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## Anxiety Sensitivity as a Mediator of the Relationship between Moderate-Intensity Exercise and Coping-Oriented Marijuana Use Motives

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### Abstract

The present study examined the working hypothesis that moderate-intensity exercise is associated with coping-oriented marijuana use motives through its association with the fear of somatic arousal (i.e., anxiety sensitivity). Using data from 146 young adult current marijuana users we found evidence consistent with this hypothesis. Specifically, moderate-intensity exercise was associated with coping-oriented use motives, even after controlling for frequency of current marijuana use and other co-occurring marijuana use motives. This relationship became non-significant after entering anxiety sensitivity as an additional predictor variable, denoting a putative mediational role for this cognitive factor. These findings extend previous work and offer support for the potential utility of moderate-intensity aerobic exercise for the treatment of marijuana use problems.

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Marijuana is the most widely used illicit substance in the United States.<sup>1</sup> Moreover, the prevalence of marijuana abuse and dependence has risen significantly from the early 1990s to the early 2000s.<sup>2</sup> These data are striking given frequent marijuana use and related disorders have been associated with a number of negative outcomes, including increased risk of physical health disorders,<sup>3–5</sup> increased use of other substances<sup>6</sup> as well as reduced educational attainment<sup>7</sup> and work productivity.<sup>8</sup>

One area of work that has helped guide the development of effective interventions for marijuana use and related disorders is the study of motivational bases of marijuana use. Extending its utility for understanding the nature of alcohol and tobacco use,<sup>9,10</sup> this approach has provided meaningful theoretical and clinical insight into the patterns of marijuana use. Indeed, coping, enhancement, social, and expansion motives for marijuana use have each been found to be associated with frequency of marijuana use, even after controlling for theoretically-relevant variables (e.g., concurrent substance use).<sup>11–14</sup> These findings also indicate that reasons for marijuana use vary across and within individuals.<sup>14</sup>

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#### Declaration of Interest

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One line of inquiry in regard to the study of marijuana use motives has focused on relations between emotional vulnerability factors and coping-oriented marijuana use.<sup>15,16</sup> This work has been influenced by the recognition that anxiety symptoms and disorders co-occur with frequent (e.g., daily) and problematic marijuana use.<sup>17–24</sup> For example, marijuana dependence has prospectively predicted an increased risk for panic attacks.<sup>24</sup> Anxiety sensitivity is one possible contributing factor for these observed linkages between anxiety and marijuana use problems. Anxiety sensitivity reflects individual differences in the fear of anxiety and arousal-related sensations.<sup>25,26</sup> When anxious, individuals high in anxiety sensitivity become acutely fearful due to beliefs that these interoceptive sensations have harmful physical, psychological, or social consequences.<sup>27</sup> Over time, elevated levels of anxiety sensitivity predict greater risk for anxiety and its disorders.<sup>28–34</sup> Additionally, anxiety sensitivity is significantly related to coping-oriented marijuana use motives among adolescents<sup>16</sup> and adults.<sup>11,35,36</sup> To the extent that anxiety sensitivity is associated with increased risk for anxiety symptoms, persons with high compared to low levels of this factor may desire to use drugs, such as marijuana, to cope with such distressing symptoms. In this sense, this emotional sensitivity factor may be important for understanding the putative linkages between marijuana use problems and anxiety and depressive emotional disturbances

Importantly, anxiety sensitivity is malleable in response to psychosocial interventions.<sup>37</sup> That is, psychosocial interventions delivered in prevention or treatment context can decrease anxiety sensitivity, and such change can subsequently improve clinical outcome.<sup>37,38</sup> The prominent ingredient of psychosocial treatment for anxiety sensitivity is interoceptive exposure.<sup>38</sup> Interoceptive exposure involves repeated confrontation to somatic arousal with the intention of providing an opportunity for a corrective learning experience (i.e., somatic arousal is not dangerous but safe). Because moderate-intensity exercise induces many of the somatic sensations (e.g., heart racing, rapid breathing, and sweating) that high anxiety sensitivity individuals respond to with fear,<sup>39</sup> exercise can serve as a means to provide interoceptive exposure.<sup>40–42</sup> Here, three studies have demonstrated that an exercise program involving moderate-intensity exercise outperforms waitlist<sup>40,42</sup> and low-intensity exercise<sup>41</sup> in reducing anxiety sensitivity among healthy adults with clinical levels of anxiety sensitivity. Accordingly, by reducing anxiety sensitivity, moderate-intensity aerobic exercise may be a viable option to target coping-oriented motives for marijuana use.

