

## Effects of physical exercise on quality of life and memory in drug users\*

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**Objective:** to analyze changes in cardiorespiratory fitness, perception of quality of life and memory of users of alcohol and other drugs, being treated, in a Therapeutic Community, after the application of a Physical Exercise Program (PEF).

**Method:** 33 adult men with a mean age of 37 years ( $\pm$  6.32) participated, divided into two groups: Intervention group (n = 19) who participated in the PEF and control group (n = 14) who did not participate. The evaluations were made at the beginning and at the end of the eight weeks of the PEF. **Results:** the increase in VO<sub>2</sub>máx in the group that participated in physical PEF was approximately 13 times greater than in the control group. In memory, PEF participants obtained a gain of more than approximately 16% when compared to the control group. In the perception of quality of life, the differences were on average 16% greater in the group that participated in the PEF, reaching 21% in the domain regarding the perception of the environment they were in. **Conclusion:** a PEF collaborates positively in improving the rehabilitation of cognitive processes of learning and memory, and in the perception of the quality of life of individuals undergoing treatment.

**Descriptors:** Quality of Life; Drug Users; Recurrence; Exercise.

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## Efeitos do exercício físico na qualidade de vida e na memória de usuários de drogas

**Objetivo:** analisar as alterações da capacidade cardiorrespiratória, percepção da qualidade de vida e memória de usuários de álcool e outras drogas em tratamento, em uma Comunidade Terapêutica, após a aplicação de um Programa de Exercícios Físicos (PEF). **Método:** participaram 33 homens adultos, com média de idade de 37 anos ( $\pm 6,32$ ), distribuídos em dois grupos: grupo de intervenção (n=19), que participaram do Programa de Exercícios Físicos, e grupo-controle (n=14), que não participaram. As avaliações foram feitas no início e no final das oito semanas do Programa de Exercícios Físicos. **Resultados:** o aumento do Volume Máximo de Oxigênio Metabolizado pelo Organismo no grupo que participou do Programa de Exercícios Físicos foi aproximadamente 13 vezes maior que no grupo-controle. Na memória, os participantes do Programa de Exercícios Físicos obtiveram um ganho a mais de aproximadamente 16% quando comparados aos do grupo-controle. Na percepção da qualidade de vida, as diferenças foram, em média, 16% maiores no grupo que participou do Programa de Exercícios Físicos, chegando a 21% no domínio referente à percepção do ambiente que estavam. **Conclusão:** um Programa de Exercícios Físicos colabora positivamente na reabilitação dos processos cognitivos de aprendizagem e memória e na percepção da qualidade de vida dos indivíduos em tratamento.

**Descritores:** Qualidade de Vida; Usuários de Drogas; Recidiva; Exercício Físico.

## Efectos del ejercicio físico sobre la calidad de vida y la memoria de los usuarios de drogas

**Objetivo:** analizar cambios en la aptitud cardiorrespiratoria, percepción de la calidad de vida y memoria de los consumidores de alcohol y otras drogas, en tratamiento, en una Comunidad Terapêutica, luego de la aplicación de un Programa de Ejercicio Físico (PEF). **Método:** participaron 33 hombres adultos con una edad media de 37 años ( $\pm 6,32$ ), dividido en dos grupos: grupo de intervención (n = 19) que participaron en el PEF y grupo control (n = 14) que no participaron. Las evaluaciones se realizaron al inicio y al final de las ocho semanas del PEF. **Resultados:** el aumento de VO<sub>2</sub>máx en el grupo que participó en PEF físico fue aproximadamente 13 veces mayor que en el grupo control. En la memoria, los participantes de PEF obtuvieron una ganancia de más de aproximadamente el 16% en comparación con el grupo de control. En la percepción de la calidad de vida, las diferencias fueron en promedio 16% mayores en el grupo que participó en el PEF, alcanzando el 21% en el dominio con respecto a la percepción del entorno en el que se encontraban. **Conclusión:** un PEF colabora positivamente en la mejora de la rehabilitación de los procesos cognitivos de aprendizaje y memoria, y en la percepción de la calidad de vida de las personas en tratamiento.

**Descriptores:** Calidad de Vida; Consumidores de Drogas; Recurrencia; Ejercicio Físico.

## Introduction

The use and abuse of alcohol and other drugs has been a factor with negative impact on the various areas that influence the Quality of Life (QOL) of people around the world<sup>(1)</sup>. The users of these substances face physical, psychological and behavioral changes, which negatively influence their lives<sup>(2-3)</sup>.

The direct and indirect effects of substance use considerably reduce QOL and are responsible for a large number of preventable deaths<sup>(4)</sup>. In 2018, an estimated 35.6 million people, representing approximately 0.8% of the global adult population, were estimated to have drug use disorders, including addiction<sup>(5)</sup>.

Emerging evidence suggests that cocaine users may have deficits in several cognitive domains, which may include verbal and working memory and executive functions<sup>(6)</sup>. The changes caused by alcohol and psychoactive substance use cause mainly deficits related to memory and visual and spatial functions. Substance use-related memories can be triggered by exposure factors to the drug or to drugging environments<sup>(7)</sup>. Healthy changes in behavior, habits and lifestyle, such as body mass control and physical exercise, can positively contribute to future memory re-learning, as well as improve physical health and influence the proposed treatment<sup>(8)</sup>.

Given the importance of memory deficits in perceived QOL<sup>(9)</sup>, creating effective methods, based on the results and impacts that studies with interventions and physical exercise programs provide in the re-establishment of cognitive and executive functions, as well as developing PEF models adapted to different types of populations, aiming at re-establishing memory, can provide positive results in the perception of QOL.

