Roberts et al., 2017). This may be explained by the general decline in physical activity levels and increases in sedentary behaviour that are often observed in adolescence (Contardo Ayala et al., 2019; Harding et al., 2015).

Youth are an important target population for physical activity programs because the majority are not meeting the physical activity guidelines (Colley et al., 2017; Janssen et al., 2017; ParticipACTION, 2018; Roberts et al., 2017) and their physical activity levels tend to decrease as they age (Contardo Ayala et al., 2019; Harding et al., 2015). Additionally, in adolescence, habitual health behaviours such as physical activity and sedentary behaviour are developed and formed (Kelder et al., 1994; Leatherdale & Ahmed, 2015; Licence, 2004; Tremblay et al., 2016) presenting the opportunity for programs to help establish physical activity habits that can be maintained into adulthood (Kjønniksen et al., 2008; Risto Telama et al., 2014). Schools are an ideal setting to offer physical activity programming because the majority of Canadian children and youth are enrolled in elementary or secondary school (Statistics Canada, 2018) and they spend 6–7 h per weekday in school (U.S Department of Health and Human Services, 2012). School-based physical activity programs provide youth an opportunity to be physically active while reducing potential barriers (e.g., socioeconomic status and athletic ability) that may prevent some youth from participating in extracurricular physical activities such as community sports (Dwyer et al., 2006). Intramural (intra-scholastic) sports are an inclusive example of school-based physical activity programming because they are generally less competitive and are more accessible compared to varsity (inter-scholastic) sports because they are available to all students regardless of skill level and typically do not require a fee to participate (Action for Healthy Kids, 2015). Participation in intramural sports is positively associated with MVPA (Fuller et al., 2011; Hobin et al., 2013; Kurc & Leatherdale, 2009) and is associated with lower screen time and sedentary behaviour (Katapally et al., 2018). Lastly, participating in sports in adolescence is positively associated with physical activity in adulthood (Kjønniksen et al., 2008; Murphy et al., 2017; Richards et al., 2007), highlighting the potential longitudinal health benefits of youth intramural sport participation.

With ongoing changes to the funding provided to schools for physical activity programs (Government of Canada, 2019), there are continuous changes made to school-level physical activity programming. These continuous changes can be considered as *natural experiments*, as they are interventions that are implemented with no manipulation by the researcher (Brownson et al., 2009; Leatherdale, 2019). It is important to evaluate these natural experiments to determine how these changes in school physical activity programs affect youth physical activity, and to ultimately provide schools with evidence to inform their offering of these programs. With the inclusive and accessible nature of intramurals, their positive association with physical activity and the low cost to offer these programs, it is important to evaluate how changes in intramurals are associated with youth physical activity. To our knowledge, there is limited research examining how changes in school-level intramurals are associated with youth physical activity (U.S Department of Health and Human Services, 2012). Therefore, the main purpose of this study was to examine if changes in the number of intramurals offered were associated with MVPA over time. A secondary objective of this research was to explore the association between sport participation and physical activity among youth over time. This study aims to fill this research gap and to provide a longitudinal quasi-experimental evaluation of how changes in intramurals are associated with youth physical activity in Canadian secondary schools. This research will provide schools with practice-based evidence to inform their offerings of intramurals to maximize participation and physical activity among students (Petticrew et al., 2005).

2. Materials and methods

2.1. Design

The COMPASS study is a school-based prospective cohort study that collects longitudinal student- and school-level data from a convenience sample of students (grade 9–12) and the secondary schools they attend in Alberta, British Columbia, Ontario and Quebec (Leatherdale et al., 2014). Students within schools were recruited using an active-permission passive consent procedure as this approach limits self-selection and response biases (Leatherdale et al., 2014; Thompson-Haile et al., 2013). The COMPASS study collects student-level data on a variety of health behaviours and collects school-level data on the programs, policies and built environment over time through annual school data collections (Leatherdale et al., 2014). Data from the COMPASS study are used to evaluate how changes in school programs, policies, and/or the built environment are related to changes in youth health behaviours over time (Leatherdale et al., 2014).

