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The Changes of the Cognitive and Psychomotor Functions in the Chronic Cannabis Users after a Month of Remission

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ABSTRACT:

The changes of the cognitive and psychomotor functions in the chronic cannabis users after a month of remission

Objective: In our study, it is aimed to investigate impacts of cannabis use on information processing and psychomotor functions and to examine changes in the cognitive functions at the end of abstinence over a month.

Method: The study was initiated with 34 volunteer participants using cannabis at least over two years, directed by a forensic unit. 34 persons were assessed at admission and were planned to assess after a month of remission. As 14 participants discontinued the study 20 participants only were assessed again at the end of a month. The participants were applied The Montreal Cognitive Assessment (MOCA) test, Edinburgh Handedness Inventory, Finger Tapping Test (FTT), Adult Memory and Information Processing Battery (AMIPB) A and B, and simple reaction time tests (auditory and visual) in admission and were applied Finger Tapping Test (FTT), Adult Memory and Information Processing Battery (AMIPB), and simple reaction time tests (auditory and visual) at the end of a month.

Results: There was no statistically significant difference between participants continue to the treatment and those discontinue in terms of sociodemographic and clinical characteristics. The participants discontinue were using more daily cannabis dose. The auditory reaction time of the group continue to the treatment decreased statistically significantly after a month whereas there was no statistically significant difference in the visual reaction time. The scores of the AMIPB-A and AMIPB-B were detected statistically higher after a month compared to admission. The score of the dominant hand FTT after a month was detected statistically higher than that in admission whereas there was no statistically significant difference in the non-dominant hand score.

Conclusion: Improvements in scores of AMIP-A, AMIP-B, FTT and auditory reaction time after one month of quitting cannabis suggest that cannabis use may impair cognitive functions such as information processing, reaction time and motor functions. We suggest that future studies to assess cognitive functions after either a shorter (i.e. 1 week) or a longer (i.e. 2 months) period of cannabis abstinence in larger samples may provide further useful data about the relationship between cannabis use and cognitive functions.

Keywords: cannabis, remission, cognitive functions, psychomotor functions

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INTRODUCTION

Cannabis is one of the most frequently used substances all over the world. According to the data of World Health Organization, 3% of the adult population of world abuse cannabis[1]. In the United States, 2 to 3 million new users are introduced to cannabis each year, and two thirds of these are between 12-18 years of age[2,3]. One of every 12 subjects who use cannabis becomes addicted[4]. At

present, there are no effective treatments for cannabis abuse/dependence. Behavioral therapies are effective to some extent[5]. It may lead to acute and chronic health problems1. Active cannabis compounds have 64 different isomers (cannabinoids) and each of these has various effects on human health and behavior[6].

Many studies reported that chronic cannabis use leads to cognitive dysfunction. It has been stated that cognitive dysfunction due to cannabis use is generally associated with acute consumption[7,8]. Attention, working memory, verbal learning, and memory are among the most affected cognitive functions[9-11]. Those studies have methodological differences. In general, the patients are taken to a detailed examination after a short period of soberness (17-72 h). Yet the half life of delta-9 tetrahydrocannabinol (THC) has been measured to be 4.1±1.1 day on average in chronic users[12]. Therefore, it is not possible to understand whether these effects were resulting from THC residue remaining in the body of patients, or from withdrawal symptoms such as irritability and anxiety, or from its effects on the brain[13]. In another study, Pope and colleagues[14] grouped patients based on the dose and performed memory tests on Day 0, 1, 7, and 28. The authors stated that cognitive functions recovered on Day 7. This period is consistent with wash out period of THC residues.

The first cannabis use usually occurs during early ages and, development and the severity of cognitive dysfunction is related with early starting age[15]. During adolescence period, the higher potential for developing addiction or the more severe addiction may be related with this. Another explanation suggested that cannabis exposure to developing brain may result in permanent structural and functional changes[16]. Therefore, recently the impacts of cannabis use during adolescent period has been examined separately from cannabis use in adulthood[8].

