



Gendered associations between e-cigarette use, cigarette smoking, physical activity, and sedentary behaviour in a sample of Canadian adolescents

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ABSTRACT

Objectives: To examine associations between e-cigarette use, cigarette smoking, physical activity, and sedentary behaviour among a large sample of Canadian adolescents (Grades 9–12) by sex.

Methods: Cross-sectional data from 55,629 students who participated in COMPASS Year 6 (2017–2018) were used. Exposures included e-cigarette use and cigarette smoking. Outcomes included meeting recommendations for moderate- to vigorous- physical activity (MVPA; ≥ 60 min/d), muscular strengthening exercises (MSE; ≥ 3 time/wk), and recreational screen time (ST; ≤ 2 h/day) and participating in intramurals or competitive team sports. Logistic regressions were performed after adjusting for relevant covariates.

Results: Male adolescents showed higher prevalence of e-cigarette use (40.0% vs 31.3%) and cigarette smoking (4.4% vs 2.9%) than females. Both males and females who used e-cigarettes were more likely to meet MVPA and MSE recommendations, but less likely to meet the ST recommendation than those who did not use e-cigarettes. E-cigarette use was also consistently associated with more sport participation in males, however, among females the results were mixed. Current cigarette use was associated with meeting the MVPA recommendation and less participation in intramurals in males; however, in females, current cigarette smoking was consistently associated with less participation in any sports. Former cigarette use was associated with participation in competitive team sport within school and meeting the MSE recommendation in females only.

Conclusions: This study found that associations between e-cigarette use and cigarette smoking with physical activity, sedentary behaviour, and sport participation are largely gendered. Identifying differential co-occurrence of risk behaviours by gender is important for future health promotion efforts targeting physical activity among adolescents.

1. Introduction

Preventing adolescent initiation of cigarette smoking has been a public health priority in Canada for decades [1]. Consequently, cigarette smoking by adolescents in Canada has markedly decreased over the past few decades [2]. In parallel with this decrease, however, there has been a large increase in e-cigarette use in recent years [3]. Perhaps the most immediate negative effect of e-cigarette use among adolescents is the risk of developing a nicotine dependence [3]. Nicotine is capable of altering brain development among teens [3]. While e-cigarettes are believed to be less harmful to overall health compared to cigarettes [4], evidence suggesting that e-cigarette use may be associated with cigarette smoking initiation indicates that e-cigarette use is a unique risk factor for cigarette smoking initiation, for which negative health consequences have been well studied [3]. These consequences include a clustering of unhealthy behaviours

among adolescents, including poor diet, poor sleep quality, and reduced levels of physical activity [4].

Obtaining high levels of physical activity, regardless of type, and reducing sedentary time is associated with positive health outcomes, such as a healthy body composition and cardiometabolic biomarkers, positive behavioural conduct, cognition, quality of life, bone health, self-esteem, motor development, as well as mental and psychosocial health [5,6]. Based on such evidence, the Canadian 24-Hour Movement Guidelines for Children and Youth [5] are developed to provide evidence-based recommendations for optimal activity levels daily among adolescents to gain health benefits. Evidence suggests that cigarette smoking is associated with physical inactivity and higher sedentary behaviour [4,7]; however, evidence pertaining to the associations between e-cigarette use and other health- behaviours (e.g. physical activity and sedentary behaviour) is largely mixed, with studies reporting bi-directional [8], protective [9–12], harmful [9], [12], [13],

Abbreviations: MVPA, Moderate- to Vigorous-intensity Physical Activity; ST, Screen Time; MSE, Muscular Strengthening Exercises; OR, Odds Ratio; CI, Confidence Interval.

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curvilinear [14] or null [4] associations, depending on the health behaviour in question. Such emerging but mixed evidence suggests that additional investigation on the relationships between e-cigarette use, physical activity, and sedentary behaviour are required.