Changes in intramurals are considered a natural experiment, and a longitudinal quasi-experimental design was used to evaluate how these changes associate with youth MVPA over time. The longitudinal quasi-experimental design involves pre- and post-intervention measures from non-randomized intervention and control groups (Leatherdale, 2019). In this study, student-level data on the outcome were collected from the COMPASS host study at pre-intervention (Year 5), intervention (Year 6) and post-intervention (Year 7) time points and were compared between non-randomized intervention and control groups, that were classified by their changes to intramurals. The longitudinal quasi-experimental design is considered the gold standard research methodology in natural experimental studies (Leatherdale, 2019). Important school- and student-level covariates were measured and controlled for through both stratification and adjustment to mitigate bias due to confounding from lack of randomization (Leatherdale, 2019).

A full description of the COMPASS study methods can be found in print (Leatherdale et al., 2014) or online (www.compass.uwaterloo.ca). All procedures were approved by the University of Waterloo Office of Research Ethics (reference number 30118) and appropriate school board committees.

2.2. Participants

This study used three years of linked longitudinal school- and student-level data from Ontario schools in year 5 (2016–2017), year 6 (2017–2018) and year 7 (2018–2019) of the COMPASS study. Schools in Alberta, British Columbia and Quebec were excluded from this study because of differences in provincial physical activity policies and programs and small school-level sample sizes at baseline. Schools were only included in the sample if they participated in data collection in year 5 (Y5), year 6 (Y6) and year 7 (Y7) and had complete data on intramurals for these years. Students from these schools who were in grade 9 and 10 at Y5 with linked data across all three of the time points were included in the study, as students who were in grade 11 or 12 in Y5 or students in grade 9 that were newly admitted into the study in Y6 or Y7 were not able to be successfully linked for all 3 years, and were therefore not included in the sample.

A total of 5514 students were linked over the three-year study period (Y5, Y6 and Y7). The main reasons for non-linkage were students transferring schools, students not providing data for grade in Y5 or Y6, students who were absent or had a scheduled spare during the time of Y5 or Y6 data collection, those who left secondary school early, or inaccurate data provided to link measures on the Cq. Details on the methods of COMPASS data linkage are available elsewhere (Battista et al., 2019). Only students with: (1) complete data on all covariates and (2) complete data or monotone missingness on the outcome were included in the analysis (n = 4417). The response rate for our study's inclusion criteria

among the 55 schools was 76% in Y5, 79% in Y6 and 78% in Y7.

2.3. Data collection

2.3.1. School-level data (SPP questionnaire and statistics Canada data)

School-level data were collected using the COMPAS School Policies and Practices Questionnaires (SPP). The SPP is an online survey completed by a school administrator (e.g., principal, guidance councillor, or teacher) that is most knowledgeable about the programs and policies within the school. School-level demographic data were collected from the from the 2016 census. All school-level covariates were measured at baseline (Y5).

2.3.1.1. Predictor. Changes in intramurals from Y5 to Y6 was determined by asking school contacts to "Please select the intramural programs/club activities involving physical activity that were offered to students at your school during the past 12 months." The intramural program selections include a variety of activities including team sports (e.g., soccer, basketball) and individual activities (e.g., yoga, running club). School contacts were also asked to indicate whether the intramural offerings were for females only, males only, or co-ed and there was space to indicate any activities not listed. *Changes in intramurals from Y5 to Y6* were determined by comparing intramural data from in Y5 to Y6. Schools made many changes from Y5 to Y6, and to ensure cell counts were large enough, these changes were categorized into three main groups (1) schools that added and removed the same number of intramural programs, (2) schools that added more programs than removed, or added programs only and (3) schools that removed more programs than added, or removed programs only. These groups were then coded into the following categories: (1) no net change, (2) primarily added programs and (3) primarily removed programs (reference).

2.2.1.2. Covariates. Changes in physical activity programs: School-level SPP data were used to assess whether schools made any other relevant changes to programs that may affect MVPA and/or intramural participation. Data on these programs were compared between Y5 and Y6 and the variable was categorized as either: "no changes in physical activity programs", "added physical activity programs" and "removed physical activity programs".

School neighbourhood median income in Y5: Data on the median income of school are based on the median income of the area surrounding the school. This variable is continuous and was determined using school postal code and household income data from the 2016 Canadian census data (Statistics Canada, 2016).

