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Patterns of marijuana use and physical health indicators among Canadian youth

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We examine how trajectories of marijuana use in Canadian youth (ages 15 to 28) are related to physical health indicators in adolescence and young adulthood. Youth were initially recruited in 2003 ($N = 662$; 48% male; ages 12 to 18) and followed for six waves. Five trajectories of marijuana use (Abstainers-29%, Occasional users-27%, Decreasers-14%, Increases-20% and Chronic users-11%) were identified. Chronic users reported more physical symptoms, poorer physical self-concept, less physical activity, poorer eating practices, less sleep, and higher number of sexual partners during adolescence than other classes. Decreasers also reported poorer physical self-concept and poorer eating practices than abstainers. Other trajectory classes showed few significant health problems. Chronic users also reported more acute health problems (i.e. serious injuries, early sexual debut, higher number of sexual partners, greater likelihood of having a STI) in young adulthood than all other classes contributing to costs of healthcare. Youth who engage in early, frequent and continued use of marijuana from adolescence to young adulthood are at-risk of physical health problems in adolescence and young adulthood.

Keywords: Marijuana use; Physical health; Trajectories; Longitudinal design; Health behaviours; Adolescence; Young adulthood.

As movement towards legalisation of recreational marijuana use advances in Canada, healthcare providers will need to better understand how patterns of marijuana use are associated with health problems and health promotion efforts. Marijuana use in adolescence and young adulthood is of particular concern, as these age groups are associated with increased risk for harmful mental and physical health, and neurocognitive consequences (see Levine, Clemenza, Rynn, & Lieberman, 2017; Volkow, Baler, Compton, & Weiss, 2014). Use of marijuana is also prevalent among Canadian adolescents and young adults; approximately one in four adolescents (i.e. 28% ages 11 to 15 and 22% ages 15 to 19) and young adults (i.e. 26% ages 20 to 24; Statistics Canada, 2015; UNICEF, 2013) report using marijuana in the past year. Research suggests approximately 5% of Canadian and 3% of

American youth will develop a cannabis use disorder (i.e. addiction) and the likelihood of developing a cannabis use disorder triples for those who start using in adolescence (Center for Behavioural Health Statistics and Quality, 2016; George & Vaccarino, 2015). Given the debilitating effects of marijuana use on relationships and academic and occupational outcomes (Thompson, Leadbeater, Ames, & Merrin, 2018a; Brook, Chensu, Leakefeld, & Brook, 2016; Brook, Lee, Brown, Finch, & Brook, 2011), it is likely that many of these youth will come to the attention of primary healthcare and mental health professionals. An awareness of the physical health profile and problems of these youth may also contribute to the effectiveness of their treatment plans. For example, the use of marijuana for sleep or pain treatment may undermine motivation to reduce use. However, little research

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has investigated the associations between marijuana use and physical health in adolescents and young adults.

Research shows many young people perceive marijuana as safe and a viable treatment of physical health complaints (Chabrol, Beck, & Laconi, 2017; McKiernan & Fleming, 2017). However, the association between marijuana use with various indicators of health in these early age groups remains unclear. Past research has focused mainly on young adults using cross-sectional data. Findings from these studies show significant associations between marijuana use and reports of poorer overall subjective health (Arria et al., 2016; Ellickson, Martino, & Collins, 2004), lower engagement in health-promoting behaviours (Rodondi, Pletcher, Liu, Hulley, & Sidney, 2006; Terry-McElrath & O'Malley, 2011; Whitehurst, Fogler, Hall, Hartmann, & Dyche, 2015), and more sexual risk behaviours (Patrick, O'Malley, Johnston, Terry-McElrath, & Schulenberg, 2012). Associations between marijuana use and cardiometabolic risks such as body mass index (BMI) are typically not significant (Arria, Caldeira, Bugbee, Vincent, & O'Grady, 2016; Bechtold, Simpson, White, & Pardini, 2015; Rodondi et al., 2006). Associations between marijuana use and having a serious injury are inconsistent (Arria et al., 2016; Bechtold et al., 2015).

Physical health is a multi-component construct that refers to health complaints and acute health concerns (notably injuries), but also includes lifestyle choices like commitments to physical activity and nutritious diets. Adolescence and young adulthood are periods when healthy lifestyles and health behaviours are typically established and high risk patterns of marijuana use may reduce motivation for these health choices. We extend past research by examining several physical health indicators in adolescence and young adulthood for youth following different marijuana use trajectories, assessed from ages 15 to 28. In examining young adult health, we account for baseline (i.e. adolescent) health assessments in our models to examine whether health problems are limited to adolescence or continue and persist (i.e. worsen) into young adulthood, allowing us to identify salient periods to target interventions.

MARIJUANA USE AND PHYSICAL HEALTH

Research suggests marijuana use may have harmful health consequences and these effects may be most deleterious for those who start early (i.e. in adolescence) and use regularly (Hall, 2015; Volkow et al., 2014). Findings from studies on young adult physical health show differences on ratings of overall subjective health across marijuana use trajectories (Arria et al., 2016; Ellickson et al., 2004). For example, Ellickson et al. (2004) found "early high users" of marijuana reported lower levels of overall health at age 29 than lower risk groups. Arria et al.

(2016) found significant differences between marijuana use trajectories and overall health at age 30; but post-hoc analyses showed no significant differences between the higher risk groups (e.g. chronic, late-increase) and the non-use group. In adolescence and young adulthood, overall health is typically rated as "good" and range may be limited (Eriksson, Unden, & Elofsson, 2001). More specific assessments of physical symptoms may be needed to further examine individual differences. In this study, we include subjective assessments of physical symptoms (i.e. backaches, headaches, stomachaches and dizziness) as well as a measure of physical self-concept that includes a composite of overall health, body satisfaction, and perceptions of physical capabilities (Hager & Leadbeater, 2016), which develops in adolescence and may impact feeling well, as well as engagement in health behaviours (Babic et al., 2014).