A recent Canadian study [13] of adolescents in Grades 9 and 12 examining the associations between e-cigarette use, cigarette smoking, physical activity, and sedentary behaviour stratified by sex suggested that the positive association between e-cigarette use and physical activity (including sport participation) is more evident in males while the negative association between cigarette smoking and physical activity is more apparent in females. However, discussions on a potential role of sex and gender on the associations have been largely unexplored in earlier research. Given that adolescence is a unique developmental period with great complexity [15] and that adolescents establish health behaviours that can track into adulthood [16], it is important to pay attention to identifying and enhancing protective factors for the current and future health of adolescents [15].

Building on previous evidence [13], the objective of this study was to investigate the associations between e-cigarette use, cigarette smoking, physical activity (including sport participation), and sedentary behaviour among a sample of Canadian adolescents by sex. Sex is a well-known moderator of health behaviours among adolescents and thus examining the associations between varying health behaviours have been stratifying their analysis by sex [7,13]. Given that sex and gender (i.e., the socially constructed “femaleness” or “maleness” in a society) are inextricably interconnected and reciprocally influence each other [17] and that sex is being investigated in relation with different behaviours that are known to vary greatly and influenced by gender—“doing gender (p. 216)” as suggested by West and Zimmerman [18]—, our study used the biological sex (females and males) variables in the analysis, but findings were interpreted and discussed while integrating gender. The objectives of this study align with the United Nations (UN) Sustainable Development Goal (SDG) #3 – “Ensure healthy lives and promote well-being for all at all ages” [19], because a better understanding of the associations between health behaviours will help inform more appropriate interventions for health promotion for adolescents.

2. Methods

The COMPASS Study (COMPASS) is a prospective cohort study (2012–2021) that collects longitudinal data from a large sample of students in Grades 9 through 12 and the Canadian secondary schools they attend [20]. A full description of COMPASS and its methods are available in print [20] or online (www.compass.uwaterloo.ca). All survey protocol and data collection procedures were approved by the University of Waterloo Office of Research Ethics (#30118). Ethics for this specific paper was approved by the Queen's University General Research Ethics Board (#6028216).

2.1. Sample characteristics

This study used cross-sectional data from the 2017–2018 wave of COMPASS that were collected from 66,434 students (81.7% participation rate) in Ontario, Alberta, Quebec, and British Columbia. Reasons for not participating in the study included self or parental-refusal (<1%) and student not being present at school on the day of data collection (e.g., absences, field trips). Out of 66,434 participants, 10,805 were excluded from the analysis due to missing data ($n = 7377$) and the age restriction (those aged 18 years+ were excluded due to the Guidelines age restriction being ≤ 17 years) ($n = 3428$) (see Table 1 for more details), leaving a total of 55,629 eligible participants. Participants 18 years of age or older were excluded because they do not fall under the *Canadian 24-Hour Movement Guidelines for Children and Youth* (ages 5–17 years) [5].

All schools that participated in COMPASS provided consent. Active-information passive-consent parental permissions protocol was used for child participants. Further, any student could choose not to participate at any time should they not want to complete the COMPASS questionnaire.

Table 1
Composition of excluded cases.

Variable	Excluded Cases
Age Not Stated	273
Age 18+ years	3428
Sex Not Stated	562
Missing Competitive Sports at School / Response “None Offered at My School”	2143 (1113 – Not Stated; 1010 – “None offered at my school”)
Missing Competitive Sports Outside School / Response “None Offered Where I live”	1918 (1098 – Not Stated; 820 – “None offered where I live”)
Missing Club or Intramural Participation / Response “None Offered at My School”	3658 (1241 – Not Stated; 2417 – “None offered at my school”)
MSE Exercises Not Stated	1329
Daily MVPA Levels Not Stated	1515
Ethnicity Not Stated	437
Typical Week of Physical Activity – No Response	1522
Inconsistent Reporting of Alternative Tobacco Products	495
Total Missing Cases	10,805

Note: Many cases left multiple fields blank, which is why the addition of each variable does not equate to the number total missing cases ($n = 10,805$).

