International Journal of Drug Policy 21 (2010) 511–513

Contents lists available at ScienceDirect

International Journal of Drug Policy

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

Short report

Pulmonary function in cannabis users: Support for a clinical trial of the vaporizer

Nicholas T. Van Dam, Mitch Earleywine*

Department of Psychology, University at Albany, SUNY, United States

ARTICLE INFO

Article history:
Received 24 February 2010
Received in revised form 25 March 2010
Accepted 4 April 2010

Keywords:
Cannabis
Pulmonary function
Medical cannabis
Harm reduction

ABSTRACT

Background: Debates about cannabis policy often mention respiratory symptoms as a negative consequence of use. The cannabis vaporizer, a machine that heats the plant to release cannabinoids in a mist without smoke and other respiratory irritants, appears to have the potential to minimize respiratory complaints.
Methods: Twenty frequent cannabis users (uninterested in treatment) reporting at least two respiratory symptoms completed subjective ratings of respiratory symptoms and spirometry measures prior to and following 1 month's use of a cannabis vaporizer in a pre/post-design. Outcome measures included self-reported severity of nine respiratory symptoms as well as spirometry measures, including the maximum amount of air exhaled in 1 s (forced expiratory volume; FEV1) and maximum total lung volume (forced vital capacity; FVC).
Results: The 12 participants who did not develop a respiratory illness during the trial significantly improved respiratory symptoms ($t(11) = 6.22$, $p = 0.000065$, $d = 3.75$) and FVC, $t(11) = 2.90$, $p = 0.007$, $d = 1.75$. FEV1 improved but not significantly $t(11) = 1.77$, $p = 0.053$, $d = 1.07$.
Conclusions: These preliminary data reveal meaningful improvements in respiratory function, suggesting that a randomized clinical trial of the cannabis vaporizer is warranted. The vaporizer has potential for the administration of medical cannabis and as a harm reduction technique.

Although studies examining the efficacy of cannabis as an alternative therapeutic have increased recently, drug policy has attenuated experimental evaluation (Hall, Christie, & Currow, 2005). One major concern about medical cannabis is a safe delivery method. Although cannabis smoke lacks the carcinogenic effects of tobacco smoke (Melamede, 2005), it is associated with increased respiratory symptoms and aerodigestive cancers (Hall et al., 2005; Hall, 2009; Tashkin, Baldwin, Sarafian, Dubinett, & Roth, 2002; Tetrault et al., 2007), an effect likely magnified by the common mixing of cannabis with tobacco (Robertson, Miller, & Anderson, 1996).

One alternative to smoking cannabis requires the vaporizer. Vaporized cannabis creates subjective effects and plasma concentrations of Δ^9-tetrahydrocannabinol (THC) comparable to that of smoked cannabis (Abrams et al., 2007) but minimizes smoke and associated byproducts that cause respiratory irritation (Gieringer, St. Laruent, & Goodrich, 2004). Vaporizer users report less respiratory irritation than cannabis smokers (Earleywine & Smucker Barnwell, 2007), and four cases of users with respiratory irritation improved pulmonary function after 1 month of vaporization (Earleywine & Van Dam, in press). To our knowledge, no large-scale exploration of vaporization in lieu of smoked cannabis exists. The present study investigated vaporization's impact in cannabis smokers who reported respiratory irritation.

Procedure

Potential participants responded to an advertisement requesting regular cannabis users. Inclusion criteria, determined via phone, included minimum age of 18 years, regular cannabis consumption (≥4 days/week), and at least 2 of 9 respiratory symptoms (detailed below). Current (within the last year) tobacco smokers and inhalant users were excluded (see Earleywine & Van Dam, in press).

On an initial laboratory visit, eligible participants provided informed consent, completed a cannabis use interview, a 9-item respiratory distress questionnaire (detailed below), and spirometry measures of pulmonary function. Participants then received a vaporizer (Vaporbrothers standard vaporizer, Vaporbrothers Inc., Torrance, CA) and training in use. Participants consumed a legal herb in the laboratory to ensure proper technique. All agreed to use the vaporizer exclusively until follow-up. Participants also received training using a calendar to record cannabis use (e.g., Armeli, Carney, Tennen, Affleck, & O'Neil, 2000). Participants agreed to record a quantity in grams – a common unit for purchas-

* Corresponding author at: Department of Psychology, University at Albany, Social Sciences 399, 1400 Washington Ave, Albany, NY 12222, United States.
Tel.: +1 518 442 4836; fax: +1 518 442 4867.
E-mail address: mearleywine@albany.edu (M. Earleywine).