Early adoption of health-promoting behaviours can influence subjective health, self-concept, and healthy lifestyle choices (Babic et al., 2014; Nelson et al., 2008; Sawyer et al., 2012); yet, health-promoting behaviours (e.g. physical activity, sleep; Ames, Leadbeater, & MacDonald, 2018; Ames, Holfeld, & Leadbeater, 2016; Duncan et al., 2007; Maslowsky & Ozer, 2014) show significant declines in these age periods. Trajectories of marijuana use may be related to these behaviours; however, the association has not been well studied. Terry-McElrath and O'Malley (2011) found associations between higher initial levels and increases in physical activity with lower marijuana use in young adulthood. Cross-sectional research with college students and adults indicate marijuana use is associated with daytime sleepiness (Gillin & Drummond, 2000), but not sleep duration (Whitehurst et al., 2015). Longitudinal studies show no differences in marijuana use trajectories related to BMI in young adulthood (Arria et al., 2016; Bechtold et al., 2015; Rodondi et al., 2006).

In terms of acute health risks, research shows injury rates among adolescents are higher than any other age group (Billette & Janz, 2015) and represent a significant personal and economic burden (Leadbeater, Babul, Jansson, Scime, & Pike, 2010). Arria et al. (2016) found marijuana groups were related to the number of days college students reported being limited in their usual activities due to an accident or injury; however, others have found no differences between marijuana trajectories and past year injury (Bechtold et al., 2015). Finally, research with young adults shows associations between marijuana use and sexual risk behaviours (Patrick et al., 2012).

PATTERNS OF MARIJUANA USE

Longitudinal research using person-centred approaches (i.e. latent class growth curve analyses; LCGA) has identified typically four to six distinct classes of marijuana use

that vary with regard to age of onset, frequency and duration of use over time (e.g. Bechtold et al., 2015; Brook et al., 2011; Caldeira et al., 2012; Ellickson et al., 2004; Epstein et al., 2015; Schulenberg et al., 2005). In general, findings show youth classified into high risk trajectories (e.g. chronic; early onset, high levels of use) demonstrate poorer educational and economic attainment, higher levels of comorbid substance use and more mental health problems compared to non-users (e.g. abstainers; Thompson et al., 2018a; Thompson, Merrin, Ames, & Leadbeater, 2018b; Brook et al., 2011; Caldeira et al., 2012; Ellickson et al., 2004; Epstein et al., 2015; Schulenberg et al., 2005). Studying longitudinal patterns or trajectories of marijuana use allows us to better understand the extent to which high risk use patterns are more vulnerable and may require targeted prevention efforts.

Research with the current sample (Thompson et al., 2018b) previously identified five marijuana use trajectories (see Table 1 and Figure 1) including: *Abstainers* ($n = 183$; 29%) who never used marijuana in the past year; *Occasional users* ($n = 172$; 27%) who started as abstainers and increased use to a “few times a year” by age 17; *Decreasers* ($n = 89$; 14%) who used marijuana a few times per month by age 15 and decreased to less than a few times per year by age 23; *Increasers* ($n = 127$; 20%) who used a few times per year by age 15 and increased rapidly, peaking to using more than once per week by age 22; and, *Chronic users* ($n = 69$; 11%) who used marijuana more than once per week across all ages. Chronic users were more likely to be male, had more behavioural problems and use of other substances, higher frequency of driving risks and more depressive symptoms as young adults (Leadbeater et al., 2017; Thompson et al., 2018b). Over half of the Chronic users (59%) met diagnostic criteria for cannabis use disorder. Decreasers reported more depressive symptoms than Chronic users in adolescence and less co-use of other substances in young adulthood. Increasers were similar to Chronic users in young adulthood, but had higher illicit drug user and lower levels of depressive and behavioural symptoms. Moreover, both Chronic users and Increasers also had lower educational and occupational achievement compared in young adulthood and Chronic users reported more debt and delaying medical attention for financial reasons (Thompson et al., 2018a). Co-use of alcohol was high in all classes (Leadbeater et al., 2017; Thompson et al., 2018b).

The present study

The current study adds to our growing understanding of the health of Canadian youth with differing marijuana use trajectories by examining how marijuana use frequency is related to physical health indicators in adolescence and young adulthood. We extend past research by examining how trajectories of marijuana use are

related to multiple physical health indicators; subjective health, health-promoting behaviours, body mass index, serious injuries and sexual risk behaviours. By accounting for baseline levels of health indicators in young adult models, we can identify whether health problems are time-limited, or endure and worsen over time.

METHOD

Participants and procedure

The Victoria Health Youth Survey (V-HYS) collected data from 662 participants (48% male) six times from 2003 to 2013 (see Leadbeater, Thompson, & Gruppuso, 2012 for full study details). In brief, the majority of participants identified as Caucasian (85%) and the sample is representative of diverse socioeconomic classes. Households ($n = 1036$) with an eligible youth (ages 12 to 18) were identified from a random sample of 9500 telephone listings; 662 youth and their parents provided written consent to participate. At each wave, trained interviewers assessed participants through individual interviews; however, sensitive items (e.g. substance use, sexual behaviours) were self-administered to enhance privacy and increase responding. Retention rates were high: 87% (T2), 81% (T3), 69% (T4), 70% (T5) and 72% (T6). The university's research ethics board approved the research protocol at each wave.