The psychometric properties of the COMPASS questionnaire are described elsewhere [20–23].

2.2. Measures

2.2.1. E-cigarette use

E-cigarette use was determined by asking participants if they ever tried an electronic cigarette, also known as an e-cigarette, with binary response options (“Yes,” “No”). If answered “Yes,” adolescents were asked to report on the frequency of e-cigarettes they used in the last 30 days from 1 day to everyday. Adolescents who declared that they used e-cigarettes at least 1 day during the last 30 days were considered as using e-cigarettes currently [13].

2.2.2. Cigarette smoking

Cigarette smoking was determined by asking participants if they ever tried cigarette smoking, even just a few puffs and if they ever smoked 100 or more cigarettes in their life with binary response options (“Yes,” “No”). Adolescents were asked to report on the frequency of cigarette smoking in the last 30 days from 1 day to everyday. Consistent with previous research [7,13,22], adolescents who declared ever smoking 100 cigarettes in their lives and reported any smoking in the previous 30 days were categorized into the current-smoking status group, adolescents who declared that they had smoked 100 cigarettes in their lives but did not smoke in the past 30 days were categorized into the former-smoking status group, and those who declared that they never smoked 100 cigarettes and had not smoked in the past 30 days were categorized into the non-smoking status group.

2.2.3. Physical activity

Physical activity was determined by asking participants on the amount of time engaged in vigorous (i.e., elevate your heart rate and make you breathe quickly and sweat) and moderate (i.e., lower intensity activities that do not cause a significant increase in heart rate or breathing) physical activity in the past 7 days. Adolescents were also asked to indicate frequency of engaging in muscular strengthening exercises (MSE) during the last 7 days. Based on the *Canadian 24-Hour Movement Guidelines for Children and Youth* (aged 5–17 years) [5], responses were categorized into 1) meeting MVPA (on average participating in ≥ 60 min daily across the week) and 2) MSE (≥ 3 days/week) recommendations, separately, and not meeting the recommendations.

2.2.4. Recreational screen time (ST)

Recreational ST was assessed by asking participants to report the number of minutes per day that were spent watching TV, playing video games,

surfing the internet, or texting / messaging. Based on the *Canadian 24-Hour Movement Guidelines for Children and Youth* (aged 5–17 years) [5], responses were categorized into meeting (≤ 2 h/day of recreational ST) or not meeting the ST recommendation.

2.2.5. Organized sport participation

Sport participation was determined by asking participants if they participate in (1) before-school, noon hour, or after school physical activities organized by your school (e.g., intramurals, non-competitive clubs), (2) competitive school sports teams that compete against other schools (e.g., junior or varsity sports), and (3) league or team sports outside of school. Response options were: “Yes”, “No”, “None offered at my school”, or “None offered where I live”. Based on participant responses, respondents were dichotomously categorized as either participating in the mentioned organized sport or not participating in the mentioned organized sport. Participants who responded “None offered at my school” or “None offered where I live” were excluded from the analyses (Table 1).

2.3. Covariates

Participants' age (≤ 14 years, 15 years, 16 years and 17 years), ethnicity/race (European-Caucasian, white and ethnic minority/non-white person) and the amount of weekly spending money were considered as covariates. Previous literature indicated that these factors are associated with e-cigarette use, cigarette smoking, sport participation, MVPA, and recreational ST [13].

2.4. Statistical analysis

Descriptive statistics were performed in the total sample and stratified by sex (male, female). Pearson's Chi-square tests for categorical and Independent *t*-tests for continuous variables were conducted to determine if any significant sex differences existed. A series of logistic regressions models were conducted to examine the associations between e-cigarette/cigarette smoking, organized sport participation, and meeting physical activity and ST recommendations after controlling for covariates (i.e., age, race/ethnicity, and weekly allowance) and accounted for clustering of students by school. All analyses were stratified by sex given the previous studies suggesting that these behaviours vary greatly by sex [13]. Sex \times e-cigarette use and sex \times cigarette smoking interaction terms were tested for each outcome and yielded statistical significance ($p < .001$), indicating that sex is an important effect modifier. Statistical significance alpha level was set at $p < .05$; however, the interpretation was focused on statistical significance of $p < .001$ as well as odds ratios (OR) and 95% confidence intervals (95% CI) given the large sample size. IBM SPSS v25.0 (Armonk, NY) was used for all analyses.