There are studies suggested that cognitive side effects are related with the dose. For instance, deficits may be irreversible in heavy users[17]. In another study, it has been reported that cognitive and psychomotor performance involvements were proportional to daily amount of consumption[18]. In this study, reaction time and motor control worsened with increasing doses of THC. On the other hand, it has been demonstrated that deficits may recover after four weeks without cannabis, and may be intractable when the daily dose is very high[17]. Similarly, another study reported that resistant impairments may be seen in attention, memory and executive functions of individuals who consume higher doses[11] and partial recovery may be achieved[19]. A meta-analysis revealed that semantic memory disorders were the latest recovered or persistent disorder among cognitive dysfunctions resulted from chronic cannabis use[20].

As mentioned above, previous studies on the impacts of cannabis use focused on executive functions, attention, and memory. Therefore, in this study we aimed to examine the impacts of cannabis use on information processing and psychomotor speed. We also planned to examine the changes in these cognitive functions after quiting cannabis. Information processing and psychomotor speed are cognitive fields closely related with the integrity of neuronal circuits[21]. In addition, tests for evaluating these functions are more convenient for follow up studies and repeated applications have lesser problems than the other tests.

METHOD

This study included 34 participants among those who were arrested with cannabis, underwent legal judgement and directed to AMATEM Clinics (Alcohol and Drug Research, Treatment and Training Center), Bakırköy Training and Research Hospital, Department of Psychiatry, Neurology and Neurosurgery, under forcement of Supervised Probation Office. They were all diagnosed with cannabis abuse/dependence according to the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I). Subjects who were admitted to the AMATEM Clinics were invited to the study, and volunteers who were using cannabis on daily basis at least the last two years were included to the study. Three participants were taking 30 mg/day mirtazapine and two participants were taking 50

mg/day quetiapine for problem falling asleep, one participant was taking 300 mg/day bupropion for smoking cessation and rest were taking no medication. Interviews related to cannabis use with all participants who continued were performed once every week during a month. The Ethics Committee approval was obtained before the study, all patients were informed about interviews and tests. They were assured that this procedure would not lead to any positive or negative change in treatment and control programs. Finally, verbal and written informed consents were obtained.

According to the study protocol, MOCA cognitive screen test and Edinburgh Hand Preference Inventory, to determine the dominant hand, were applied to the participants. Then, Finger Tapping Test (FTT), simple reaction time to verbal and visual stimuli (RT), Adult Memory and Information Processing Battery (AMIPB-A and B) were applied. One month later, FTT, RT (verbal and visual), and AMIPB-A and B tests were planned for comparison, but 8 patients continued to smoke cannabis and did not come to control visit, another 6 patients dropped out due to positive urine drug tests. Thus, comparison of initial tests to one month control tests included 20 volunteers.

Exclusion criteria were presence of morphological deformity or functional disability in one extremity (atrophic weakness, innervation problems, etc.), asymmetrical vision defect and amblyopia, alcohol or other substance abuse disorder, positive urine test for metabolites other than cannabis, significant impairment of cognitive functions verified by MOCA (8 patients were excluded due to scores less than 21 that was recommended as the cut off value), significant impairment of sleep duration and quality, heavy drug use that may affect reaction time.

MATERIALS

A standard form containing information such as age, gender, educational status, family , and profession was used in order to collect sociodemographic data of participants. Following that form, another questionnaire containing cannabis information such as duration, amount, frequency, and starting age of use was completed. Diagnoses were evaluated by a structured interview according to DSM-IV (SCID-I)[22,23] and all participants underwent cognitive evaluation. Cognitive assessment tests that are described in the following section were administered. Researcher psychiatrists (GU, HYC and OH) were trained by an experienced neuropsychologist (CK) to use detailed cognitive tests. Each researcher surely administered the tests for 5 times before applying it by themselves.