0955-3959/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.drugpo.2010.04.001

Table 1
Demographic characteristics.

Demographic	$N = 22$
M (SD)	
Age in years	20.4 (1.5)
Education in years	14.1 (1.2)
Age first cannabis use	14.7 (2.4)
Age regular cannabis use	16.7 (2.2)
Cannabis use per week (days)	6.5 (1.0)
Cannabis use per week (g)	11.7 (6.0)
Average "High" (range = 0–6)	3.9 (1.2)
% of sample	
Male	63.6
Current alcohol use	85.7
History of tobacco use	23.8
History of cocaine use	23.8
History of ecstasy use	9.5
History of LSD use	19
History of mushroom use	47.6
History of opiate use	28.6
History of prescription Stimulant use	28.6
History of sedative use	9.5

ing cannabis. This estimation approach of cannabis consumption correlates with other estimates of use and associated negative consequences (Walden & Earleywine, 2008).

Participants returned approximately 30 days later (range = 26–46 days, $M = 30.6$, SD = 5.3). Participants repeated the initial assessments and an exit interview, reporting cannabis use methods other than vaporization, use of inhalants, and respiratory illness (RI) during the intervention. Participants were then debriefed, informed they could keep the vaporizer and paid US $40. Procedures were approved by the local institutional review board.

Participants

Twenty-two (22) participants took part in the study. Prior to intervention, cannabis consumption ranged from 2.4 to 23.4 g/week. Participants reported an average of 3.2 years (SD = 2.0) of consumption at their current rate. Other demographics appear in Table 1.

Measures

Pulmonary function

Participants performed spirometry to American Thoracic Society (ATS) standards using the Astra 100 Spirometer (SDI Diagnostics, Easton, MA). The best forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) from three reproducible attempts (within 0.2) were recorded in litres. FEV1 and FVC are two common measures of pulmonary functioning (Anthonisen, Connett, & Murray, 2002; Volkova, Kodani, Hilario, Munyaradzi, & Peterson, 2009).

Subjective respiratory distress

Participants responded "yes" or "no" to nine questions on respiratory distress, including: asthma, cystic fibrosis, usual cough, coughing up phlegm regularly, wheezy or whistling chest sounds, shortness of breath related to walking, breathlessness related to walking, coughing up phlegm in the morning, and tightness in the chest at night (cf. Tetrault et al., 2007; Wang, Collet, Shapiro, & Ware, 2008). Participants rated severity from 0 "*not present*" to 8 "*very severe*" (internal consistency at time 1 (Cronbach's $\alpha = 0.85$) and time 2 (Cronbach's $\alpha = 0.74$)).

Table 2
Pre- and post-intervention outcomes for individuals without respiratory illness ($n = 12$).

	Pre-M (SD)	Post-M (SD)	t(df)	p
Respiratory distress	26.1 (14.2)	6.92 (4.66)	6.22 (11)	0.000[a]
FEV1	3.22 (0.77)	3.60 (1.27)	1.83 (11)	0.047[a]
FVC	4.54 (1.12)	4.76 (1.23)	2.97 (11)	0.007[a]

t = one-way paired samples t-test, df = degrees of freedom, FEV1 = forced expiratory volume (L) in 1 s, FVC = forced vital capacity (L).
[a] Statistically significant.

Cannabis use

Participants completed an interview assessment of cannabis use in the previous 30 days at the initial laboratory visit (Timeline Followback, Sobell & Sobell, 2000). They also tracked their use during the intervention using a calendar approach (described above).

Statistical analyses

Naturally acquired respiratory illness (RI) significantly decreases pulmonary function (O'Connor et al., 1979; Rappaport, Gilliland, Linn, & Gauderman, 2002), a problem relevant to smokers (Blake, Abell, & Stanley, 1988). Separate analyses were conducted for individuals with and without RI during the intervention. We hypothesized that 1 month of vaporizer use would (1) decrease respiratory symptoms and (2) increase pulmonary function. We also examined the percentage of individuals pre- and post-intervention meeting a cut-score of 0.80 for FEV1/FVC (cf. Tetrault et al., 2007).