3. Results

Compared to those excluded ($n = 10,805$), the included sample ($n = 55,629$) had more females, more white participants, and younger age groups, and had more spending money per week than those excluded ($p < .001$). Table 2 describes the characteristics of the total sample and sample stratified by sex. More males than females reported e-cigarette use (40.0% vs 31.3%) and cigarette smoking (4.4% vs 2.9%). Also, more males (4.1%) than females (2.5%) reported dual use of both cigarettes and e-cigarettes. A larger proportion of males participated in sports as compared to females. Further, more males than females met the MVPA (46.5% vs 31.2%) and MSE recommendations (51.9% vs 42.4%). However, more females (6.1%) met the ST recommendation than males (4.1%).

Table 3 illustrates sex differences in the key study variables after controlling for covariates. Male adolescents were more likely to meet MVPA (OR:1.92; 95% CI:1.86–1.98) and MSE (OR:1.47; 95% CI:1.42–1.52) recommendations, but less likely to meet the ST recommendation (OR:0.68; 95% CI:0.64–0.74) than their female counterparts. Male adolescents were also more likely to engage in intramurals (OR:1.20; 95% CI:1.16–1.24),

Table 2

Sample characteristics in the total sample and by sex among Canadian adolescents (12–17 years)—2017–2018 COMPASS ($n = 55,629$).

	Prevalence, %			χ^2	<i>p</i> -value
	Total	Female	Male		
Age (years)					
14 or younger	30.1	30.6	29.4	8.691**	0.003
15	25.6	25.1	26.1	6.539*	0.011
16	25.2	25.3	25.1	0.156	0.692
17	19.1	19.0	19.4	1.068	0.301
Sex					
Female	51.1	–	–	–	–
Male	48.9	–	–	–	–
Race/ethnicity					
European Caucasian, white	74.8	75.8	73.8	30.373***	< 0.001
Ethnic minority, non-white	25.2	24.2	26.2		
Spending money (\$/week)					
Zero	16.1	14.3	18.0	142.004***	< 0.001
1–5	6.0	6.2	5.7	7.713**	0.005
6–10	7.2	7.2	7.3	0.242	0.623
11–20	12.7	13.0	12.5	3.299	0.069
21–40	11.2	11.5	10.9	3.804	0.051
41–100	12.6	13.9	11.3	80.683***	< 0.001
>100	17.6	16.2	18.8	83.103***	< 0.001
I do not know how much money I get each week	15.9	17.2	14.4	82.414***	< 0.001
Not stated	0.6	0.5	0.7	5.910*	0.015
Exposure					
Current E-cigarette use	35.6	31.3	40.0	465.267***	< 0.001
Cigarette use					
No	95.7	96.5	94.9	91.958***	< 0.001
Current	3.6	2.9	4.4	88.063***	< 0.001
Former	0.6	0.6	0.7	5.247*	0.022
Dual use	3.2	2.5	4.1	114.637***	< 0.001
Outcome					
Meeting physical activity and screen time recommendations within the Canadian 24-h Movement Guidelines					
MVPA (≥ 60 min/d)	38.7	31.2	46.5	1368.369***	< 0.001
MSE (≥ 3 time/wk)	47.0	42.4	51.9	508.476***	< 0.001
Screen time (≤ 2 h/d)	5.1	6.1	4.1	106.937***	< 0.001
Sport Participation					
Intramurals (yes)	36.2	34.1	38.3	104.325***	< 0.001
Competitive/team sports within school (yes)	35.4	32.0	39.1	307.316***	< 0.001
Competitive/team sports outside of school (yes)	42.1	37.9	46.6	434.018***	< 0.001

Abbreviations: MVPA = Moderate- to vigorous-intensity physical activity, MSE = Muscular strengthening exercises.