School size in Y5: Data on the size of each school are based on the number of students attending the school. This wass determined by the response on the SPP and is a continuous variable.

Number of intramurals in Y5: The number of intramurals offered in the 2016–2017 year is a continuous variable calculated by examining the intramural data on Y5 of the SPP.

2.3.2. Student-level data (COMPASS questionnaire)

The student-level data were self-reported using the COMPASS questionnaire (Cq) that is administered during class time. Based on previous research, there are many sociodemographic and behavioural characteristics that are associated with the outcome of MVPA. Many of these characteristics are measured by the Cq and were included in the model as covariates. MVPA, varsity, community and intramural sport participation were measured at all three time points (Y5, Y6 and Y7) while the remaining covariates were measured at baseline (Y5).

2.3.2.1. Outcome. MVPA in Y5, Y6 and Y7: The Cq asks students to record their daily time (hours and/or minutes) spent engaging in hard and moderate physical activity each day for the last 7 days (e.g., Monday-Sunday) and includes all physical activity during physical education class, lunch, after school, evenings and spare time. The average combined moderate and vigorous activity per day is a variable derived by summing the total time in minutes of moderate physical activity for each day (Monday-Sunday) and the total time in minutes of hard (vigorous) physical activity for each day (Monday-Sunday) and dividing this sum by 7 days. The result is a continuous variable for MVPA.

2.3.2.2. Covariates. Gender in Y5: Data on gender are measured by asking "Are you male or female?" The responses were coded into two categories: Female (Reference) and Male.

Grade in Y5: Data on the age of students are measured by asking "What grade are you in?" The responses were coded as Grade 9(Reference) and Grade 10.

Ethnicity in Y5: Data on the ethnicity of students are measured by the question "How would you describe yourself?". To ensure adequate cell counts ethnicity wass coded as White (Reference) and Other.

Weekly spending money in Y5: Weekly spending money is proxy measure of socioeconomic status and is measured by asking "About how much money do you usually get each week to spend on yourself or to save? (Remember to include all money from allowances and jobs like babysitting, delivering papers, etc.)", and was coded as "Zero" (Reference) , "$1-$20", "$21-$100" and "$100+".

Varsity sport participation in Y5, Y6 and Y7: Varsity sport participation is measured each year by the question "Do you participate in competitive school sports teams that compete against other schools? (e.g., junior varsity or varsity sports)", followed by the options of "No" (Reference) and "Yes".

Community Sport Participation in Y5, Y6 and Y7: Community sport participation is measured each year by asking "Do you participate in league or team sports outside of school?" and is followed by the options of "No" (Reference) and "Yes".

Intramural Participation in Y5, Y6 and Y7: Intramural participation is measured each year by asking students "Do you participate in before-school, noon hour, or after school physical activities organized by your school? (e.g., intramurals, non-competitive clubs)", and is followed by the options of "No" (Reference) and "Yes".

2.4. Data analysis

All analyses were performed in SAS 9.4 (SAS Institute, Cary, NC). Descriptive school-level (N = 55) and student-level characteristics (N = 4417) were calculated. Chi-Square was used to examine exploratory differences between female and male students on the student-level characteristics at baseline.

An empty linear mixed regression model was used to estimate the intraclass correction (ICC) to determine the variability in MVPA among schools. Linear mixed regression models were used via PROC MIXED to model whether changes in intramurals in Y5 to Y6 were associated with longitudinal MVPA and were stratified by sex. These models were hierarchical to account for clustering of students within schools and students over time. These models also controlled for the following relevant student-level factors: grade, ethnicity, weekly spending money, intramural participation, varsity sport participation, community sport participation, and the following school-level factors: changes in physical activity programs, number of intramurals in Y5, school size, and school neighbourhood median income. A novel modeling approach to program evaluation was utilized to create indicator variables representing the yearly intramural change: (i) intramural change in year 6 and (ii) intramural change in year 7. These indicator variables were included in the model and allowed for the assessment of their effect at those respective years. For year 7, the effect of intramural change was assessed under the supposition that changes from year 6 could continue (in a similar manner) onto year 7. This research intended to evaluate how changes in schools' intramural offerings from Y5 to Y6 were associated with youth MVPA over time, so supposing the changes from Y5 to Y6

onto Y7 was reasonable to meet this objective. This novel modeling approach has been used in other research to assess changes in provincial policies on health outcomes (McArthur et al., 2018) and to assess changes in the environment on alcohol use (Simons-Morton et al., 2016), tobacco and cannabis use (O'Brien et al., 2018) over time. The non-randomized intervention groups included schools classified as: (1) no net change and (2) primarily added programs, and the non-randomized comparison group included schools classified as (3) primarily removed programs (reference).