Attrition analyses compared youth who remained in the study by T6 ($n = 478$) and those who did not have data ($n = 184$) on T1 demographic and study variables. Participants who remained in the study were more likely to be female ($\chi^2(1, 662) = 8.77, p = .003$) and had slightly higher T1 socioeconomic status (SES; $M = 6.73, SD = 1.66$), $F(1, 636) = 19.39, p < .001$, compared to non-participants ($M = 6.05, SD = 1.94$). On study variables, participants who remained in the study reported healthier eating practices at T1 ($M = 5.29, SD = 2.25$), $F(1, 657) = 7.07, p = .008$, compared to non-participants ($M = 4.76, SD = 2.47$). No other differences were significant.

Measures

Marijuana use frequency

Youth were asked “How often did you use marijuana in the past 12 months?” Responses were coded as 0 = *never*, 1 = *a few times a year*, 2 = *a few times a month*, 3 = *once a week* and 4 = *more than once a week*.

Subjective health

Physical symptoms were assessed using four items from the Health Behavior in School-Aged Children scale

TABLE 1
Means and standard deviations of covariates and physical health variables by marijuana use class

	<i>Abstainers</i> (<i>n</i> = 183; 29%) Mean (SD) or <i>n</i> (%)	<i>Occasional</i> (<i>n</i> = 172; 27%) Mean (SD) or <i>n</i> (%)	<i>Decreasers</i> (<i>n</i> = 89; 14%) Mean (SD) or <i>n</i> (%)	<i>Increases</i> (<i>n</i> = 127; 20%) Mean (SD) or <i>n</i> (%)	<i>Chronic</i> (<i>n</i> = 69; 11%) Mean (SD) or <i>n</i> (%)
Covariates (T1)					
Sex					
Male	74 (40%)	72 (42%)	42 (47%)	78 (61%)	41 (59%)
Female	109 (60%)	100 (58%)	47 (53%)	49 (39%)	28 (41%)
Age	15.09 (1.91)	14.97 (1.89)	15.12 (2.06)	15.28 (1.79)	15.10 (1.87)
SES	6.66 (1.69)	6.75 (1.63)	6.64 (1.76)	6.56 (1.82)	6.00 (1.85)
Characteristics of marijuana use^a					
Average age of onset	17.07 (2.68)	16.56 (2.53)	14.37 (1.76)	15.11 (1.65)	13.28 (1.98)
Frequency of marijuana use at T1 (ages 12 to 18)					
<i>Never</i>	170 (93%)	123 (72%)	33 (37%)	62 (49%)	19 (28%)
<i>A few times per year</i>	9 (5%)	42 (24%)	25 (28%)	28 (22%)	3 (4%)
<i>A few times per month</i>	4 (2%)	5 (3%)	20 (23%)	23 (18%)	7 (10%)
<i>Once a week</i>	0 (0%)	0 (0%)	4 (5%)	5 (4%)	6 (9%)
<i>More than once per week</i>	0 (0%)	2 (1%)	7 (8%)	9 (7%)	34 (49%)
Frequency of marijuana use at T6 (ages 22 to 29)					
<i>Never</i>	130 (95%)	28 (21%)	49 (78%)	6 (6%)	1 (2%)
<i>A few times per year</i>	7 (5%)	70 (53%)	13 (21%)	23 (25%)	3 (7%)
<i>A few times per month</i>	0 (0%)	21 (16%)	1 (2%)	16 (17%)	3 (7%)
<i>Once a week</i>	0 (0%)	5 (4%)	0 (0%)	13 (14%)	6 (13%)
<i>More than once per week</i>	0 (0%)	9 (7%)	0 (0%)	36 (38%)	32 (71%)
Quantity of use at T6 ^b (ages 22 to 29)	.04 (.23)	.55 (.73)	.17 (.40)	1.27 (1.12)	2.60 (2.33)
% Cannabis use disorder ^b at T6 (ages 22 to 29)	0 (0%)	17 (13%)	0 (0%)	30 (32%)	26 (59%)
Health in adolescence (T1; ages 12 to 18)					
<i>Subjective health</i>					
Physical symptoms	5.32 (2.78)	5.68 (3.09)	5.89 (2.94)	5.50 (2.99)	6.78 (3.04)
Physical self-concept	18.35 (4.06)	17.71 (4.33)	16.96 (4.27)	18.19 (3.66)	16.92 (3.65)
<i>Health-promoting behaviours</i>					
Physical activity	4.09 (1.95)	4.09 (1.94)	3.91 (1.83)	4.34 (1.74)	3.73 (1.83)
Healthy eating practices	5.66 (2.24)	5.25 (2.28)	4.89 (2.43)	4.95 (2.45)	4.13 (2.13)
Sleep duration	8.21 (1.25)	8.20 (1.09)	8.03 (1.53)	8.27 (1.42)	7.91 (1.37)
<i>Body mass index (kg/m²)</i>					
Body mass index	21.58 (3.51)	20.61 (2.87)	21.64 (3.44)	21.47 (2.92)	21.75 (3.77)
<i>Serious injuries</i>					
Number of serious injuries (past 12 months)	.62 (.93)	.62 (.93)	.75 (.93)	.72 (1.01)	.93 (1.16)
No injuries	111 (61%)	106 (62%)	46 (52%)	76 (60%)	37 (54%)
One injury	45 (25%)	39 (23%)	25 (28%)	21 (17%)	11 (16%)
Two injuries	12 (7%)	14 (8%)	12 (14%)	19 (15%)	10 (15%)
Three or more injuries	15 (8%)	13 (8%)	6 (7%)	11 (9%)	11 (16%)
<i>Sexual risk behaviours</i>					
Number of sexual partners	.47 (1.19)	.67 (1.21)	1.37 (1.74)	1.38 (1.66)	2.15 (2.08)
Health in young adulthood (T6; ages 22 to 29)					
<i>Subjective health</i>					
Physical symptoms	5.57 (2.95)	6.19 (2.66)	5.76 (3.17)	5.71 (2.75)	8.11 (2.76)
Physical self-concept	19.46 (5.52)	17.80 (6.41)	19.27 (5.04)	19.79 (5.97)	17.21 (6.91)
<i>Health-promoting behaviours</i>					
Physical activity	3.15 (2.05)	3.13 (2.08)	3.39 (1.74)	3.22 (1.97)	2.04 (1.58)
Healthy eating practices	6.64 (2.21)	6.08 (2.17)	6.82 (2.15)	6.30 (2.61)	6.00 (2.22)
Sleep duration	7.12 (1.10)	7.01 (1.07)	7.01 (1.27)	7.03 (1.16)	7.28 (1.23)
<i>Body mass index (kg/m²)</i>					
Body mass index	25.02 (5.15)	24.98 (4.68)	25.20 (5.06)	25.05 (4.57)	25.15 (5.46)
% Underweight/normal weight	79 (59%)	75 (57%)	38 (58%)	53 (58%)	25 (56%)
% Overweight	36 (27%)	43 (33%)	21 (32%)	27 (29%)	13 (29%)
% Obese	20 (15%)	14 (11%)	7 (11%)	12 (13%)	7 (16%)
<i>Serious injuries</i>					
Number of serious injuries (past 12 months)	.26 (.53)	.31 (.54)	.36 (.69)	.32 (.63)	.59 (.81)
No injuries	107 (78%)	98 (73%)	49 (74%)	71 (76%)	26 (57%)