* $p < .05$, ** $p < .01$, *** $p < .001$.

competitive sports outside school (OR:1.46; 95% CI:1.41–1.50), and competitive sports at school (OR:1.38; 95% CI:1.34–1.43).

Among females (Table 3, Females only), those who reported e-cigarette use were more likely to meet the MVPA recommendation (OR:1.11, 95% CI:1.05–1.17), the MSE recommendation (OR: 1.13, 95%CI: 1.07–1.19), or participate in competitive team sports at school (OR:1.10, 95% CI:1.04–1.16), but less likely to meet the ST recommendation (OR: 0.38, 95%CI:0.33–0.44) or participate in intramurals (OR:0.89, 95% CI:0.84–0.94) relative to females who did not use e-cigarettes. Female adolescents who currently smoke were less likely to participate in intramurals (OR:0.47, 95%CI:0.32–0.70), competitive team sports in school (OR:0.54, 95%CI:0.37–0.79), or competitive team sports outside of school (OR:0.62, 95%CI:0.43–0.89) relative to those who do not smoke. Female adolescents who smoked previously were more likely to meet the MSE recommendation (OR:1.67, 95%CI:1.18–2.37) or participate in competitive team sports at school (OR:1.62, 95%CI:1.05–2.50) relative to those who never smoked.

Among males (Table 3, Males only), those who reported e-cigarette use were more likely to meet the MVPA recommendation (OR:1.43, 95% CI:1.36–1.51), the MSE recommendation (OR:1.39, 95%CI:1.32–1.46), or more likely to participate in intramurals (OR:1.08, 95%CI:1.03–1.14),

Table 3Sex-stratified associations between e-cigarette and cigarette use, meeting physical activity and sedentary behaviour recommendations, and sport participation among Canadian adolescents (12–17 years)—2017–2018 COMPASS ($n = 55,629$).

Variables	Meeting Canadian physical activity and screen time recommendations within the 24-h Movement Guidelines			Sport participation		
	MVPA (≥ 60 min/d)	MSE (≥ 3 time/wk)	Screen time (≤ 2 h/d)	Intramurals	Competitive team sports within school	Competitive team sports outside of school
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex						
Female ($n = 28,430$)	1.00 (reference)	1.00	1.00	1.00	1.00	1.00
Male ($n = 27,199$)	1.92 (1.86–1.98)***	1.47 (1.42–1.52)***	0.68 (0.64–0.74)***	1.20 (1.16–1.24)***	1.38 (1.34–1.43)***	1.46 (1.41–1.50)***
Females only						
E-cigarette use						
No	1.00 (reference)	1.00	1.00	1.00	1.00	1.00
Yes	1.11 (1.05–1.17)***	1.13 (1.07–1.19)***	0.38 (0.33–0.44)***	0.89 (0.84–0.94)***	1.10 (1.04–1.16)**	1.00 (0.94–1.05)
Cigarette smoking						
Not smoking	1.00 (reference)	1.00	1.00	1.00	1.00	1.00
Currently smoking	0.96 (0.68–1.35)	1.08 (0.78–1.48)	0.56 (0.23–1.37)	0.47 (0.32–0.70)***	0.54 (0.37–0.79)**	0.62 (0.43–0.89)**
Former smoking	0.86 (0.59–1.25)	1.67 (1.18–2.37)**	2.67 (0.90–7.94)	1.56 (1.00–2.41)	1.62 (1.05–2.50)*	1.37 (0.92–2.04)
Males only						
E-cigarette use						
No	1.00 (reference)	1.00	1.00	1.00	1.00	1.00
Yes	1.43 (1.36–1.51)***	1.39 (1.32–1.46)***	0.57 (0.49–0.65)***	1.08 (1.03–1.14)**	1.31 (1.24–1.38)***	1.32 (1.26–1.39)***
Cigarette smoking						
Not smoking	1.00 (reference)	1.00	1.00	1.00	1.00	1.00
Currently smoking	1.41 (1.06–1.88)*	0.98 (0.75–1.33)	0.75 (0.31–1.84)	0.71 (0.52–0.97)*	0.82 (0.61–1.10)	0.78 (0.58–1.04)
Former smoking	0.98 (0.72–1.33)	1.00 (0.74–1.36)	0.75 (0.29–1.93)	1.21 (0.87–1.69)	1.13 (0.82–1.55)	1.06 (0.77–1.45)