The present study sought to provide an initial test of the potential utility of moderate-intensity exercise for this application. Specifically, using cross-sectional data of 146 adults who reported currently using marijuana in the past 30 days, we examined the hypothesis that moderate-intensity exercise is negatively associated with coping-oriented motives because of its negative association with anxiety sensitivity. This mediational hypothesis was tested using the causal steps approach to mediation.<sup>43</sup>

## METHOD

### Participants

Participants were a community-recruited sample of 146 (70 female) adults ( $M_{\text{age}} = 20.45$  years,  $SD = 5.06$ ) who reported current (past 30 day) marijuana use. Generally consistent with the racial distribution of Vermont,<sup>44</sup> approximately 94.5% of participants self-identified as white/non-Hispanic, 0.7% as African American, 0.7% as Hispanic, 0.7% as Asian, 0.7% as Biracial, and 2.8% as “Other” or did not specify ethnicity. Inclusion criteria included being at least 18 years of age and endorsing marijuana use within the past month. In terms of marijuana use in the past month, 33.6% of participants reported using marijuana less than once per week, 9.6% reported using marijuana once per week, and 56.8% of participants reported using marijuana more than once per week. Of those reporting

marijuana use more than once per week, 22.6% reported using marijuana more than once per day. In terms of DSM-IV<sup>45</sup> diagnoses, 45 (30.8%) participants met criteria for marijuana abuse and 42 (28.8%) participants met criteria for marijuana dependence.

The current study data were collected as part of a larger laboratory investigation. Exclusion criteria included current Axis I psychopathology (with the exception of the abuse and dependence of marijuana, tobacco, and alcohol), current use of psychotropic medication, current suicidal ideation, current or past chronic cardiopulmonary illness (e.g., chronic obstructive pulmonary disease; severe asthma), current respiratory illness (e.g., bronchitis), seizure disorder, cardiac dysfunction, or other serious medical illness (e.g., history of seizures, emphysema), pregnancy (specific to females), and/or inability to provide written, informed consent. Exclusionary criteria were employed to rule out alternative explanations related to any observed effects (e.g., confounding effects resulting from psychopathology rather than the studied variables).<sup>46</sup>

## MEASURES

### Clinical Interview

The Structured Clinical Interview-Non-Patient Version for DSM-IV (SCID-N/P)<sup>47</sup> was used to assess current marijuana abuse and dependence (with the inclusion of substance withdrawal criteria as defined by the DSM-IV for other drugs and as assessed by the SCID-N/P for other drug classes), Axis I diagnoses, suicidal ideation, and medication use. Demographic characteristics also were collected using the SCID-N/P. If a participant endorsed psychopathology on the SCID-N/P screener, they were excluded from the investigation.

### Marijuana Use

The Marijuana Smoking History Questionnaire (MSHQ)<sup>48</sup> was employed as an index of current marijuana use. The MSHQ is a 21-item questionnaire, which assesses current and lifetime marijuana use. The specific item used to measure current marijuana use frequency consisted of participants' ratings of frequency of use within the past month on an eight-point Likert-type scale (0 = *no use* to 8 = *more than once a day*). Current marijuana use status was defined as responses of one or greater on this item, indicating at least low levels of use within the past 30 days.

### Marijuana Use Motives

The Marijuana Motives Measure (MMM)<sup>14</sup> is a 25-item measure in which respondents indicate on a 5-point Likert-type scale (1 = *almost never/never* to 5 = *almost always/always*) the degree to which they have smoked marijuana for a variety of possible reasons (e.g., *to be sociable*). Factor analysis of the scale indicates that it has five first-order factors entitled Enhancement (e.g., *because it's exciting*), Conformity (e.g., *to fit in with the group I like*), Expansion (e.g., *to expand my awareness*), Coping (e.g., *to forget my worries*), and Social (e.g., *because it makes social gatherings more fun*).<sup>14,49</sup> The MMM has high levels of internal consistency for each of the five factors (range of alpha coefficients: .72 to .92) and has been successfully used in the past to measure motivation for using marijuana.<sup>12</sup>