Urine metabolite screen tests were performed by using semiquantitative CEDIA device of toxicology laboratory of the hospital and the threshold value of 50 ng/mL was accepted positive for cannabis.

MOCA

MOCA includes visuo-spatial functions, executive function, attention, memory, working memory, speaking and abstract thinking test elements. It is a sensitive tool in diagnosis of mild cognitive impairment and mild cognitive insufficiency[24,25]. Sensitivity and specificity of MOCA test were found better than Mini Mental State Test[24]. It may be used in various clinical conditions in neurology and psychiatry. Individuals with a MOCA score lower than 21 were excluded from the study.

Edinburgh Hand Preference Test

It is aimed to determine hand preference by using a Likert scale[26]. This includes hand preference during handling of scissors, knife or spoon besides catching a ball and hand writing. In order to increase reliability, assumptions (cutting with scissors, cutting bread with a knife) may be useful.

Finger- Tapping Test

This test measures swing speed of index finger (manual motor speed). Participants are asked touch a button as quick as possible with their index finger of dominant and non-dominant hands for

10 seconds. The procedure, in order to prevent the over-effect of outliers on score, includes 5 consequent trials with both hands[27]. The test allows maximum ten trials and a trial is cancelled when the difference from previous trials is more than 5 point. There are various finger tapping devices which may lead to variations in results. In our study, we used the device of PARINC® and it was adapted especially for the counting.

Adult Memory and Information Processing Battery (AMIPB)

AMIPB aims to measure information processing by taking motor speed into account. Run speed may determine reaction time. In the first trial, according to instructions recommended by Coughlan and Hollows[28] (A form), the participant is asked to find the second highest number among 5 numbers. In the second trial (B form), the participant is asked to find redundant number on the right side among two different group of numbers separated by a line. Four minutes time limitation is recommended for each form.

An example of AMIPB form

AMIPB-A	AMIPB-B
23 17 88 84 56	5 8 3 - 3 8 4 5
46 52 65 75 77	2 7 4 5 - 6 7 4 5 2

Reaction Time Test

For a simple reaction time test, visual and verbal stimuli (ten for each) were given by using a computer program[29]. In order to prevent expectation effect, the stimuli were randomized to 1 to 6 second time intervals. Recordings of response intervals and reporting (the mean scores) were made by a computer program. Participants were asked to press the space bar as soon as possible when they receive the stimulus (verbal or visual). The highest and the lowest values were analyzed as outlier scores may affect the mean values. In case of extreme values, the participant repeated the test.

Visual: A 22" LED monitor (Samsung model BX2231) was used to expose visual stimuli. Refresh speed of this monitor was 75 Hz, brightness 250 cd/m^2 and reaction time 2 millisecond. Stimulus was a 6x10 cm green rectangle placed on a orange-coloured background.

Sound: As in the visual stimulus, the same software was adapted for sound stimulus. A white screen and bilateral speakers were used. Speakers were adjusted to 80 dB and 1500 Hz frequency for sound stimulus.

According to the study protocol, first, all participants underwent MOCA cognitive screen test, and Edinburgh Hand Preference Inventory to determine dominant hand. Then, finger tapping test (FTT), simple reaction time test (RT, sound and visual), adult memory and information processing battery (AMIPB-A and B) were applied. One month later, FTT, RT, AMIPB (AMIPB-A and AMIPB-B) repeated. Of the 34 participants, 8 subjects did not come to follow up visit and 6 patients had positive urine test for cannabis metabolites. These participants were dropped out and comparisons between initial measurements and one-month measurements included 20 subjects.