Abbreviations: OR = Odds ratio, CI = Confidence interval.

Note: All analyses were adjusted for age, race/ethnicity, and spending money (\$/week).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

competitive sports at school (OR:1.31, 95%CI:1.24–1.38) or competitive sports outside of school (OR:1.32, 95%CI:1.26–1.39), but less likely to meet the ST recommendation (OR:0.57, 95%CI:0.49–0.65). Male adolescents who reported that they are currently smoking were more likely to meet the MVPA recommendation (OR:1.41, 95%CI:1.06–1.88) but less likely to participate in intramurals (OR:0.71, 95%CI:0.52–0.97) relative to those who do not smoke. Former smoking status was not associated with any of the outcome variables.

4. Discussion

This study investigated associations between e-cigarette use, cigarette smoking, physical activity (including sport participation), and sedentary behaviour among a sample of Canadian adolescents. The findings of this study support the findings of previous literature using the most recent data and build on the evidence for gendered associations. The most pronounced associations (moderate strength) were observed between e-cigarette use and not meeting the ST recommendation in both sexes and the current cigarette smoking status and not participating in sport of any types among females only. This study also found gendered associations between e-cigarette use, cigarette smoking, sport participation, and meeting physical activity guidelines. Specifically, the associations between e-cigarette use and sport participation were largely mixed within the female sample, while among males, e-cigarette use was positively albeit weakly associated with all types of sport participation in a consistent manner. The associations between cigarette smoking and meeting PA recommendations were also largely mixed between male and female adolescents. In conjunction with the literature on how masculinity and femininity play a role in shaping health behaviours among adolescents [24–27], this study added to the literature in explaining how sex differences in health behaviours are also largely gendered.

Our descriptive results also reflect alarming patterns of health behaviours among Canadian adolescents. For example, 95% of adolescents did not meet the ST recommendation and the majority of adolescents did not meet the MVPA (61%) or MSE (53%) recommendations. This study also demonstrated a 33% decrease in the cigarette smoking prevalence and 260% increase in the e-cigarette smoking prevalence among Canadian adolescents within only a three-year period [13]. Though it is important to note that these changes were based on two different samples measured at different time-points, a temporal snapshot of e-cigarette and cigarette use among Canadian adolescents in the same geographical locations (i.e., Ontario, Alberta, Quebec, and British Columbia) provide timely evidence with the current progression towards Canada's legalization of e-cigarettes [3].

The inverse association between e-cigarette use and not meeting the ST recommendation was substantial in both sexes in our study. This is a pressing concern given the increasing prevalence of e-cigarette smoking among Canadian adolescents, compounded with the low prevalence of meeting the ST recommendation (5%) that were shown in our study. It is also noteworthy to mention that though females were more likely to meet the ST recommendation, the associations between e-cigarette use and not meeting the ST recommendation was stronger in female adolescents than their male counterparts. Based on these results, it is suggestive that e-cigarette use may tend to co-occur with high ST more than it does with low physical activity or sport participation, particularly among female adolescents. Common determinants of these two potentially synergistic behaviours should be identified to inform developing interventions to reduce ST among Canadian adolescents, while considering gender.

