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Cannabis Use and Blood Pressure Levels: United States National Health and Nutrition Examination Survey, 2005–2012

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Abstract

Objective—Pre-clinical studies have reported acute cardiovascular effects of cannabis including a dose-dependent increase in blood pressure while orthostatic hypotension may follow as a result of decreased vascular resistance. In case reports, evidence links cannabis with acute cardiovascular events in young and middle aged adults. Here, we offer epidemiologic estimates on cannabis use-blood pressure levels association from the United States (US) National Health and Nutrition Examination Surveys 2005–2012 (n=12426).

Methods—Computer-assisted self-interviews assessed cannabis use. Blood pressure was determined by an average of up to four measurements taken during a single examination. Regression modeling was used to examine cannabis use– blood pressure association.

Results—Recently active cannabis use was associated with increase in systolic blood pressure ($\beta = 1.6$; 95% CI: 0.6, 2.7) in the age-sex adjusted model. Additional covariate adjustment did not affect the positive association. No association between cannabis use and diastolic blood pressure was detected.

Conclusion—A modest association between recent cannabis use and systolic blood pressure was detected among a relatively large nationally representative sample of US adults. With the legalization of cannabis, there a need for pre-clinical, clinical and prospective population-based research on the cardiovascular effects of cannabis use.

Keywords

Cannabis; Blood pressure; NHANES

INTRODUCTION

Puzzles have emerged from research on the cardiovascular health effects of cannabinoids. Pre-clinical studies reported acute cardiovascular effects of cannabis including a dose-dependent increase in heart rate, an increase in blood pressure while orthostatic hypotension

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may follow as a result of decreased vascular resistance [1]. Case reports of acute cardiovascular events among young and middle aged adults after cannabis use have appeared in the clinical literature [2–5]. Limited population-based studies in this area seem to show that cannabis use per se does not influence cardiovascular health [6, 7]. A 15-year prospective study has found a positive association between cannabis use and systolic blood pressure that has been mainly confounded by greater alcohol use in cannabis users [8]. In addition, recent studies have suggested a better cardiometabolic profile among cannabis users when compared to never users [9–14].

With the increased legalization of cannabis use for recreational and medical purposes in the United States (US), the aim of the current study is to add new epidemiological evidence on the association of cannabis use and blood pressure levels, an important indicator of cardiovascular health [15]. We used data on young and middle aged adult participants who have completed the questionnaire and the examination components of the US nationally representative National Health and Nutrition Examination Survey (NHANES), 2005–2012.

METHODS

Design and study participants

The study population consists of non-institutionalized community residents of the US, with probability sampling, recruitment, and assessment for the NHANES 2005–2012, as designed to yield nationally representative survey estimates [16]. Survey procedures were approved by the National Center for Health Statistics ethics review board. The study population was designated to include adults 20–59 years who completed the drug use questionnaire during the NHANES mobile examination center (n=12702). Some participants had missing information on blood pressure levels. For this reason, the effective unweighted sample size for the current study is 12426.

Main exposure

Cannabis use was assessed via standardized self-report items during an audio computer-assisted self-interview. On this basis, participants were classified as never users; former users (used cannabis at least once in lifetime but not in the 30 days prior to the interview); and recently active cannabis users (used cannabis at least once in the 30 days prior to the interview). The number of days of recent cannabis use was determined by the question “During the past 30 days, on how many days did you use marijuana or hashish?”

Outcome of interest

After resting quietly in a sitting position for 5 minutes and determining the maximum inflation level, three and sometimes 4 blood pressure measurements (mmHg) are taken. The systolic and diastolic blood pressure variables used was based on the average of at least 4 readings. Pulse pressure (mmHg) was calculated as the numeric difference between the systolic and diastolic blood pressure [17].

Covariates

The initial guiding conceptual model was one in which the response variable of interest namely blood pressure levels was expressed as a function of cannabis use with covariate adjustment for age (years), age squared and sex (male/female). Subsequent models were controlled for ethnic self-identification (ESI: non-Hispanic White/non-Hispanic Black/Hispanic/all others), education attainment (less than high school/high school/above high school), poverty-income ratio (PIR), tobacco cigarette smoking (never/ former/recently active), alcohol intake in the past 12 months (never/ former/recently active), history of extra-medical drug use (cocaine, heroin and/or methamphetamine), and body mass index (BMI; calculated as weight in kilograms divided by height in meters squared, and then rounded to one decimal place).