Results

Attrition was low and adherence high; 2 participants failed to follow-up and 4 participants reported smoking cannabis (instead of vaporizing) more than 3 days (5 times: $n = 3$, 10 times: $n = 1$). Grams per day dropped marginally from pre- ($M = 1.75$, SD = 0.90) to post- ($M = 1.46$, SD = 0.71) intervention, $t(18) = 1.34$, $p = 0.10$. This change was larger in participants reporting an RI ($M = -0.36$, SD = 1.11 vs. $M = -0.25$, SD = 0.63). Individuals reporting an RI during the study ($n = 8$) showed no changes across time, all p's > 0.05. RI and non-RI groups did not differ on any pre-intervention or demographic variables. Individuals who did not acquire an RI ($n = 12$) significantly decreased respiratory symptoms ($t(11) = 6.22$, $p = 0.000065$, $d = 3.75$) and improved pulmonary function. A large change on FEV1 did not quite reach statistical significance, $t(11) = 1.77$, $p = 0.053$, $d = 1.07$; FVC improved significantly $t(11) = 2.90$, $p = 0.007$, $d = 1.75$. Details appear in Table 2.

Pre-intervention, approximately 64% of the sample had ratios below the FEV1/FVC cut-score of 0.80 ($M = 76.5$, SD = 14.4). Post-intervention, the proportion of participants below the cut-score decreased to 30% ($M = 78.0$, SD = 17.7), a drop that failed to reach statistical significance ($p > 0.10$).

Discussion

These preliminary results suggest that the vaporizer might improve pulmonary function in cannabis users who experience respiratory symptoms. Following 1 month of vaporizer use, the sample showed changes comparable to those in long-term tobacco cessation (Anthonisen et al., 2002). Given the potential interactions between tobacco and cannabis on lung function, the findings reported here, which focused only on those who do not use tobacco, may actually underestimate the effect the vaporizer could have with cannabis users who also smoke tobacco. Individuals who consume both tobacco and cannabis separately might decrease tobacco

consumption congruent with efforts to minimize respiratory ailments associated with cannabis consumption (Earleywine & Van Dam, in press).

Several caveats are appropriate for the interpretation of these data. The impact of the vaporizer was limited to individuals not reporting a respiratory illness (RI). Given the direct impact of RI on pulmonary function (e.g., O'Connor et al., 1979; Rappaport et al., 2002) and the commonality of RI in smokers (Blake et al., 1988), a high rate of RI could be characteristic of studies with heavy cannabis smokers. The relationship of RI to cannabis use needs further exploration. Additionally, the huge effect of the vaporizer on self-reported respiratory irritation ($d = 3.75$) may be partially due to participant bias. Spirometry measures are less susceptible to bias, offering more compelling evidence of vaporizer-associated improvements. The limits of any pre/post-experimental design also apply.

These data suggest a randomized controlled trial is warranted. One approach may be random assignment to vaporizer use vs. smoked cannabis with a pre-, middle-, and post-assessment period over 6–12 months. Based on medium effects, and a repeated measures design, a sample of approximately 80 would provide adequate power to detect a within–between interaction, though potential attrition should also be considered (see Anthonisen et al., 2002). Non-tobacco smokers would provide the ideal sample (Earleywine & Van Dam, in press), though this may be difficult to achieve (cf. Robertson et al., 1996). Minimally, a clinical trial of the vaporizer should control for other smoked substances and inhalant use (Tetrault et al., 2007). Outcome variables might follow those utilized here (cf. Anthonisen et al., 2002; Volkova et al., 2009). As habitual cannabis smokers seem to exhibit the most marked respiratory impairment (Tashkin et al., 2002), individuals who have used regularly for several years might be the optimal population. Given increased risk for aerodigestive cancers in cannabis smokers (e.g., Hall et al., 2005), histopathological examination of lung and immune cells over the course of the trial may also prove informative (cf. Tashkin et al., 2002).

Given that cannabis plants contain components that can counteract adverse effects of THC (e.g., cannabidiol), it may have advantages over synthetic THC (dronabinol; Degenhardt & Hall, 2008). While many factors will continue to influence cannabis-related drug policy (Hall, 2009), the present results suggest a safer means of exploring the utility of medical cannabis and an important harm reduction technique. Larger scale controlled clinical trials are necessary to explore the potential of the vaporizer to minimize respiratory complications.

Acknowledgements

This work was supported by a grant from the Marijuana Policy Project. Marijuana Policy Project had no input on the design, analysis, written manuscript, or decision to submit for publication. The authors thank Jon Rosen for helpful advice, the staff at Vapor Brothers, and the participants. Author N.V.D. declares no conflict of interest. Author M.E. declares involvement with a number of cannabis law reform groups.