3. Theory

The socio-ecological model (SEM) is a theoretical framework used to understand how multidimensional factors interact to influence behaviour (Unicef, 2015). This model highlights how proximal (e.g., individual, interpersonal) and distal (e.g., environmental and organizational) factors interact to influence physical activity (Unicef, 2015). There are many integrated factors determining youth physical activity behaviours (Biddle et al., 2011), however, an important environmental factor associated with youth physical activity continues to be the school environment.(Centers for Disease Control and Prevention, n. d.) As a modifiable factor, it is important to study the effect of the school environment (e.g., intramural changes) on youth physical activity.

4. Results

4.1. School-level descriptive statistics

The characteristics of the school-level sample are presented in Table 1. Most schools in the sample reported primarily adding intramurals from Y5 to Y6 (n = 35), while 17 schools reported primarily removing programs and 3 schools reported no net change. Only 5 schools reported changes in physical activity programs from Y5 to Y6, and all 5 reported adding programs, as opposed to removing them. The mean school median income was $69,804 (SD = $15,404.29) and the mean school size was 670 students (SD = 289). The mean number of intramurals offered in Y5 was 5.38 (SD = 4.12).

4.2. Student-level descriptive statistics

The characteristics of this sample can be found in Tables 2 and 3. As shown, 54% (n = 2402) of the sample was female and 73% (n = 3210) were white. Most students (43%, n = 1875) reported $1-$20 in weekly spending money at baseline. Intramural participation among female students was 38% in Y5, 36% in Y6 and 33% in Y7. Among male students, intramural participation was 39% in Y5, 37% in Y6 and 36% in Y7. Both male and female students participated in less average daily MVPA over time, with females accumulating 105 min (SD = 66) in Y5, 97 min (SD = 64) in Y6 and 89 min (SD = 61) in Y7 while males accumulated an average of 117 min (SD = 68) in Y5, 109 min (SD = 68) in Y6 and 102 min (SD = 65) in Y7.

Table 1
Descriptive Statistics for School-Level Characteristics for the sample (n = 55) from Year 5 (2016–2017) of the COMPASS study.

Variable		Freq/ Mean	%/SD
Changes in Intramurals	Primarily Removed (Ref)	17	30.9
	No Net Change	3	5.5
	Primarily Added	35	63.6
Changes in Other Physical Activity Programs	No Change (Ref)	50	90.9
	Added Programs	5	9.1
School Neighbourhood Median Income		$69, 804	$15,404.3
School Size		669.2	288.1
Number of Intramurals Offered in Y5		5.4	4.12

4.3. Results from longitudinal mixed models

Based on the ICC, school-level differences accounted for 1.91% of the variability in MVPA among females and 2.09% among males, suggesting modest differences between schools on MVPA. Results from the linear mixed models are presented in Table 4. Female and male students in grade 10 at baseline accumulated significantly less daily MVPA minutes on average compared to students in grade 9 at baseline (Females: $\widehat{\beta}$ = -8.391, $p < 0.001$, Males: $\widehat{\beta} = 7.307$, $p < 0.001$). Year was negatively associated with MVPA for both females and males, although this relationship was only significant for females (Females $\widehat{\beta} = -7.255$, $p = 0.004$, Males $\widehat{\beta} = -1.080$, $p = 0.698$). Females participating in intramurals accumulated an average of 4.987 more daily minutes of MVPA ($p = 0.003$) and males accumulated an average of 9.709 more daily minutes of MVPA ($p < 0.001$) compared to females and males not participating in intramurals respectively. Female and male students reporting varsity sport participation accumulated significantly more average daily MVPA minutes compared to their non-participating counterparts (Females: $\widehat{\beta} = 16.128$ $p < 0.001$, Males: $\widehat{\beta} = 18.020$, $p < 0.001$). Females participating in community sports achieved an average of 26.060 more minutes of MVPA per day ($p < 0.001$) and males accumulated an average of 20.267 more minutes of MVPA per day ($p < 0.001$) compared to females and males not participating in community sports respectively.