Statistical Analysis

The data were analyzed by using SPSS 15.0 for Windows software package. Besides descriptive statistics (median, 25-75% values, percents and frequencies), we performed Chi-square test to investigate the relationship of categorical variables, and Mann-Whitney U test for continuous variables of independent groups when they are not normally distributed, and Wilcoxon Signed Ranks Test for dependent groups. Spearman's rho correlation analysis was conducted between tests of cognitive functions and psychomotor function. Multiple regression analysis was performed to predict scores of AMIPB-A, MOCA and FTT from age, duration of education, used cannabis as gram/day and duration of cannabis use. Significance level for Spearman's rho correlation analysis was accepted as $p<0.01$, and for the remaining analyses as $p<0.05$.

RESULTS

Table 1 shows comparison of the groups compliant to the treatment (n=20) or not (n=14) in terms of sociodemographic characteristics and cannabis use. The study included 34 participants aged between 21 to 52 years. The median age, the median age of first use and the median age of regular use of participants were 27 (25-31), 17.50 (15-22), and 21 (18.75-24.25), respectively. The median daily consumption and duration of use were 3 g (2-3.25) and 8 (5-12) year, respectively. The mean duration of education was 8.50 (5.75-12) years. Of the participants, 20 (58.82%) attended and completed the program, whereas 14 (41.18%) subjects quit the treatment. Compliant and non-compliant groups were comparable in terms of age, marital status, employment, duration of education, route of cannabis use, duration of use, the age of first use, age of regular use and withdrawal symptoms and no statistically significant differences were found (p>0.05). The amount of daily cannabis consumption was higher in non-compliant group and the difference was statistically significant (p=0.012) (Table 1).

Reaction times, MOCA scores, AMIPB-A, AMIPB-B, dominant hand and non-dominant hand finger tapping tests were similar in compliant and non-compliant groups (p>0.05) (Table 2).

Wilcoxon Signed Ranks Test revealed that comparison of the median reaction time to sound stimulus was statistically significantly different between initial measurements and one-month measurements in compliant group (p=0.003) whereas reaction time to visual stimulus was non-significant (p=0.076). Reaction time to sound stimulus had reduced during one month treatment. Comparison of AMIPB scores showed that AMIPB-A and AMIPB-B scores after

Table1: Comparison of sociodemographic characteristics and cannabis use in compliant and non-compliant groups

	Continuation to Treatment				
	No		Yes		
	n=14	%	n=20	%	p
Marital status					0.928
Single	10	71.42	14	70.00	
Married	4	28.58	6	30.00	
Employment					0.379
Employed	13	92.86	16	80.00	
Unemployed	1	7.14	4	20.00	
Type of consumption					0.251
Smoking	14	100.00	17	85.00	
Bucket and smoking	0	0.00	3	15.00	
Cessation attempt	12	85.71	19	95.00	0.555
Positive withdrawal symptoms	11	78.57	14	70.00	0.577
Withdrawal symptoms					
Irritability/nervousness	10	71.42	13	65.00	0.693
Sleeplessness	6	42.85	8	40.00	0.868
Nausea	0	0.00	1	5.00	1.000
Loss of appetite	2	14.28	2	10.00	1.000
	[e]Median (25-75% values)		[e]Median (25-75% values)		
Age	27.50 (24.75-31.00)		27.00 (25.00-29.75)		0.847
Education duration	9.00 (5.75-12.50)		8.00 (5.50-10.75)		0.547
Cannabis amount (gr/d)	3.00 (2.75-4.00)		2.00 (1.25-3.00)		0.012*
Duration of use (year)	9.50 (6.50-15.50)		8.00 (4.25-10.75)		0.291
Age of the first use	16.00 (14.75-20.00)		18.00 (16.00-25.25)		0.134
Age of regular use	21.00 (17.75-24.25)		21.00 (19.00-25.50)		0.673

Chi-Square Test, [e]Mann-Whitney U Test, p<0.05*

Table 2: Comparison of reaction time scores and results of cognitive performance tests between the compliant and non-compliant groups