TABLE 1
continued

	<i>Abstainers</i> (<i>n</i> = 183; 29%) Mean (SD) or <i>n</i> (%)	<i>Occasional</i> (<i>n</i> = 172; 27%) Mean (SD) or <i>n</i> (%)	<i>Decreasers</i> (<i>n</i> = 89; 14%) Mean (SD) or <i>n</i> (%)	<i>Increasesers</i> (<i>n</i> = 127; 20%) Mean (SD) or <i>n</i> (%)	<i>Chronic</i> (<i>n</i> = 69; 11%) Mean (SD) or <i>n</i> (%)
One injury	26 (19%)	32 (24%)	11 (17%)	17 (18%)	15 (33%)
Two injuries	3 (2%)	5 (4%)	5 (8%)	5 (5%)	3 (7%)
Three or more injuries	1 (1%)	0 (0%)	1 (2%)	1 (1%)	2 (4%)
<i>Sexual risk behaviours</i>					
Early sexual debut (<15 years)	8 (5%)	15 (9%)	13 (16%)	22 (18%)	30 (44%)
Number of sexual partners (lifetime)	3.06 (2.10)	4.75 (1.77)	5.33 (1.70)	5.57 (1.49)	5.93 (1.26)
Ever had a STI (<i>n</i> = 136)	22 (14%)	37 (22%)	21 (25%)	29 (24%)	27 (40%)

Note: Participants were classified into weight categories for descriptive purposes based on body mass index (BMI): underweight/normal weight (BMI < 25 kg/m²), overweight (25 kg/m² ≤ BMI < 30 kg/m²) or obese (BMI ≥ 30 kg/m²). Waist circumference cut-off is ≥102 cm for males and ≥ 88 cm for females (Statistics Canada, 2015). STI = sexually transmitted disease.

^aPlease also see Thompson, 2018a, b for further details. ^bQuantity of use is based on the following item: “During the last 3 months, on a day when you used marijuana, cannabis or hashish roughly how many joints did you usually have in that day? (Count 10 puffs, 5 bong or pipe hits or 1/2 gram as equivalent to one joint)” (Zeisser et al., 2012). Cannabis use disorder is based on DSM-5 (APA, 2013; Sheenan et al., 1994) criteria (see also Thompson et al., 2018b). **p* < .05, ***p* < .01, ****p* < .001.

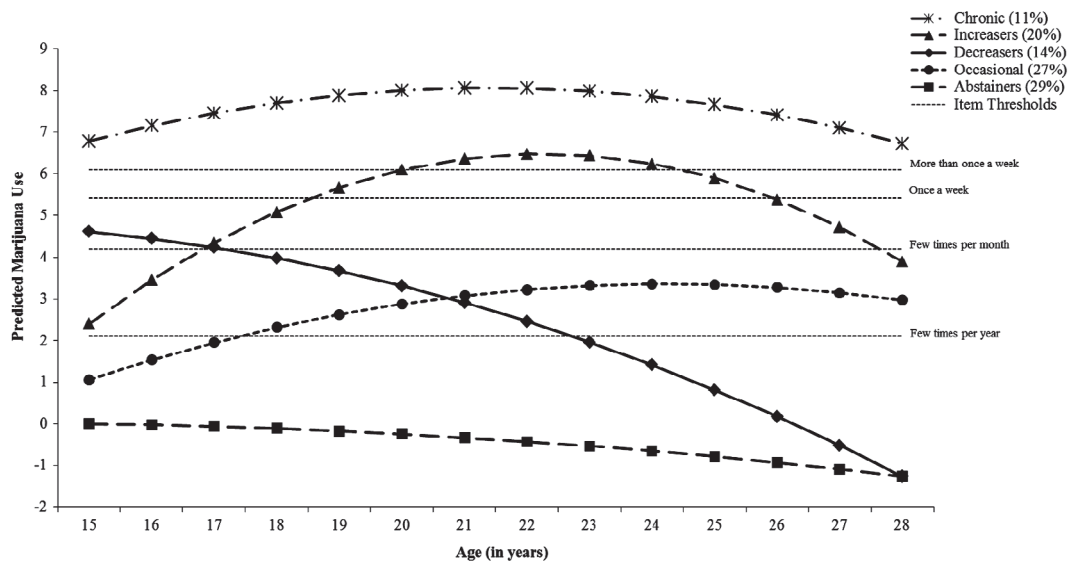


Figure 1. Marijuana use trajectories from ages 15 to 28. Because the log-odds trajectories are on arbitrary scales, the estimated thresholds that divide the categories of observed data are shown as dashed lines to facilitate interpretation. Source: Thompson et al., 2018b.