### Anxiety Sensitivity

The Anxiety Sensitivity Index (ASI)<sup>50</sup> is a 16-item measure in which respondents indicate on a 5-point Likert-type scale (0=*very little* to 4=*very much*) the degree to which they are concerned about possible negative consequences of anxiety symptoms (e.g., *It scares me when I feel shaky*). The ASI is unique from, and demonstrates incremental validity relative

to, trait anxiety<sup>51</sup> as well as negative affectivity.<sup>52</sup> The ASI has high levels of internal consistency (range of alpha coefficients: 0.79 to 0.90) and good test–retest reliability ( $r = 0.70$  for 3 years).<sup>53</sup>

### Moderate-Intensity Exercise

The Exercise Habits Questionnaire-Revised (EHQ-R)<sup>54</sup> is a self-report measure used to obtain information about participants' engagement in physical activity. The EHQ-R asks respondents to indicate for 29 different physical activities (e.g., running, stair stepping, walking/hiking, swimming, hockey, golf, martial arts, rock climbing, yoga), the number of sessions they have completed in the past two weeks, as well as the time spent per session (e.g., less than 20 minutes; 20–29 minutes; 30–39 minutes; 40–49 minutes; 50 minutes or more). For minutes spent per session, we used the midpoint of the range (e.g. 1 = < 20 minutes equaled 10 minutes; 2 = 20–29 minutes equaled 24.5 minutes) and for “50 minutes or more,” we used 50 minutes. We classified activities associated with metabolic equivalent (METs) values between 3 and 5 as moderate-intensity. This information was used in combination with the compendium of physical activities<sup>55</sup> to calculate total minutes of weekly moderate-intensity exercise.<sup>56</sup>

## PROCEDURE

Interested persons, responding to various community-based advertisements, who contacted the research team were given a detailed description of the study over the phone and scheduled for an appointment. Upon arrival to the laboratory, each participant was greeted by a research assistant and provided verbal and written consent to participate in the research study. Next, participants were administered the SCID-N/P by trained interviewers to assess for the key exclusionary/inclusionary criteria. If deemed eligible, participants then completed a battery of self-report measures. At the end of the laboratory session, participants were debriefed and compensated \$25 for their participation.

## Results

Table 1 presents descriptive data for predictor and criterion variables. First, a hierarchical linear regression was conducted to examine Path C of the model (see Figure 1), that is, the relation between moderate-intensity exercise (the predictor) and marijuana use coping motives (the criterion). Frequency of current marijuana use, as well as all co-occurring marijuana use motives (i.e., Enhancement, Conformity, Expansion, and Social subscales), were included as covariates at step 1, and moderate-intensity exercise was entered at step 2. Step 1 of the model revealed that a lower frequency of marijuana use was related to lower levels of marijuana use coping motives ( $\beta = .23; p < .01$ ). In addition, lower levels of conformity ( $\beta = .18; p < .05$ ) and expansion ( $\beta = .22; p = .01$ ) motives for marijuana use significantly predicted lower levels of marijuana use coping motives. In step 2, greater moderate-intensity exercise was significantly predictive of lower marijuana use coping motives ( $\beta = -.15; p < .05$ ).

Next, as a test of Path A (see Figure 1), a hierarchical linear regression was conducted to examine the association between moderate-intensity exercise (the predictor) and anxiety sensitivity (the proposed mediator). Here, greater moderate-intensity exercise was associated significantly with decreased anxiety sensitivity ( $\beta = -.22; p < .01$ ). Third, a hierarchical linear regression was conducted to examine Path B in the model (see Figure 1), that is, the link between anxiety sensitivity (the proposed mediator) and marijuana use coping motives (the criterion). Frequency of current marijuana use, as well as all of the other marijuana use motives and moderate-intensity exercise, were included as covariates at step 1, and anxiety sensitivity was entered at step 2. Step 1 of the model revealed that a lower frequency of

marijuana use ( $\beta = .22$ ;  $p = .01$ ), as well as lower levels of conformity ( $\beta = .17$ ;  $p < .05$ ) and expansion ( $\beta = .26$ ;  $p < .01$ ) motives for marijuana use, and greater moderate-intensity exercise ( $\beta = -.15$ ;  $p < .05$ ) significantly predicted lower levels of marijuana use coping motives. In step 2, lower levels of anxiety sensitivity significantly contributed to the prediction of lower levels of marijuana use coping motives ( $\beta = .30$ ;  $p < .01$ ).