Statistical analysis

Our first step involves assessing the distributions of the variables of interest and examining outliers. We ran linear regression models to estimate the differences in systolic and diastolic blood pressure (mmHg) by cannabis use status. To further ensure that the association was parallel for subgroups, we performed subgroup analyses by ESI, education, BMI, alcohol and smoking categories.

In post-exploratory steps, we ran logistic regression models to estimate the odds ratio and 95% CI of prehypertension (defined as systolic blood pressure 120–139 mmHg and/or diastolic blood pressure 80–89 mmHg), high pulse pressure (defined as pulse pressure > 40 mmHg), isolated systolic hypertension (defined as systolic blood pressure \geq 140 mmHg and diastolic blood pressure <90 mmHg), and hypertension (defined as use of antihypertensive medications, and/or systolic blood pressure \geq 140 mmHg and diastolic blood pressure \geq 90 mmHg) by cannabis use status using never users as the referent group.

NHANES examination weights that account for the unequal probabilities of selection, oversampling and non-response in the NHANES survey were applied for all analyses. Analyses were conducted using STATA (V.13.1) software. Standard errors were estimated using the Taylor series linearization method.

RESULTS

Compared to never users, recently active cannabis users were younger, and more likely to be males, non-Hispanic Whites with income below the federal poverty threshold. Recently active cannabis users also were more likely to be recently active tobacco and alcohol users (Table 1).

The main estimates of the study are presented in Table 2. Compared with never use, recent cannabis use was associated with higher systolic blood pressure ($\beta = 1.6$; 95% CI= 0.6, 2.7) in the age-sex adjusted model. Additional covariate adjustment did not affect the positive association ($\beta = 1.4$; 95% CI = 0.3, 2.3). Stratifying by the participants' characteristics, recently active cannabis use was associated with increased systolic blood pressure within the stratified subgroups. We found no appreciable variations among subgroups of ESI, education, tobacco cigarette smoking, alcohol drinking, or BMI. There was no association

between former cannabis use and systolic blood pressure levels. There was no association between cannabis use (both recent and former) and diastolic blood pressure. Our results did not change when excluding those who reported current use of antihypertensive medications.

Table 3 displays the association of cannabis use frequency and blood pressure levels. Number of days of cannabis use in the 30 days prior to the interview was associated with increased systolic blood pressure in the age-sex as well as the covariate-adjusted models. There was no association between days of cannabis use and diastolic blood pressure levels.

Table 4 presents the association of cannabis use and prehypertension, high pulse pressure, isolated systolic hypertension and hypertension. Compared to never users, recently active cannabis use was associated with high pulse pressure (Odds ratio =1.3; 95% CI = 1.1, 1.6). There was no association between cannabis use and hypertension or prehypertension.

DISCUSSION

The main findings of this study may be summarized succinctly as follows. First, we detected a modest association between recent cannabis use and increased systolic blood pressure. No association was detected between cannabis use and diastolic blood pressure levels. A statistically robust positive association between recent cannabis use and high pulse pressure was detected, whereas no association was detected between cannabis use and hypertension or prehypertension. No association was detected between lifetime history of cannabis use and blood pressure levels.

Before detailed discussion of these results, several of the more important study limitations merit attention, of most important is the cross sectional nature of NHANES which constrains causal or temporal inferences. Cannabis use was self-reported and was not ascertained by drug testing. Harrison et al. compared the validity of self-reported cannabis use in a general population survey with the results of drug tests of urine specimens obtained from those same respondents. The overall congruence between self-report and urinalysis was 89.8% [18]. There were no data on the route of administration of cannabis (smoking vs. other routes). Blood pressure measurement errors may occur since blood pressure was measured at a single NHANES examination. To account for that we averaged blood pressure levels on up to four readings. There was no data on the frequency of cannabis use beyond the 30 days prior to the interview and hence it is difficult to distinguish whether the association of cannabis use and blood pressure is of a short term or of a chronic nature. We stratified our analysis by the participants' characteristics to probe any subgroup variation in the estimates; however results from these stratified analysis are limited by multiplicity related to the number of analyses. Despite limitations such as these, the study findings are of interest because of the NHANES standardized data collection approaches, and the ability to adjust for potential confounders. Rodondi et. al. have previously reported a positive association of cannabis use and systolic blood pressure that was confounded by greater alcohol use in cannabis users using 15 years of longitudinal data from 3617 biracial young adults from four US cities [8]. The current study included a relatively larger nationally representative multiethnic sample of US adults which may enable us to detect differences.