(Aarø, Wold, Kannas, & Rimpelä, 1986). Participants rated how often they experienced headaches, abdominal pain, backaches and dizziness in the past 6 months on a 0 (*never*) to 5 (*about every day*) scale. One item tapping sleep difficulties was removed from the physical symptoms measure to avoid overlap with health-promoting behaviours. Items were summed with higher scores indicating more physical symptoms (T1 to T6 α 's ranged from .55 to .65).

Physical self-concept was constructed from self-evaluations of (a) overall physical health (one item; “How often do you notice you are physically healthy?”); (b) appearance (four items; “How satisfied are you with each of the following aspects of your body?

Face, muscle, height, and weight”); and (c) physical development and abilities (nine items; e.g. “I am proud of my body”). Items were summed with higher scores indicating more positive physical self-concept (T1 to T6 α 's ranged from .80 to .85). Confirmatory factor analysis supported the latent structure of the physical self-concept scale in a previous study with the current sample (Hager & Leadbeater, 2016).

Health-promoting behaviours

Physical activity was assessed using three items adapted from Gillis’ (Gillis, 1997) Adolescent Lifestyle Questionnaire (ALQ; e.g. “In an average week, I exercise

three to four times (e.g. running, swimming, other sports”). *Healthy eating practices* were assessed using five items (e.g. “I usually limit my intake of ‘junk food’ for snacks”) adapted from the ALQ. Responses were coded on a three-point scale (0 = *never*, 1 = *sometimes*, 2 = *always*). Measurement invariance across time for physical activity and healthy eating practices was previously reported (Ames, Leadbeater, & MacDonald, 2018). Items were summed; higher scores reflect higher levels of physical activity (T1 to T6 α 's ranged from .74 to .83) and healthier eating practices (T1 to T6 α 's ranged from .72 to .80). Participants reported the average number of hours of *sleep* they attain each night.

Body mass index

At T1, *body mass index (BMI)* was computed using self-reported height and weight. Research supports the validity of adolescent self-reported height and weight (Vaughan & Halpern, 2010). Standardised measurements of height and weight were collected at T6 by the interviewers.

Serious injuries

Participants were asked “In the past 12 months, did you have an injury (such as broken bones, bad cuts or sprains) that was serious enough to limit your normal daily activities?” and, if yes, were asked “How many times were you seriously injured (in the past 12 months)?” The *number of serious injuries* was coded on a scale ranging from 0 (*no injuries*) to 3 (*three or more injuries*).

Sexual risk behaviours

Responses to “Have you ever had sex? (adding that by ‘sex,’ we mean vaginal, oral, or anal sex)” were coded “*yes*” or “*no*.” If yes, participants were also asked their age the first time they had sex. *Early sexual debut* was coded as 1 < 15 years and 0 \geq 15 years; Vasilenko, Kugler, Butera, & Lanza, 2015). *Number of sexual partners* (i.e. “How many different people have you ever had sex with?”) was coded as 0 = *none*, 1 = *one*, 2 = *two*, 3 = *three*, 4 = *four*, 5 = *5–10*, 6 = *11–20*, 7 = *21–100*, 8 = *more than 100* (Patrick et al., 2012). Participants responses to “Have you ever been told by a doctor or nurse that you had a sexually transmitted infection (STI)?” were coded as 1 = *yes* or 0 = *no*.

Covariates

Participants reported their sex and age. Participants provided information on their parent(s)’ occupation which was coded from 1 to 9 using the Hollingshead Occupational Status Scale (Bornstein, Hahn, Suwalsky,

& Haynes, 2003). Additional analyses accounted for alcohol use assessed by *heavy episodic drinking (HED)*; participants indicated how often they had five or more drinks in the past year on a 5-point scale (0 = *never*, 1 = *a few times a year*, 2 = *a few times a month*, 3 = *once a week* and 4 = *more than once a week*). The definition of a standard drink was provided.

Plan for analyses

Trajectories of marijuana use from ages 15 to 28 were identified using latent class growth analysis (Figure 1; Thompson et al., 2018b). Multinomial logistic regression was used to assess adolescent (T1; ages 12 to 18) correlates of trajectory class membership and linear regression was used to examine young adulthood (T6; ages 22 to 29) correlates of marijuana use trajectories. We used a three-step approach that adjusts for uncertainty in class membership (Asparouhov & Muthén, 2014). Variables were entered into models grouped by subjective health, health-promoting behaviours, body mass index, number of serious injuries and sexual risk behaviours. Sex, age at T1 centred and SES were included as covariates and respective T1 assessments (e.g. T1 BMI was entered when examining T6 BMI) were also included in young adult (T6) models. Models were fit with Mplus version 7.3 (Muthén & Muthén, 2007) using full information maximum likelihood (FIML) to address missing data. We address any non-normality by using the robust maximum likelihood estimator (MLR) that adjusts estimated standard errors (Muthén & Muthén, 2007).

RESULTS

Table 1 presents the means, standard deviations or frequencies for study variables across marijuana trajectory classes.