The procedure proposed by Kenny, Kashy, and Bolger<sup>43</sup> was employed to test for mediation (see Table 2). As shown earlier, there was a significant association between the predictor (moderate-intensity exercise) and criterion (marijuana use coping motives), after controlling for marijuana use frequency as well as all other marijuana use motives (Path C; see analysis 1 in Table 2 and Figure 1). Next, the predictor (moderate-intensity exercise) was related to anxiety sensitivity (the proposed mediator; Path A; see analysis 2 in Table 2 and Figure 1). Third, after controlling for the predictor (moderate-intensity exercise), current marijuana use frequency, and all other marijuana use motives in step 1, the proposed mediator (anxiety sensitivity) was related to the outcome (marijuana use coping motives; Path B; see analysis 3 in Table 2 and Figure 1). Fourth, the relation between moderate-intensity exercise and marijuana use coping motives was reduced and rendered non-significant ( $\beta = -0.09$  versus  $-0.15$ ) by the inclusion of anxiety sensitivity in the model, indicating full mediation (see analysis 4 in Table 2). Finally, the significance of the mediated pathway was tested by using the distribution of products test.<sup>57,58</sup> The distribution of products test calculates the magnitude of the joint mediated pathway (the *A-B* pathway; see Figure 1) and the 95% confidence interval (CI) for this product (i.e.,  $a * b$ ). The CI ( $-0.000392$ – $-0.00041$ ) did not include zero and thus indicated significant mediation.<sup>59</sup>

## DISCUSSION

The present study examined the working hypothesis that moderate-intensity exercise is associated with coping-oriented marijuana use motives through its association with anxiety sensitivity. Using data from 146 adult marijuana users, we found evidence globally consistent with this hypothesis. Specifically, moderate-intensity exercise was significantly associated with coping-oriented use motives, even after controlling for theoretically relevant variables such as frequency of current marijuana use and co-occurring marijuana use motives, but this relation became non-significant after entering anxiety sensitivity as an additional predictor variable.

This is the first study that has examined direct and indirect relations between exercise and motives for marijuana use. The observed findings extend existing work demonstrating that (a) individuals who engage in moderate-intensity exercise experience reduced anxiety sensitivity;<sup>40–42</sup> (b) decreased levels of anxiety sensitivity are associated with a decreased motivation to use marijuana for coping reasons;<sup>11,36</sup> and (c) greater physical activity is associated with decreased use of marijuana.<sup>60–62</sup> Collectively, these findings support further investigation into moderate-intensity exercise as a potential intervention for marijuana use problems.

Overall, the present study provides novel data showing that moderate-intensity exercise is significantly associated with coping-oriented marijuana use motives and that this relation is mediated by reduced anxiety sensitivity. Theoretically, the present data suggest that the moderate exercise-marijuana coping motive association may, at least in part, be accounted for by anxiety sensitivity. The identification of anxiety sensitivity as a key mechanism in this relation serves as a potentially clinically important step in the elucidation of the pathways through which certain individuals are more prone to develop marijuana use problems or disorders. Here, it is particularly noteworthy that certain types or patterns of marijuana use (e.g., heavy usage) can be associated with panic psychopathology.<sup>24</sup> Future

work may benefit by exploring the role of anxiety sensitivity as a common mechanism in regard to influencing the association between marijuana use-panic psychopathology.