	Continuation to Treatment		
	No (n=14)	Yes (n=20)	
Test Scores	Median (25-75% values)	Median (25-75% values)	p
Sound reaction time	0.240 (0.220-0.265)	0.225 (0.220-0.260)	0.385
Visual reaction time	0.275 (0.257-0.295)	0.265 (0.252-0.297)	0.832
MOCA total score	23.50 (21.00-26.50)	24.00 (21.25-26.00)	0.944
AMIPB-A	71.50 (55.75-80.50)	58.00 (50.50-73.25)	0.132
AMIPB-B	69.50 (57.75-79.50)	61.50 (48.00-73.00)	0.327
FTT, dominant hand	50.20 (46.50-52.90)	48.80 (44.90-51.55)	0.354
FTT, non-dominant hand	45.80 (44.00-48.70)	46.30 (41.95-48.55)	0.861

Mann-Whitney U test, p<0.05*. AMIPB-A: Adult Memory and Information Processing Battery-A, AMIPB-B: Adult Memory and Information Processing Battery-B, MOCA: The Montreal Cognitive Assessment, FTT: Finger Tapping Test.

Table 3: Comparison of test scores between initial and one-month measurements in compliant group (n=20).

	Before quitting cannabis	1 month after quitting cannabis	
Test Scores	Median (25-75% values)	Median (25-75% values)	p
Sound reaction time	0.225 (0.220-0.260)	0.220 (0.202-0.230)	0.003*
Visual reaction time	0.265 (0.252-0.297)	0.240 (0.222-0.280)	0.076
AMIPB-A	58.00 (50.50-73.25)	64.50 (57.00-81.75)	0.021*
AMIPB-B	61.50 (48.00-73.00)	68.50 (50.00-82.00)	< 0.001*
FTT, dominant hand	48.80 (44.90-51.55)	52.40 (50.05-54.00)	< 0.001*
FTT, non-dominant hand	46.30 (41.95-48.55)	47.30 (44.10-50.55)	0.184

Wilcoxon Signed Ranks Test, p<0.05* . AMIPB-A: Adult Memory and Information Processing Battery-A, AMIPB-B: Adult Memory and Information Processing Battery-B, FTT: Finger Tapping Test.

Table 4: Correlations between cognitive and psychomotor function, (n=34)

Correlations	Correlation Coefficient	p
FTT-AMIPB-A	0.445	0.008*
FTT-AMIPB-B	0.489	0.003*
FTT-MOCA	0.523	0.001*

Spearman's rho correlation, p<0.01*. AMIPB-A: Adult Memory and Information Processing Battery-A, AMIPB-B: Adult Memory and Information Processing Battery-B, MOCA: The Montreal Cognitive Assessment; FTT: Finger Tapping Test.

one-month treatment were higher than initial values and the difference was statistically significant (p=0.021, p<0.001, respectively). The number of taps with dominant hand was higher after one-month and the difference was statistically significant (p<0.001), whereas number of taps with non-dominant hand was similar through the treatment period (p=0.184) (Table 3).

Spearman's rho correlation analysis was conducted between tests of cognitive function and psychomotor function. Moderate correlations were found among mentioned variables. The result of a Spearman's rho analysis indicated a statistically significant positive association between AMIPB-A and FTT; $\rho(32)=0.445$, p=0.008, between AMIPB-B and FTT; $\rho(32)=0.489$, p=0.003, and between MOCA and FTT; $\rho(32)=0.523$, p=0.001 (Table 4). Multiple regression analysis was run to predict scores of AMIPB-A, MOCA and FTT from age, duration of education, used cannabis as gram/day and duration of cannabis use. Age and duration of education from these variables statistically significantly predicted AMIPB-A score; $F(4, 29)=2.931$, p=0.038, $R^2=0.288$. Duration of education statistically significantly predicted MOCA score; $F(4, 29)=2.945$, p=0.037, $R^2=0.289$ and as well as statistically significantly predicted FTT score; $F(4, 29)=3.480$, p=0.019, $R^2=0.324$ (Table 5).