Cardiovascular disease is the leading cause of death both globally and in the US [19]. Previous studies have linked cannabis use to myocardial infarction, angina, and stroke [20–22]. However, the association between cannabis use and cardiovascular disease is not always consistent [6]. Although both systolic and diastolic blood pressure levels correlate significantly with cardiovascular morbidity and mortality, recent studies have suggested that systolic blood pressure is more strongly correlated than diastolic blood pressure [23, 24]. The results of this study indicate a modest association between recently active cannabis use and increased systolic blood pressure which is consistent with pre-clinical studies indicating an acute increase in blood pressure after cannabis use [1]. The current study cannot elucidate if cannabis use is associated with chronic elevation in blood pressure. We did not detect an association between cannabis use and hypertension. There is a possibility that cannabis users who were diagnosed with hypertension were advised to stop cannabis use. However, lifetime history of cannabis use was not associated with hypertension in the current study.

The use of non-steroidal anti-inflammatory drugs (NSAIDs) is associated with increase in blood pressure [25]. In a sensitivity analysis excluding those who reported NSAIDs use in the past 30 days, our results did not change. Recent cannabis use was associated with systolic blood pressure (covariate adjusted $\beta = 1.4$; 95% CI = 0.4, 2.3) whereas an association with diastolic blood pressure was not detected (covariate adjusted $\beta = -0.05$; 95% CI = -1.0, 0.9).

We detected a modest association between recent cannabis use and increased pulse pressure. Increased pulse pressure may be a strong predictor of cardiovascular disease [26]. A strong association between increased systolic blood pressure, increased pulse pressure, increased arterial stiffness and the prevalence of cardiovascular disease was detected [27]. Aging is a major risk factor for arterial stiffness and increased pulse pressure [23]. The study participants are young and middle aged adults. We statistically controlled for age and age polynomials to account for any non-linear association with age. In addition, stratifying by age subgroups, the positive association persisted among young adults <40 years of age.

Although we detected a positive statistical association between recently active cannabis use and systolic blood pressure, the clinical significance of our findings is not clear. For each day of cannabis use, there is a 0.10 mmHg increase in systolic blood pressure. This implies that the systolic blood pressure increase among those who have used cannabis every day in the 30 days prior to the interview is only 3 mmHg. The pitfall could be that the difference may be too small to adopt cannabis-blood pressure policy in clinical practice. In conclusion, future cannabis-CVD studies, both population-based and pre-clinical, are needed especially with the social trend in the direction of relaxed law enforcement approaches when cannabis is used for medical and recreational use.

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Table 1
 Baseline Characteristics of the Study Sample by Cannabis Use Status. Data for the United States based on the National Health and Nutrition Examination Survey, 2005–2012 (n=12426)