Primarily adding intramurals had a positive but non-significant association with female MVPA in Y6 and a non-significant negative association with male MVPA in Y6 regardless of whether youth participated in intramurals, compared to schools that primarily removed intramurals (Females: $\widehat{\beta} = 4.810$ $p = 0.065$, Males: $\widehat{\beta} = -2.087$, $p = 0.480$). Schools that made no net changes to intramurals were positively, but non-significantly associated with both female and male MVPA in Y6 regardless of whether youth participated in intramurals, both compared to schools that primarily removed intramurals (Females: $\widehat{\beta} = 2.248$ $p = 0.484$, Males: $\widehat{\beta} = 5.133$, $p = 0.147$).

Next, assuming the intramural changes in Y6 were maintained in Y7, their effect on MVPA in Y7 was estimated for female and male students. If the schools that primarily added intramurals maintained these changes in Y7, it was estimated to have a positive yet non-significant effect on MVPA among females in Y7 ($\widehat{\beta}$=3.135, $p = 0.230$) and a negative and non-significant effect on MVPA among males in Y7 ($\widehat{\beta}$= −0.666, $p = 0.822$). If schools that made no net changes to intramurals maintained this change into Y7, it was estimated to have a negative and non-significant effect on MVPA among females in Y7 ($\widehat{\beta}$= −1.489, $p = 0.783$) and a positive and non-significant effect on MVPA among males in Y7 ($\widehat{\beta}$= 8.758, $p = 0.138$).

5. Discussion

To our knowledge, this was the first study to evaluate how changes in intramurals were associated with MVPA over time. We explored this association using a large sample of linked longitudinal data, and employed an innovative methodology that allowed us to examine how the effect of changes in intramurals affected MVPA in Y6 and into Y7, under the assumption these changes were maintained from Y6. Our results suggest that youth MVPA declines over time and changes in intramurals did not significantly protect youth against this negative trend in MVPA. Despite these results, this study contributes to our understanding of how real-world changes in intramurals affect MVPA over time.

Female and male students in grade 10 at baseline accumulated significantly less daily MVPA minutes compared to those in grade 9 at baseline. Cross-sectional research using objective measures of physical activity have found similar results, as younger youth accumulated

Table 2
Descriptive Statistics for Baseline Student-Level Characteristics for the sample (n = 4417) from Year 5 (2016–2017) of the COMPASS study.

Variable		Total n = 4417	Female (Ref) n = 2402 (54%)	Male n = 2015 (46%)			
		Counts (%)	Counts (%)	Counts (%)	DF	Chi-Square	P-Value
Grade	Grade 9 (Ref)	2434 (55.1)	1335 (55.6)	1099 (54.5)	1	1.431	0.232
	Grade 10	1983 (44.9)	1067 (44.4)	916 (45.5)			
Ethnicity	White (Ref)	3210 (72.7)	1744 (72.6)	1466 (72.8)	1	0.036	0.849
	Other	1207 (27.3)	658 (27.4)	549 (27.2)			
Weekly Spending Money	Zero (Ref)	1130 (25.6)	541 (22.5)	589 (29.2)	3	107.4002	<.0001
	$1-$20	1875 (42.5)	1062 (44.2)	813 (40.3)			
	$21-$100	1065 (24.1)	628 (26.1)	437 (21.7)			
	$100+	347 (7.9)	171 (7.1)	176 (8.7)			

Percent values may not equal 100 due to rounding.

Table 3
Descriptive Statistics for Time-Varying Student-Level Characteristics for the sample (n = 4417) from Year 5 (2016–2017), Y6 (2017–2018) and Y7 (2018–2019) of the COMPASS study.