Table 5: Multiple linear regression analyze of tests of cognitive functions and psychomotor function (n=34)

	B	p	R^2	F	p	%95 Confidence Interval for B	
						Lower Bound	Upper Bound
Model-AMIPB-A			0.288	2.931	0.038*		
Constant	6.961	0.701				-29.757	43.680
Age	1.295	0.037*				0.080	2.509
Duration of education	2.312	0.009*				0.625	3.998
Model-MOCA			0.289	2.945	0.037*		
Constant	14.507	0.001*				6.472	22.542
Duration of education	0.534	0.006*				0.165	0.903
Model-FTT			0.324	3.480	0.019*		
Constant	33.328	0.001*				21.746	44.910
Duration of education	0.916	0.001*				0.384	1.448

Dependent variables, AMIPB-A: Adult Memory and Information Processing Battery-A, MOCA: The Montreal Cognitive Assessment, FTT: Finger Tapping Test. Independent variables, age, duration of education, used cannabis as gram/day and duration of cannabis use. $p<0.05$*

DISCUSSION

Compliant and non-compliant groups were similar in terms of cognitive functions initially and subjects with a higher amount of daily cannabis consumption were non-compliant. Deficits in MOCA test appeared mostly in memory subfield and attention subfield (counting backwards starting from 100 by sevens up to 5 levels). Those subjects might not be aware of their condition as their cognitive functions were impaired more than the others. This might lead to non-compliance to the treatment. Studies which reported irreversible cognitive loss[17] and significant relationship between cognitive and psychomotor performance deficits and daily amount of consumption[18] support this finding. In our study, significant improvements in information processing, reaction time, and motor functions only one-month after quitting cannabis use may suggest negative impacts of cannabis on these cognitive functions and abilities. In literature, there are studies that reported improvement in cognitive functions one-month after quitting cannabis, and our findings support those of previous reports[17,19]. Eight subjects with a MOCA score lower than 21 were excluded and the mean score of included subjects was close to 24 which is only 3 points less than 21, the cut-off value for dementia. Atagun and colleagues[30] studied the effects of lateralization on motor and mental speed in 68 euthymic bipolar patient and 65 healthy controls and found the mean MOCA total scores of 26.8 and 27.3, respectively. The mean MOCA total score in our study is lower than those of both healthy subjects and bipolar patients in their study.

Information processing is described as the fundamental aspect of concentration and attention, and also the building stone of higher cognitive functions[31]. Attention, working memory, response inhibition, affective processes, decision-making and goal-oriented behaviors are functions ascribed to prefrontal cortex[32]. It has been shown that regional cerebral blood flow (rCBF) was reduced in prefrontal cortex of cannabis abusers[33]. It was found that acute cannabis exposure was associated with functional alterations in prefrontal cortex, an area cannabinoid receptors are concentrated[34]. Cannabinoids exert their effects through specific endogenous cannabinoid receptors such as CB1 and CB2[35]. CB1 receptor density is high especially in brain regions involved in memory and learning such as prefrontal cortex, hippocampus, basal ganglia, anterior cingulate, and cerebellum[36,37]. Studies in mice showed that lack of CB1 receptors had a sophisticated memory function[38]. Solowij et al.[11] found that information processing evaluated by paced auditory serial addition test was worse in long-term cannabis users than in short-term users or no users. Frontal Assessment Test, a neurocognitive function test, showed worse performance of cannabis users when compared to