Characteristics	Never Use (n= 5679)	Past Use (n=5169)	Recently Active Cannabis Use (n=1578)
Weighted Percentage (95% CI) or Mean (95% CI)			
Age (years)	39.8	39.2, 40.5	40.4
Women (%)	56.5	55.2, 57.9	47.9
Race/ethnicity (%)			
Non-Hispanic White	55.6	50.6, 60.5	76.7
Non-Hispanic Black	12.0	10.0, 14.3	9.9
Hispanic	22.5	19.0, 26.5	9.5
All other	9.9	8.2, 11.8	3.9
Education (%)			
< High School	18.6	16.7, 20.6	12.1
High school	21.3	19.5, 23.2	21.9
> High School	60.1	57.4, 62.8	66.0
PIR \leq	14.5	12.7, 16.6	11.7
Tobacco cigarette (%)			
Never	78.5	76.6, 80.3	43.1
Former	10.4	9.2, 11.7	28.1
Recently active	11.1	9.9, 12.4	28.8
Alcohol Drinking (%)			
Never	19.4	17.6, 21.2	1.8
Former	14.5	13.3, 15.7	13.8
Recently active	66.2	64.1, 68.2	84.5
Ever use other drugs (%)	1.9	1.5, 2.5	29.5
BMI (Kg/m²)	29.1	28.8, 29.4	28.7
Systolic Blood Pressure (mmHg)	117.9	117.2, 118.5	118.2
Diastolic Blood Pressure (mmHg)	71.2	70.6, 71.9	72.0
Pulse Pressure (mmHg)	46.7	46.0, 47.3	46.2
Mean arterial pressure (mmHg)	86.8	86.2, 87.3	87.4

Percentages may not add to 100% due to rounding

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Table 2

Association of Recently Active (Past 30-days) Cannabis Use* and Blood Pressure Levels Using Linear Regression Models. Data from the National Health and Nutrition Examination Survey and the United States National Surveys on Drug Use and Health, 2005–2012.

Characteristics	Systolic Blood Pressure (mmHg)		Diastolic Blood Pressure (mmHg)	
	Age Sex Adjusted Estimated Difference [†] (95% CI)	Covariate Adjusted Estimated Difference [†] (95% CI)	Age Sex Adjusted Estimated Difference [†] (95% CI)	Covariate Adjusted Estimated Difference [†] (95% CI)
Full sample	1.6 (0.6, 2.7)	1.3 (0.4, 2.3)	0.3 (-0.5, 1.0)	-0.01 (-1.0, 0.9)
ESI				
NH-White	1.4 (0.1, 2.7)	1.1 (-0.3, 2.5)	-0.2 (-1.2, 0.8)	0.1 (-1.2, 1.3)
NH-Black	1.1 (-0.6, 2.9)	1.8 (-0.3, 3.9)	0.4 (-1.6, 2.3)	-0.1 (-2.3, 2.1)
Hispanic	1.7 (-0.1, 3.5)	3.0 (1.4, 4.7)	1.3 (-0.5, 3.0)	0.6 (-1.5, 2.7)
All others	3.6 (-1.7, 8.9)	3.3 (-1.1, 7.6)	-0.0 (-2.3, 2.3)	-0.1 (-2.4, 2.7)
Education				
<High School	2.4 (0.4, 4.4)	2.3 (0.4, 4.1)	1.7 (0.1, 3.3)	1.1 (-0.7, 2.9)
High School	0.9 (-1.2, 3.0)	1.6 (-0.9, 4.1)	-0.6 (-2.2, 1.0)	-0.5 (-2.7, 1.7)
>High School	1.7 (0.1, 3.4)	1.3 (-0.2, 2.9)	0.3 (-0.8, 1.3)	0.1 (-1.2, 1.3)
Tobacco Smoking				
Non-smoker	2.1 (0.2, 4.0)	1.7 (0.5, 3.0)	-0.04 (-1.3, 1.2)	-0.6 (-1.6, 0.4)
Recently Active	1.8 (-0.2, 3.7)	2.1 (0.1, 4.1)	1.9 (0.5, 3.4)	1.6 (-0.1, 3.4)
Alcohol Drinking				
Non Drinker	1.2 (-2.4, 4.8)	1.3 (-2.7, 5.3)	0.5 (-2.5, 1.6)	0.5 (-2.3, 3.4)
Recently Active	1.7 (0.6, 2.8)	1.3 (0.2, 2.4)	0.2 (-0.7, 1.2)	-0.1 (-1.1, 1.0)
BMI				
<25 Kg/m ²	3.2 (1.7, 4.7)	1.9 (0.1, 3.7)	1.0 (-0.1, 2.0)	1.3 (-0.1, 2.6)
25–29.9 Kg/m ²	1.7 (0.2, 3.3)	1.3 (-0.6, 3.2)	0.8 (-0.6, 2.1)	-0.6 (-2.1, 0.9)
≥30 Kg/m ²	1.8 (0.1, 3.5)	0.7 (-1.0, 2.4)	0.3 (-1.0, 1.6)	-0.5 (-1.9, 0.9)

*The referent group is never cannabis use ($\beta=0$).