Marijuana trajectory class differences in adolescent health indicators

Adolescent (T1; ages 12 to 18) findings are summarised in Table 2. Chronic users reported more physical symptoms than all other classes. Chronic users and Decreasers reported poorer physical self-concept in adolescence than Abstainers; Decreasers also reported poorer physical self-concept than Increasesers. Chronic users reported less physical activity than Increasesers. Chronic users also reported poorer eating practices and sleep than Abstainers, Occasional users, and Increasesers. Decreasers reported poorer eating practices than Abstainers. Occasional users had lower levels of BMI than all other classes. Class differences were not significant for serious injuries. Chronic users and Increasesers reported more

sexual partners than Abstainers and Occasional users and Decreasers reported more sexual partners than Occasional users. Given the high rates of heavy episodic drinking (HED) in this sample (Leadbeater et al., 2017; Thompson et al., 2018b), models were re-examined with adolescent HED as an additional covariate (Table S1, Supporting information). Findings were similar for subjective health, physical activity, eating practices, BMI and sexual risk behaviours. Differences in sleep were no longer evident after accounting for HED.

Marijuana trajectory class differences in young adult health indicators

Young adult (T6; ages 22 to 29) findings are summarised in Table 3. Chronic users reported more physical symptoms than all other classes. Class differences for physical self-concept were not significant, after accounting for adolescent levels. Chronic users participated in less physical activity than all other classes. No class differences were significant for healthy eating practices, sleep or body mass index. Chronic users reported more serious injuries than all other classes; Occasional users also reported more injuries than Increasesers. Chronic users had a greater likelihood of early sexual debut than all other classes. Abstainers reported fewer sexual partners than all other classes. Chronic users also had a greater likelihood of ever having a STI compared to Abstainers and Increasesers. Models were rerun with the addition of adolescent HED as a covariate and findings were largely consistent (Table S2).

DISCUSSION

Consistent with research on other social and behavioural outcomes related to marijuana use trajectories (Hall, 2009; Hall, 2015; Volkow et al., 2014), Chronic users in this study reported the most physical symptoms and had poorer indicators of healthy lifestyle choices in both adolescence and young adulthood, whereas other trajectory classes showed few significant health problems. Although causal relations are not established in this research, health problems in adolescence may contribute to the early onset and chronic use of marijuana if youth are using marijuana to treat health complaints and symptoms of pain (Chabrol et al., 2017; McKiernan & Fleming, 2017). We discuss the specific findings for adolescents and young adults in the following sections.

Marijuana use trajectory differences in adolescent health

The higher levels of physical symptoms observed for Chronic users in adolescence suggests that early users may begin using marijuana to treat pain (Chabrol

et al., 2017; McKiernan & Fleming, 2017), but the directionality of this association could not be determined as Chronic users were already using marijuana frequently at the initial wave. However, if Chronic users seek healthcare for their physical complaints, this could provide an opportunity for early identification of users and education. Longitudinal and qualitative research with younger samples could provide information about the aetiology and management of physical symptoms in adolescence and whether marijuana may be used for self-treatment. Education about the risks for addiction to marijuana and the availability of safer pain and stress relief strategies may be important for adolescents to reduce early experimentation with marijuana.

Chronic users reported poorer physical self-concept than Abstainers. Decreasers, like Chronic users, initiated marijuana use before age 15, and also reported poorer physical self-concept than Abstainers and Increasesers. Physical self-concept reflects feelings of health satisfaction and beliefs about physical competence and past research shows that youth with higher physical self-concept are less likely to engage in health-risk behaviours such as alcohol and cigarette use (Andrew, Tiggemann, & Clark, 2016) and more likely to engage in physical activity (Babic et al., 2014). Alternatively, early and heavy marijuana use may contribute to lack of motivation, inactivity and poor eating habits which in turn limit body satisfaction and perceived physical competence.

Our findings showing poorer health-promoting behaviours in Chronic users are consistent with past research (Smith et al., 2016; Terry-McElrath & O'Malley, 2011). In the current study, Chronic users reported less physical activity than Increasesers (who typically delay use until after age 15 and increase thereafter). Youth involved in individual or team sports may decline marijuana as part of their training goals. Engagement in vigorous physical activity in early adolescence may deter marijuana use or delay onset of use and reduce motivation to use marijuana by improving sleep and giving alternate outlets for stress (Terry-McElrath & O'Malley, 2011).

Chronic users and Decreasers also reported less healthy eating practices in adolescence than other classes and previous findings show heavy marijuana use is associated with poor eating habits (Smith et al., 2016) and increased appetite (Kirkham, 2009). Similar to research showing marijuana use alters sleep architecture in adolescence (Cohen-Zion et al., 2009; Smith et al., 2016), Chronic users reported sleeping fewer hours per night than all other classes (except Decreasers). In this study, sleep duration was not associated with marijuana use when concurrent alcohol use was accounted for and both substances can contribute to sleep difficulties (Cohen-Zion et al., 2009).

In adolescence, BMI was not related to marijuana use trajectories, except Occasional users had lower BMI than

TABLE 2
Marijuana trajectory class differences in adolescent (T1; ages 12 to 18) physical health indicators