Variable		Total n = 4417			Female (Ref) n = 2402			Male n = 2015		
		Year 5	Year 6	Year 7	Year 5	Year 6	Year 7	Year 5	Year 6	Year 7
		Counts (%)	Counts (%)	Counts (%)	Counts (%)	Counts (%)	Counts (%)	Counts (%)	Counts (%)	Counts (%)
Intramurals	No (Ref)	2733 (61.9)	2813 (63.7)	2903 (65.7)	1494 (62.2)	1542 (64.2)	1616 (67.3)	1239 (61.5)	1271 (63.1)	1287 (63.9)
	Yes	1684 (38.1)	1604 (36.3)	1514 (34.3)	908 (37.8)	860 (35.8)38	786 (32.7)	776 (38.5)	744 (36.9)	728 (36.1)
Varsity	No (Ref)	2568 (58.1)	2529 (57.3)	2688 (60.9)	1464 (60.9)	1447 (60.2)	1558 (64.9)	1104 (54.8)	1082 (53.7)	1130 (56.1)
	Yes	1849 (41.9)	1888 (42.7)	1729 (39.1)	938 (39.1)	955 (39.8)	844 (35.1)	911 (45.2)	933 (46.3)	885 (43.9)
Community	No (Ref)	2109 (47.7)	2394 (54.2)	2781 (63.0)	1218 (50.7)	1377 (57.3)	1599 (66.6)	891 (44.2)	1017 (50.5)	1182 (58.7)
	Yes	2308 (52.3)	2023 (45.8)	1636 (37.0)	1184 (49.3)	1025 (42.7)	803 (33.4)	1124 (55.8)	998 (49.5)	833 (41.3)
Variable		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
MVPA (min/day)[a]		110 (67) n = 4417	102 (66) n = 4414	95 (64) n = 4375	105 (66) n = 2402	97 (64) n = 2400	89 (61) n = 2380	117 (68) n = 2015	109 (68) n = 2014	102 (65) n = 1995

[a] Note that the sample sizes for MVPA in Y6 and Y7 are different compared to baseline as well as Y6 and Y7 of other covariates. This is because some subjects included in the model are missing MVPA data in Y6 and Y7 (i.e., monotone pattern).

Table 4
Linear Mixed Models examining the association between changes in intramurals in Y6 on MVPA in Y6 and Y7 of the COMPASS Study stratified by gender.

Variable		Female n = 2402			Male n = 2015		
		Estimate	95% CI	p-value	Estimate	95% CI	p-value
Effect of Intramural Change on MVPA in Y6	Primarily Removed (Ref)	–	–	–	–	–	–
	Primarily Added	4.810	−0.289-9.909	0.065	−2.087	−7.876-3.702	0.480
	No Net Change	2.248	−4.044-8.540	0.484	5.133	−1.800-12.066	0.147
Effect of Intramural Change on MVPA in Y7	Primarily Removed (Ref)	–	–	–	–	–	–
	Primarily Added	3.135	−1.979-8.248	0.230	−0.666	−6.468-5.135	0.822
	No Net Change	−1.489	−12.056-9.079	0.783	8.758	−2.817-20.333	0.138
Grade	Grade 9 (Ref)	–	–	–	–	–	–
	Grade 10	−8.391	−12.093–4.689	**<.001**	−7.307	−11.431–3.183	**<0.001**
Year		−7.255	−12.244–2.266	**0.004**	−1.080	−6.538-4.378	0.698
Intramural Sport Participation	No (Ref)	–	–	–	–	–	–
	Yes	4.987	1.753–8.221	**0.003**	9.709	6.031–13.386	**<.001**
Varsity Sport Participation	No (Ref)	–	–	–	–	–	–
	Yes	16.128	12.474–19.782	**<.001**	18.020	13.919–22.120	**<.001**
Community Sport Participation	No (Ref)	–	–	–	–	–	–
	Yes	26.060	22.760–29.360	**<.001**	20.267	16.477–24.057	**<.001**

Models controlled for changes in physical activity programs in Y6, median school neighbourhood income in Y5, school enrolment in Y5, number of intramurals in Y5, ethnicity and weekly spending money. Values significant at $\alpha = 0.05$ are bolded.