controls[39]. AMIPB-A and AMIPB-B, tests for evaluating information processing, assess working memory, attention, sustained attention, comparison, which are mainly the functions of premotor frontal region[28,32]. These tests were previously used to evaluate information processing in patients with multiple sclerosis[40], Parkinson's disease[41] and bipolar disorder[30]. In this study, they were used to evaluate cognitive dysfunction due to cannabis use for the first time. When information processing performances were compared, AMIPB-A and AMIPB-B test scores significantly increased in compliant group at the end of one-month abstinence. In the study of Kelleher[42], Inspection Time test was used to assess information processing in 22 heavy cannabis users and pre- and post-smoking (20-30 min later) results were compared. Cannabis users had lower IT test scores before smoking cannabis when compared to controls, and they showed insufficiency in information processing. In a study, it was reported that cognitive functions fully recovered at the end of 4 weeks without cannabis use[17], and another study suggested permanent cognitive dysfunction especially in attention, memory and executive functions[43]. Another study reported partial improvement in cognitive functions[19]. These controversial results about the effects of cannabis on cognitive functions may be due to duration of cannabis use, the amount of exposure, cannabis consumption pattern before tests, and differences in test protocols. Our results are in accordance with studies reported full or partial recover.

It has been shown that reaction time is related with cognitive functions in healthy controls and with cognitive functions and quality of life in malnutrition patients[44]. Kelly et al.[45] examined the effects of cannabis on driving performance and found impaired reaction time in chronic cannabis users. We found a significant decrease in reaction time to sound stimulus after one-month abstinence whereas a decrease in reaction time to visual stimulus was not significant. Cannabis was reported to slow reaction time, impair motor coordination, and cause negative impacts similar to that of alcohol and benzodiazepines[35]. Cannabinoids may inhibit GABA release in striatum, and GABA and glutamate release in some other basal nuclei. Exogenous cannabinoids may lead to reduced GABA secretion from substantia nigra and motor inhibition[46]. Besides, CB1 antagonism was shown to be related with increased locomotor activity[47]. Chronic cannabis use was found to be related with impaired psychomotor speed even after 28 days withdrawal[17]. Similarly in our study, finger tapping test for psychomotor speed revealed significantly higher scores after one-month sobriety. Reduction in GABA release through CB1 receptor activity in related brain regions may be involved in this reduction of psychomotor speed. A study suggested that structural changes of lower regional callosal fibers may be responsible for age-related bimanual motor reduction[48]. Considering that this study, we found faster motor movement after one-month abstinence and this may be due to reversible changes in lower regional callosal fibers induced by cannabis. This should be verified by advanced imaging methods in cannabis users. We found significant increase in motor speed and this was parallel to previous studies reporting negative impacts of cannabis on motor function. Additionally, we found that age and duration of education could predict cognitive function tests (in the study AMIPB-A and MOCA). Similar to our study, Tripathi et al.[49] found that age and duration of education were neurocognitive test performance determinants and suggested that traditional measures of planning and working memory should be avoided or used cautiously in the presence of low education. Duration of education also predicted psychomotor function and this may be due to positive correlation between cognitive functions and psychomotor function as we have demonstrated in the present study.

We consider that lack of a comparison with the healthy control group and relatively small sample size are the limitations of our study.

CONCLUSION

In our study, significant improvements in information processing, auditory reaction time

and motor functions only one-month after quitting cannabis use suggest that cannabis may impair cognitive functions, motor functions, and response to stimulus. This situation may be important in activities such as driving which require attention and response to stimulus. In addition, improvements in both cognitive and motor functions after one month of quitting cannabis may indicate that these effects are related to the common effect on brain activity that might influence different brain functions and networks rather than a degenerative process.

Of the 34 participants, 14 subjects quit the treatment and the amount of daily cannabis consumption was higher in this non-compliant group and this may point out that we need to pay more attention in case of high amounts of cannabis use. In these cases, it is of great importance that the family or partner takes part in the treatment process in order to support the patients to continue with the treatment program. The nature of effects of cannabis on cognitive functions, whether permanent or transient, is controversial. Thus, studies with shorter versus longer follow up (i.e., 1 week versus 2 months) should be performed. In addition, we considered that neuroimaging studies and studies compared with healthy controls may guide future studies.

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