	Occasional (<i>n</i> = 172; 27%)		Decreasers (<i>n</i> = 89; 14%)		Increasesers (<i>n</i> = 127; 20%)		Chronic (<i>n</i> = 69; 11%)		Pairwise comparisons
	Est. (SE)	OR	Est. (SE)	OR	Est. (SE)	OR	Est. (SE)	OR	<i>p</i> < .05
<i>Demographics</i>									
Sex (<i>Male</i> = 0)	-.02 (.29)	.98	-.18 (.36)	.84	-1.01** (.30)	.37	-.94* (.37)	.39	4, 5 < 1, 2; 4 < 3
Age	-.06 (.08)	.95	.03 (.11)	1.03	.09 (.07)	1.09	.03 (.09)	1.03	
SES	.04 (.08)	1.04	.00 (.11)	1.00	-.03 (.09)	.97	-.26** (.10)	.77	5 < 1, 2, 3
<i>Subjective health</i>									
Physical symptoms	.07 (.06)	1.07	.01 (.06)	1.01	.03 (.06)	1.03	.20*** (.06)	1.22	5 > 1, 2, 3, 4
Physical self-concept	-.03 (.04)	.97	-.12* (.05)	.89	-.01 (.04)	.99	-.09* (.04)	.92	3, 5 < 1; 3 < 4
<i>Health-promoting behaviours</i>									
Physical activity	-.03 (.09)	.97	-.06 (.10)	.94	.13 (.10)	1.14	-.07 (.09)	.93	5 < 4
Healthy eating practices	-.07 (.07)	.93	-.20 (.10)*	.82	-.12 (.07)	.89	-.31*** (.07)	.74	5 < 1, 2, 4; 3 < 1
Sleep duration	-.04 (.11)	.96	-.10 (.20)	.91	.07 (.14)	1.07	-.35* (.15)	.71	5 < 1, 2, 4
<i>Body mass index (kg/m²)</i>									
Body mass index	-.15** (.06)	.86	.003 (.06)	1.00	-.03 (.04)	.97	-.01 (.05)	.99	2 < 1, 3, 4, 5
<i>Serious injuries</i>									
Number of serious injuries (past 12 months)	-.03 (.15)	.97	.04 (.16)	1.04	.02 (.15)	1.02	.29 (.17)	1.34	
<i>Sexual risk behaviours</i>									
Number of sexual partners	.27 (.41)	1.31	.77 (.45)	2.17	.83* (.41)	2.29	1.09* (.43)	2.98	4, 5 > 1, 2; 3 > 2

Note: Abstainers (*n* = 183; 29%) trajectory is the reference. Models account for sex, T1 age centred, and SES. Sample sizes for each trajectory class are based on class assignment using the posterior probability of class membership.

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

all other classes. This single finding requires replication; however, Occasional users may be experimenting with marijuana use with peers, whereas youth who are overweight or obese may be stigmatised and excluded from these peer activities (Strauss & Pollack, 2003). Despite high rates of injuries in adolescence (Billette & Janz, 2015), serious injuries in adolescence were not related to marijuana use trajectories in this study. Injuries are frequently sustained in recreational sports (Billette & Janz, 2015; Leadbeater, Babul, Jansson, Scime, & Pike, 2010) and the lack of physical activity among marijuana users may reduce risks for sports injuries. Higher risk classes (i.e. Chronic users, Increasesers and Decreasers) also reported more sexual partners than lower risk classes (i.e. Abstainers, Occasional users) in adolescence.

Marijuana use trajectory differences in young adult health

In models assessing the effects of the marijuana use trajectories on young adult health, we controlled for adolescent levels for each health indicator. Hence, our findings indicate some health concerns among Chronic users persisted or worsened into young adulthood, beyond adolescent levels. Youth who chronically use marijuana may become tolerant to its effects and experience physical symptoms despite self-medication efforts. Marijuana use in young adults is also associated with lower academic achievement and occupational prestige (Thompson

et al., 2018a; Ringel, Ellickson, & Collins, 2006) and continued physical symptoms may be related to engagement in labor-intensive occupations (e.g. construction, factory work) or service positions (e.g. waitressing) that have substantial physical demands associated with chronic pain (Coenen et al., 2014). Future research into the occupational injuries of Chronic users is needed to inform motivation to reduce use and treatment strategies.

Chronic users also reported lower mean levels of physical self-concept than all other trajectory classes in young adulthood; however, these differences were not significant beyond adolescent levels. Physical self-concept may stabilise following adolescence, limiting the detection of further changes in young adulthood; however, poor physical self-concept may continue to limit perceived health and healthy lifestyle choices.

By young adulthood, Chronic users were less likely to engage in physical activity than all other classes. Poor physical self-concepts and declining physical activity in adolescence may set the stage for their lower physical activity in young adulthood. Trajectory class differences in healthy eating practices and sleep duration were not significant, and these health habits may be established in adolescence and change little into young adulthood. However, past studies using in-depth, quantitative diet histories showed marijuana use was associated with higher caloric intake in adulthood (Rodondi et al., 2006), suggesting methodological differences may contribute to our inconsistent findings. Past research found no differences between marijuana use and sleep time in an adult

TABLE 3

Adjusted means, standard errors, and probabilities of health outcomes by marijuana use trajectory in young adulthood (T6; ages 22 to 29)