significantly more MVPA compared to older youth (Colley et al., 2017; Roberts et al., 2017). Additionally, our findings are consistent with other studies that have observed decreases in MVPA as youth progress from grade 9 to grade 10 (Allison et al., 2007) and throughout the rest of high school (Lounassalo et al., 2019). Year was negatively associated with MVPA for both female and male students, however this association was only significant among females. This general decrease in MVPA over time is consistent with longitudinal research using self-report (Gordon-Larsen et al., 2004; Kjønniksen et al., 2008; R.; Telama & Yang, 2000; Van Mechelen et al., 2000; Walters et al., 2009) and objective (Contardo Ayala et al., 2019; Harding et al., 2015) measures of physical activity. This association was only significant in female students which may be explained by the greater decline in physical activity that is generally observed in females compared to males over time (Cairney et al., 2014; Metcalf et al., 2015).

Participation in intramural, varsity and community sports were all significantly and positively associated with MVPA for both males and females. These associations have been observed in other research as intramural (Hobin et al., 2013; Kurc & Leatherdale, 2009; Morton et al., 2016), varsity (Hobin et al., 2013; Kurc & Leatherdale, 2009) and

community (Kurc & Leatherdale, 2009; Murphy et al., 2017; Sallis et al., 2000; Sterdt et al., 2014) sport participation are all positively associated with youth MVPA. These sports are all opportunities for youth to be physically active which is an important predictor of youth physical activity (Biddle et al., 2011; Sterdt et al., 2014; Strong et al., 2005).

The innovative modeling method used in this study allowed us to examine how intramural change impacts students' MVPA over time. The associations between intramural change and MVPA were non-significant for both female and male youth, regardless of whether students reported participating in these programs. These results suggest that changes in school-level intramurals do not have an effect on MVPA and that perhaps adding intramurals is not an effective method to increase MVPA among students. Previous research has echoed this and suggests that school-based physical activity programs are most effective at increasing student MVPA when they are multifaceted. For example, physical activity programs that integrate a combination of curriculum, policy, environmental, community and parental strategies have shown most effective in improving youth physical activity (Timperio et al., 2004; World Health Organization, 2007). Although not effective at increasing MVPA on their own, policies to increase intramural programming could be an important part of a more comprehensive school-based physical activity strategy (Dobbins et al., 2013; Fung et al., 2012). Changes in intramurals were not associated with MVPA, however it is important to highlight that these changes may impact intramural participation, which we did not examine in this research. Intramural participation is associated with a multitude of health benefits including improved mental health (Janssen & LeBlanc, 2010; U.S. Department of Health and Human Services, 2018), improved academic performance (Centers for Disease Control and Prevention, 2010; Álvarez-Bueno et al., 2017), increased socialization, (World Health Organization, n. d.) reduced substance use (Williams et al., 2020a), and sport sampling (Cleland et al., 2012; Coté et al., 2009; Kjønniksen et al., 2008; Murphy et al., 2017; Richards et al., 2007; Tammelin et al., 2003; Telama et al., 2006; US Department of Health and Human Services, 2019), and research examining how school-based intramurals associate with intramural participation is warranted.

It is also important to note that this study did not consider additional details about the intramural changes that may be important for youth MVPA. For example, past research examining MVPA and sport participation has shown that some intramurals generate more MVPA compared to others, and that team sports are generally associated with more MVPA compared to individual activities (Bocarro et al., 2014; Smith et al., 2015). Perhaps the positive intramural changes in our study were primarily to lower-intensity or individual-based sports, and/or the negative intramural changes were primarily made to higher-intensity or team-based sports, potentially explaining our non-significant findings. Recent research found that adding team and individual intramurals were positively associated with female MVPA, regardless of intramural participation (Burns et al., 2021), which underscores the importance of examining types of intramural changes on youth MVPA. These results suggest an indirect effect between changes in intramurals and MVPA, and may be explained by the fact that adding team and individual intramurals fosters a supportive physical activity environment and addresses important proximal factors associated with female MVPA (Eime et al., 2015; Johnstone & Millar, 2012; Król-Zielinska et al., 2018; Li et al., 2014; Mcgovern et al., 2020; Rees et al., 2006; Utter et al., 2006). Additionally, we did not consider whether the intramural changes were to female-only, male-only or co-ed intramurals. Classifying intramurals by gender-offering is important in physical activity research, as it has been shown to influence intramural participation and potentially MVPA. For example, females attending schools with female-only intramurals were more likely to participate in intramurals compared to females attending schools without such programs (Williams et al., 2020b), therefore female-only intramurals may generate higher levels of physical activity among females compared to co-ed programs (Fuller et al., 2011; Hobin et al., 2013; Kurc & Leatherdale, 2009; Morton et al., 2016).