Another pronounced association observed in our study was between the current cigarette smoking status and sport participation of all types among female adolescents only. Combined with mixed and weak associations between e-cigarette use and sport participation among females versus weak, yet consistently positive associations among males, it is suggestive that

the patterns of e-cigarette use, cigarette smoking, and sport participation vary greatly by gender. Our findings support the results of the previous work [13] in which e-cigarette use was positively associated with sport participation among males only. In male adolescents, e-cigarette use and sport participation may go hand-in-hand given that both behaviours are known to be associated with masculinity and popularity [24,25]. E-cigarette advertisement messages typically include settings such as wilderness, outdoors, and sport [25] and employ masculinity frames, targeting those who want to be perceived as masculine []. These messages may be less appealing for female adolescents, who often times face different gender roles and expectations in the Western society broadly [27]; thus, cigarette smoking or e-cigarette use and sport participation may occur more exclusively from one another in female adolescents based on the patterns of their socialization. Similar gendered phenomenon was also reported in a study examining the associations between team sport culture and substance use behaviour among Canadian adolescents [9]. Furthermore, limited earlier evidence on vaping indicated that e-cigarette products are not compromising to sport performance; rather, it was perceived as ergogenic [29] to endurance [30] and muscular strength and power [31]. Perhaps this perception may have influenced male adolescents who participate in sports in a more profound way than it did for their female counterparts.

As for intramural sport specifically, interesting patterns were observed by males and females that are noteworthy to highlight. In male adolescents, current cigarette smoking was associated with a lower likelihood of participating in intramurals while in female adolescents, both e-cigarette use and cigarette smoking were negatively associated with participating in intramurals. Intramural sports are generally more inclusive than competitive sports [32] and have been suggested as an effective tool for smoking cessation among adolescents [11]. Perhaps participating in intramurals can be a viable alternative leisure and social activity to e-cigarette use or cigarette smoking for female adolescents and cigarette smoking for male adolescents in the Canadian context. A previous study among a national sample of US adolescents [12] also suggested the modest protective associations between participation in multiple sports and both traditional cigarette smoking and e-cigarette use. It is, however, important to note that these associations varied by different types of sports. For instance, playing soccer was associated with reduced risk of cigarette smoking but baseball/softball was associated with heightened e-cigarette use without a history of cigarette smoking. This further highlights the importance of investigating the associations between varying use of nicotine-based products and sport participation using longitudinal data, to strive towards ensuring healthy lives and promoting well-being among all adolescents, in accordance with the UN SDG #3 [19].

4.1. Strengths and limitations

While this study provides valuable information in understanding the risk behaviour profile of Canadian adolescents using the most up-to-date data, several limitations should be acknowledged. We used a cross-sectional study design and, therefore, directionality cannot be established. Given that the relationships between these behaviours can be bidirectional [11], better articulating the cause-effect relationship using longitudinal data is needed to develop effective behavioural modification strategies and interventions for adolescent health. For example, the positive associations between the former cigarette smoking status and certain types of physical activity were only shown among female adolescents with unknown directionality. Future longitudinal work is warranted to build on these findings. Our study relied on self-reported data and the results may be subject to different types of biases (e.g., recall bias, social desirability bias); thus, the results should be interpreted with caution. However, the COMPASS questionnaire has established validity and reliability [20–23]. We used smoking 100 cigarettes as the criterion to define current and former smoking status based on the literature [7,13,22] and the results may vary if we used different criteria. Finally, participants in the COMPASS questionnaire were asked to indicate if the level of physical activity they reported during previous week was considered “typical” or “atypical”.

Physical activity is a dynamic variable which can fluctuate on a day-to-day basis. Thus, we included adolescents who reported having atypical physical activity levels in the past week to account for natural fluctuations in health behaviours [33], as was done in previous studies [13].

5. Conclusion

In this study, the inverse association between e-cigarette use and not meeting the ST recommendation was substantial in both sexes. Moreover, the associations between e-cigarette use, cigarette smoking, and physical activity (sport participation in particular) were largely gendered, which highlights the importance of better understanding the potential role of gender in explaining the co-occurrence of risk behaviours during adolescence. Overall, the results highlight that targeted interventions may be required for those who use tobacco products to improve the behavioural profile of Canadian adolescents.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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