	<i>Abstainers</i> (<i>n</i> = 183; 29%) <i>Adjusted</i> <i>mean (SE)</i>	<i>Occasional</i> (<i>n</i> = 172; 27%) <i>Adjusted</i> <i>mean (SE)</i>	<i>Decreasers</i> (<i>n</i> = 89; 14%) <i>Adjusted</i> <i>mean (SE)</i>	<i>Increasesers</i> (<i>n</i> = 127; 20%) <i>Adjusted</i> <i>mean (SE)</i>	<i>Chronic</i> (<i>n</i> = 69; 11%) <i>Adjusted</i> <i>mean (SE)</i>	<i>Overall</i> <i>Wald</i> χ^2	<i>Pairwise</i> <i>comparisons</i> <i>p</i> < .05
<i>Subjective health</i>							
Physical symptoms	4.83 (.67)	5.65 (.64)	5.11 (.74)	5.03 (.65)	7.67 (.87)	13.78**	5 > 1, 2, 3, 4
Physical self-concept	10.57 (2.10)	8.53 (2.08)	10.71 (2.06)	10.92 (2.10)	7.95 (2.15)	7.21	
<i>Health-promoting behaviours</i>							
Physical activity	1.11 (.46)	1.17 (.49)	1.27 (.52)	.97 (.49)	.09 (.46)	14.36**	5 < 1, 2, 3, 4
Healthy eating practices	3.28 (.51)	2.84 (.50)	3.84 (.55)	3.35 (.60)	3.33 (.59)	7.16	
Sleep duration	4.88 (.54)	4.79 (.54)	4.90 (.58)	4.78 (.55)	5.20 (.51)	2.10	
<i>Body mass index (kg/m²)</i>							
Body mass index	8.37 (1.75)	9.09 (1.77)	8.98 (1.82)	8.41 (1.81)	7.93 (1.86)	2.80	
<i>Serious injuries</i>							
Number of serious injuries (past 12 months)	.31 (.14)	.44 (.14)	.30 (.14)	.26 (.14)	1.82 (.25)	97.99***	5 > 1, 2, 3, 4; 2 > 4
<i>Sexual risk behaviours</i>							
Early sexual debut ^a (Pr)	.07	.14	.33	.27	.67	27.42***	5 > 1, 2, 3, 4; 3 > 1
Number of sexual partners	3.07 (.66)	5.33 (2.21)	5.37 (.65)	5.29 (.53)	5.69 (.52)	24.80***	1 < 2, 3, 4, 5
Ever had a STI ^a (Pr)	.03	.10	.09	.08	.21	12.68*	5 > 1, 4

Note: Models account for sex, T1 age centred, SES, and their respective T1 assessment. Pr = probability of event occurrence for dichotomous outcomes (Pr = 1/(1 + exp. (Threshold))(Muthén & Muthén, 2007)); STI = sexually transmitted infection.

^aEarly sexual debut and STI did not control for T1 levels, as these are time-invariant indicators. ^bEarly sexual debut is defined as before age 15 years (Vasilenko et al., 2015). **p* < .05, ***p* < .01, ****p* < .001.

sample (Whitehurst et al., 2015). Sleep duration declines rapidly for all adolescents (Maslowsky & Ozer, 2014) and overall declines may not be specific to marijuana use trajectories.

Consistent with past research (Arria et al., 2016; Bechtold et al., 2015; Rodondi et al., 2006), marijuana use trajectory differences were not significant for BMI. Finally, Chronic users reported more acute health problems (i.e. number of serious injuries or having a STI) than other classes. As noted above, the reasons for the occurrence of serious injuries needs to be investigated and may be related to engagement in lower prestige occupations (Ringel et al., 2006) or risk-taking behaviours while intoxicated (Leadbeater et al., 2017). The higher levels of STIs may be the result of the higher number of sexual partners in adolescence in this class. These concerns may substantially contribute to the acute healthcare costs for this age group and pain from injuries may also motivate continued use of marijuana.

Overall, these findings demonstrate that several physical health problems are related to the use of marijuana from adolescence to young adulthood. Understanding and anticipating these concerns in adolescence could help to guide primary prevention strategies (e.g. by reducing use of marijuana as medication, increase opportunities and time for physical activity, teach sleep hygiene and strategies for stress reduction) and may improve treatment plans for Chronic users by addressing poor

physical self-concept, physical inactivity and management of physical symptoms.

Limitations

The majority of our sample was Caucasian, as such, findings may not generalise to other ethnic groups. With the exception of BMI in young adulthood, all measures were self-reported, possibly contributing to shared variance and common findings for some health indicators (e.g., physical symptoms and physical self-concept). However, assessments spanned a decade, reducing the likelihood of shared variance. A single item assessed sleep and number of serious injuries. To add, our measure of marijuana use was based on frequency of use and did not include assessments of amount, potency or marijuana-related negative consequences; although classes showed differential profiles on similar measures of marijuana use in young adulthood (see Table 1). Inclusion of these dimensions of marijuana use in trajectory-based analyses may allow us to further distinguish different kinds of marijuana users in these age groups (e.g., Pearson et al., 2017). Due to high use of alcohol in our sample (Leadbeater et al., 2017; Thompson et al., 2018b), it was not possible to disentangle effects because of marijuana alone, although findings were significant after accounting for HED. Sex differences could not be assessed due to sample size limitations.

Conclusion

Youth who engage in early, frequent and continued use of marijuana use from adolescence to young adulthood are at-risk of physical health problems. It is unclear how legalisation of marijuana for recreational use will impact adolescent use patterns. Preliminary findings from the United States on how policy changes influence frequency of adolescents' marijuana use are mixed (Brooks-Russell et al., 2018; Cerda et al., 2017; Fleming et al., 2016; Rusby et al., 2018). However, there is some evidence that, for youth who already use marijuana, their use may increase (Rusby et al., 2018). There is also evidence that legalisation is associated with declines in perceptions of harms and parental disapproval (Brooks-Russell et al., 2018; Cerda et al., 2017; Fleming et al., 2016). Our findings suggest educational efforts and interventions for marijuana use should consider the different patterns of use among youth. For example, efforts to delay initiation should dispel adolescents' perceptions of marijuana as a safe and non-addictive way of treating pain (Chabrol et al., 2017; McKiernan & Fleming, 2017). In primary health-care settings, assessments of adolescents' physical complaints could include inquiry into their self-treatment approaches and alternative (i.e. behavioural) interventions offered. This could also provide opportunities for education about marijuana use and associated harms. Chronic users also report a higher number of acute health problems in young adulthood contributing to costs of healthcare.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. Marijuana trajectory class differences in adolescent (T1; ages 12 to 18) physical health indicators accounting for adolescent heavy episodic drinking

Table S2. Adjusted means, standard errors, and probabilities of health outcomes by marijuana use trajectory in young adulthood (T6; ages 22 to 29) accounting for adolescent heavy episodic drinking

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