Future studies should aim to further classify intramural changes by intensity and gender-offering to account for the potential differentiating effects of these on MVPA. This research future would enhance our understanding of how changes in intramural programs are associated with MVPA, and would better aid in school-level decision making. Additionally, future research should seek to understand how intramural programs affect intramural participation over time to account for the numerous benefits of participation apart from physical activity.

5.1. Limitations

Firstly, schools were recruited using convenience sampling which may limit the generalizability of the results. However, the COMPASS study has a large sample size and utilizes active-information, passive-consent protocol to encourage participation and honest response (Thompson-Haile et al., 2013). This recruitment method has been shown to limit self-selection and response biases and generate more robust results (Leatherdale et al., 2014). Secondly, we did not examine changes in the type of intramural programs (e.g., team and individual) and gender-offering (e.g., female-only, male-only and co-ed) in our analysis. Team and individual intramurals are differentially associated with MVPA, as team sports typically generate more MVPA among youth compared to individual sports. Also, the gender-offering of intramural programs should be considered, as this affects participation and potentially physical activity. Thirdly, because schools make many intramural changes each year, the intervention groups may have been diluted (e.g., primarily added versus added only), making the association between these changes and MVPA difficult to measure. Lastly, it is possible that this study was under-powered at the school-level to detect associations between changes in intramural programs on MVPA over time.

6. Conclusion

The results of this study highlight the important effect that intramural, varsity and community sport participation have on youth MVPA, as participation in these sports were positively associated with youth MVPA. Schools should consider offering a variety of varsity and intramural sports to encourage physical activity among their student population. Although not effective at increasing MVPA on their own, intramurals could be an important part of a more comprehensive school-based physical activity strategy. When considering changes to intramural programs, schools should consider participation rates and offer intramurals that will engage a large proportion of students, including those at high risk for physical inactivity. Sport participation in youth is a predictor for physical activity later in life, therefore it is important for schools to offer a variety of sports at the intramural and varsity levels to accommodate students with a wide range of interests and athletic abilities.

Data statement

The datasets generated and analyzed for this study will not currently be shared because this is an ongoing study; however, access to the data supporting the findings of this study can be requested at https://uwaterloo.ca/compass-system/information-researchers.

Ethical statement

The data collection for this research was approved by the Research Ethics Board at the University of Waterloo. The authors have no conflicts of interest to declare.

Funding

The COMPASS study has been supported by a bridge grant from the

CIHR Institute of Nutrition, Metabolism and Diabetes (INMD) through the "Obesity – Interventions to Prevent or Treat" priority funding awards (OOP-110788; awarded to SL), an operating grant from the CIHR Institute of Population and Public Health (IPPH) (MOP-114875; awarded to SL), a CIHR project grant (PJT-148562; awarded to SL), a CIHR bridge grant (PJT-149092; awarded to KP/SL), a CIHR project grant (PJT-159693; awarded to KP), and by a research funding arrangement with Health Canada (#1617-HQ-000012; contract awarded to SL), and a CIHR-Canadian Centre on Substance Abuse (CCSA) team grant (OF7 B1-PCPEGT 410-10-9633; awarded to SL). The COMPASS-Quebec project additionally benefits from funding from the Ministère de la Santé et des Services sociaux of the province of Québec, and the Direction régionale de santé publique du CIUSSS de la Capitale-Nationale.

CRediT authorship contribution statement

Kathleen E. Burns: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Ashok Chaurasia:** Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing – review & editing. **Valerie Carson:** Conceptualization, Methodology, Writing – review & editing. **Scott T. Leatherdale:** Conceptualization, Methodology, Investigation, Resources, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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