[†] Estimates adjusted for age (years), age squared and sex.

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[‡]Estimates adjusted for age (years), sex, ethnic self-identification (non-Hispanic Whites, non-Hispanic Blacks, Hispanics, and all others), education (less than high school, high school, and above high school), poverty income ratio (<1 and ≥1), body mass index (kg/m²), alcohol drinking (never, former, and recently active), history of extra-medical drug use, and smoking status (never, former, and recently active), except for the stratified variables.

Table 3
 Frequency of Cannabis use and Blood Pressure Levels Using Linear Regression Models. Data from the National Health and Nutrition Examination Survey and the United States National Surveys on Drug Use and Health, 2005–2012.

Days of Cannabis use in the past 30 days	Systolic Blood Pressure (mmHg)			Diastolic Blood Pressure (mmHg)		
	Age Sex Adjusted Estimated Difference [†] (95% CI)	Covariate Adjusted Estimated Difference [‡] (95% CI)	Age Sex Adjusted Estimated Difference [†] (95% CI)	Age Sex Adjusted Estimated Difference [†] (95% CI)	Covariate Adjusted Estimated Difference [‡] (95% CI)	Covariate Adjusted Estimated Difference [‡] (95% CI)
0 days*	0 (referent)	0 (referent)	0 (referent)	0 (referent)	0 (referent)	0 (referent)
1–6 days	1.3 (0.03, 2.6)	1.2 (0.02, 2.5)	0.5 (–0.3, 1.4)	0.3 (–0.7, 1.2)		
7–20 days	2.0 (0.6, 3.4)	1.5 (0.2, 2.9)	0.1 (–1.2, 1.4)	–0.1 (–1.5, 1.3)		
21–30 days	2.6 (1.3, 3.9)	2.6 (1.4, 3.9)	–0.6 (–1.9, 0.6)	–0.7 (–2.0, 0.6)		
Continuous Variable for Days of Cannabis Use	0.10 (0.06, 0.14)	0.09 (0.05, 0.13)	–0.02 (–0.06, 0.02)	–0.02 (–0.07, 0.02)		

* Zero day subgroup includes never users and former users who reported no cannabis use in the 30 days prior to the interview.

[†] Estimates adjusted for age (years), age squared and sex.

[‡] Estimates adjusted for age (years), sex, ethnic self-identification (non-Hispanic Whites, non-Hispanic Blacks, Hispanics, and all others), education (less than high school, high school, and above high school), poverty income ratio (<1 and ≥1), body mass index (kg/m²), alcohol drinking (never, former, and recently active), history of extra-medical drug use, and tobacco cigarette smoking (never, former, and recently active).

Table 4
 Association of Cannabis Use and Blood Pressure Levels Using Logistic Regression Models. Data from the National Health and Nutrition Examination Survey and the United States National Surveys on Drug Use and Health, 2005–2012.

Conditions	Never Use	Former Use	Recently Active Use
Covariate Adjusted Odds Ratio * (95% CI)			
Prehypertension	1.0 (Referent)	1.0 (0.9, 1.2)	1.2 (0.9, 1.5)
High Pulse Pressure	1.0 (Referent)	1.0 (0.9, 1.1)	1.3 (1.1, 1.6)
Isolated Systolic Hypertension	1.0 (Referent)	0.9 (0.7, 1.1)	1.5 (1.0, 2.2)
Hypertension	1.0 (Referent)	0.9 (0.7, 1.1)	1.1 (0.8, 1.3)

* Estimates adjusted for age (years), sex, ethnic self-identification (non-Hispanic Whites, non-Hispanic Blacks, Hispanics, and all others), education (less than high school, high school, and above high school), poverty income ratio (<1 and ≥1), body mass index (kg/m²), alcohol drinking (never, former, and recently active), history of extra-medical drug use, and tobacco cigarette smoking (never, former, and recently active).