A number of limitations of the present investigation and points for future direction should be considered. First, the present study employed a cross-sectional design. Accordingly, we cannot make any inferences regarding the directionality of the observed relations. Although data are consistent with the hypothesis that moderate-intensity exercise is associated with reductions in coping oriented marijuana use motives by way of reductions in anxiety sensitivity, it is impossible to rule out alternative explanations. Indeed, it is possible that decreased exercise behavior is a consequence of marijuana use problems, perhaps due to lethargy associated with marijuana use. Hence, our work needs to be extended by developing studies that use experimental and longitudinal designs, allowing for tests of causality and temporal relations. Such studies should also focus on examining the potential of a dose-response relation between exercise and marijuana-use problems. The present study focused on the potential effects of moderate-intensity exercise on coping-oriented marijuana use motives, which was guided by previous work documenting a link between this level of exercise intensity and reduced anxiety sensitivity (the proposed mediator). Comparing the effects of moderate-intensity exercise to that of vigorous-intensity exercise in future studies would help guide the development of exercise-based interventions for marijuana use problems and provide useful data on the potential acceptability of such interventions. Second, the present sample is limited in that it is comprised of a relatively homogenous (e.g., primarily young, and Caucasian) group. Accordingly, our work can be extended by examining the observed relations in samples that are more representative of the U.S. adult population. Finally, shared method variance may have contributed to the observed results, because all measures were self-report. We recommend that future studies include objective assessment of physical activity (e.g., motion sensors, physiological monitoring), which would aid in the study of alternative or complementary mechanisms underlying the relation between exercise, anxiety sensitivity and marijuana use problems.

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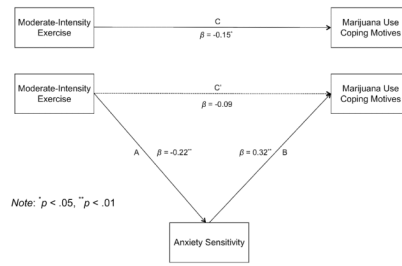
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**Figure 1.** Anxiety sensitivity as a mediator of the relation between moderate-intensity exercise and marijuana coping use motives.

**Table 1**

Descriptive Data for Predictor and Criterion Variables.

Variable Name	M (SD)	Range
Frequency of Marijuana Use	4.84 (2.49)	1.0–8.0
Moderate-Intensity Exercise	132.69 (175.41)	0.0–825.0
Anxiety Sensitivity	15.75 (8.05)	1.0–44.0
MMM - Coping	1.98 (0.94)	1.0–5.0
MMM - Enhancement	3.78 (0.98)	1.0–5.0
MMM - Social	2.51 (0.97)	1.0–4.6
MMM - Conformity	1.39 (0.52)	1.0–3.8
MMM - Expansion	2.23 (1.16)	1.0–5.0

**Table 2**

Hierarchical Multiple Regression Analyses Testing the Role of Anxiety Sensitivity in the Association Between Moderate-Intensity Exercise and Marijuana Use Coping Motives.

Independent Variable(s)	Dependent Variable	$\beta$	$t$
1 Marijuana Use Frequency (Step 1)	Marijuana Coping Motives	0.23	2.64**
Marijuana Enhancement Motives (Step 1)		0.10	1.03
Marijuana Social Motives (Step 1)		0.09	0.90
Marijuana Conformity Motives (Step 1)		0.18	2.40*
Marijuana Expansion Motives (Step 1)		0.22	2.58**
Moderate-Intensity Exercise (Step 2)		-0.15	-2.09*
2 Moderate-Intensity Exercise	Anxiety Sensitivity	-0.22	-2.66**
3 Marijuana Use Frequency (Step 1)	Marijuana Coping Motives	0.22	2.49**
Marijuana Enhancement Motives (Step 1)		0.10	1.08
Marijuana Social Motives (Step 1)		0.06	0.61
Marijuana Conformity Motives (Step 1)		0.17	2.22*
Marijuana Expansion Motives (Step 1)		0.26	3.01**
Moderate-Intensity Exercise (Step 1)		-0.15	-2.09*
Anxiety Sensitivity (Step 2)		0.30	3.97**
4 Marijuana Use Frequency (Step 1)	Marijuana Coping Motives	0.23	2.82**
Marijuana Enhancement Motives (Step 1)		0.10	1.06
Marijuana Social Motives (Step 1)		0.08	0.87
Marijuana Conformity Motives (Step 1)		0.07	0.87
Marijuana Expansion Motives (Step 1)		0.19	2.34*
Anxiety Sensitivity (Step 1)		0.32	4.34**
Moderate-Intensity Exercise (Step 2)		-0.09	-1.31

\*  $p < .05$ ,

\*\*  $p < .01$ ;

$\beta$  = Standardized beta weight;  $t$  =  $t$  statistic