References

Abrams, D. I., Vizoso, H. P., Shade, S. B., Jay, C., Kelly, M. E., & Benowitz, N. L. (2007). Vaporization as a smokeless cannabis delivery system: A pilot study. *Clinical Pharmacology & Therapeutics*, *82*, 572–578.

Anthonisen, N. R., Connett, J. E., & Murray, R. P. (2002). Smoking and lung function of lung health study participants after 11 years. *American Journal of Respiratory and Critical Care Medicine*, *166*, 675–679.

Armeli, S., Carney, M., Tennen, H., Affleck, G., & O'Neil, T. (2000). Stress and alcohol use: A daily process examination of the stressor-vulnerability model. *Journal of Personality and Social Psychology*, *78*, 979–994.

Blake, G. H., Abell, T. D., & Stanley, W. G. (1988). Cigarette smoking and upper respiratory infection among recruits in basic combat training. *Annals of Internal Medicine*, *109*, 198–202.

Degenhardt, L., & Hall, W. D. (2008). The adverse effects of cannabinoids: Implications for use of medical marijuana. *Canadian Medical Association Journal*, *178*, 1685–1686.

Earleywine, M., & Smucker Barnwell, S. (2007). Decreased respiratory symptoms in cannabis users who vaporize. *Harm Reduction Journal*, *4*, 11.

Earleywine, M. & Van Dam, N.T. (in press). Case studies in cannabis vaporization. *Addiction Research and Theory*.

Gieringer, D., St. Laruent, J., & Goodrich, S. (2004). Cannabis vaporizer combines efficient delivery of THC with effective suppression of pyrolytic compounds. *Journal of Cannabis Therapeutics*, *4*, 7–27.

Hall, W. (2009). The adverse health effects of cannabis use: What are they, and what are their implications for policy? *International Journal of Drug Policy*, *20*, 458–466.

Hall, W., Christie, M., & Currow, D. (2005). Cannabinoids and cancer: Causation, remediation, and palliation. *Lancet Oncology*, *6*, 35–42.

Melamede, R. (2005). Cannabis and tobacco smoke are not equally carcinogenic. *Harm Reduction Journal*, *2*, 21.

O'Connor, S. A., Jones, D. P., Collins, J. V., Heath, R. B., Campbell, M. J., & Leighton, M. H. (1979). Changes in pulmonary function after naturally acquired respiratory infection in normal persons. *The American Review of Respiratory Disease*, *120*, 1087–1093.

Rappaport, E. B., Gilliland, F. D., Linn, W. S., & Gauderman, W. J. (2002). Impact of respiratory illness on expiratory flow rates in normal, asthmatic, and allergic children. *Pediatric Pulmonology*, *34*, 112–121.

Robertson, J. R., Miller, P., & Anderson, R. (1996). Cannabis use in the community. *British Journal of General Practice*, *46*, 671–674.

Sobell, L. C., & Sobell, M. B. (2000). Alcohol timeline followback. In American Psychiatric Association (Ed.), *Handbook of psychiatric measures* (pp. 477–479). Washington D.C: American Psychiatric Association.

Tashkin, D. R., Baldwin, G. C., Sarafian, T., Dubinett, S., & Roth, M. D. (2002). Respiratory and immunologic consequences of marijuana smoking. *Journal of Clinical Pharmacology*, *42*, 71S–81S.

Tetrault, J. M., Crothers, K., Moore, B. A., Mehra, R., Concato, J., & Fiellin, D. A. (2007). Effects of marijuana smoking on pulmonary function and respiratory complications. *Archives of Internal Medicine*, *167*, 221–228.

Volkova, N. B., Kodani, A., Hilario, D., Munyaradzi, S. M., & Peterson, M. W. (2009). Spirometry utilization after hospitalization for patients with chronic obstructive pulmonary disease exacerbations. *American Journal of Medical Quality*, *24*, 61–66.

Walden, N., & Earleywine, M. (2008). How high? Quantity as a predictor of cannabis-related problems. *Harm Reduction Journal*, *5*, 20.

Wang, T., Collet, J.-P., Shapiro, S., & Ware, M. A. (2008). Adverse effects of medical cannabinoids: A systematic review. *Canadian Medical Association Journal*, *17*, 1669–1678.