Physical exercise has proven to be a non-pharmacological strategy with excellent results in improving the QOL of the population of alcohol and other drug users. Improvements in physical function (approximately 5%), social functioning (approximately 46%), mental health (approximately 47%), and general health (approximately 23%) were found in studies with exercise program interventions<sup>(10)</sup>. Physical exercises also produce positive results in the perception of physical and mental health of users in rehabilitation, even if they suffer from a greater severity of dependency<sup>(11)</sup>.

During the therapeutic rehabilitation program, craving, which is the extreme desire to use the preferred substance, is a factor that can end up being a determinant of relapse. There is evidence that exercise interventions can decrease craving for the drug and the negative mood related to withdrawal<sup>(12)</sup>. This reduction in craving for the substance of choice is a basic condition for increasing the length of time in the maintenance of sobriety<sup>(13)</sup>.

In view of the above, this study aimed to evaluate the changes caused by physical exercise in cardiorespiratory

capacity, memory and perception of QOL of alcohol and other drug users in treatment after the intervention of a Physical Exercise Program (PEF).

## Method

This was a prospective longitudinal controlled study. To participate in the study, subjects had to have been in treatment for at least 30 days, to ensure that they had already gone through the severe period of detoxification<sup>(14)</sup>. The intervention group was defined by the participants who agreed to participate in the PEF and those who did not agree to participate in the PEF formed the control group.

Exclusion criteria were those individuals who self-reported any physical difficulty that made it impossible to perform the physical exercises required in the program or who said yes to one of the questions in the Physical Activity Readiness Questionnaire (PAR-Q).

The groups that comprised the study, control and intervention, were defined after data collection regarding the variables that would be evaluated and compared. At the end of the eight weeks of the intervention period, all the tests mentioned above, the questionnaires and the form were applied again to all the participants, both in the intervention and control groups. The control group maintained, during the study, the normal activities of the therapeutic program; however, the individuals were instructed not to do the physical exercises that comprised the PEF and could influence the variables analyzed.

Thirty-three adult men, aged between 23 and 54 years, who were part of a rehabilitation program for alcohol and other drug users in a therapeutic community, participated in the research. The research was submitted for ethical review through *Plataforma Brasil*, and approved under CAAE: 68250617.8.0000.5689 and Opinion number: 2.072.245. All participants agreed to take part in the research and signed the Free and Informed Consent Term (FICT).

To evaluate the physical condition of the participants, the Physical Activity Readiness Questionnaire (PAR-Q), developed by the Canadian Society for Exercise Physiology and recommended by the American College of Sports Medicine (ACSM), was used<sup>(15)</sup>. The questionnaire consists of seven yes/no questions that are easy to read and understand. It aims to exclude the individual who answers yes to any of the questions in the questionnaire, thus reducing the risks during the execution of physical exercises<sup>(15)</sup>.

The participants' mass was measured with a digital scale calibrated for up to 180 kg with graduation from 100 to 100 grams.

Assessments of cardiorespiratory capacity were made by measuring the Maximum Oxygen Volume Metabolized by the Body (VO<sub>2</sub>max). For this, the Rockport One-Mile

Walk Test was used, which comprises an active walk that elevated the Heart Rate (HR) at the end of the test<sup>(15)</sup>.

1<sup>st</sup>. The individual walked one mile (1,609.34 meters) as fast as possible along a predetermined route. The walk did not turn into a run, and one of the lower limbs was in contact with the ground at all times, that is, there was no aerial phase. The time period to cover the mile was recorded.

2<sup>nd</sup>. Immediately after the completion of the one-mile walk, HR was taken. HR was obtained by manually counting the pulse for 15 seconds and multiplied by four to determine the total Beats *Per Minute* (BPM).

The participants' perception of QOL was evaluated using the World Health Organization Quality of Life-Bref (WHOQOL-bref) form, following all the pre-established protocols for its application<sup>(16)</sup>. With answers that follow a Likert scale from one to five and scores calculated separately in each set of questions, called Domains, and converted to a scale from zero to 100, the WHOQOL-bref was validated in the Brazilian version<sup>(17)</sup> and presented satisfactory internal consistency, test-retest reliability and discriminant, criterion and concurrent validities<sup>(18)</sup>. The test has a total of 26 questions, with two questions addressing QOL and general health, and another 24 distributed in four domains: Physical; Social; Psychological and Environmental<sup>(19)</sup>.

### Memory assessment

To assess participants' memory, the Hopkins Verbal Learning Test or The Hopkins Verbal Learning Test (HVLT) was used. The HVLT-R has high test-retest reliability and its constructive, concurrent and discriminant validity are well established<sup>(20)</sup>. The test consists of a list of 12 names: four words for each of three semantic categories. First, the Immediate or Learning Memory Trial occurs, when the list is read to the participants three times, and each time the participant is instructed to memorize as many words as they can and then recall them. The second is the Delayed Memory Trial, administered 20 to 25 minutes after the reading of the previous trial, in which the participant is instructed to recall the words from the previous trial without reading them again. And the third is the Late Recognition Trial, in which 12 words are added, six of which are semantically related to the previous ones, and all of which are read at random. The participant is instructed to answer yes if the word belongs to the initial list and no if it does not belong to the initial list<sup>(21)</sup>.

The PEF applied to the participants of the intervention group: 16 training sessions, two per week, during eight weeks. It had two training methods, one with a circuit of functional multi-articular exercises, such as squats, jumping, weightlifting, running, among others, and the

other with team sports (soccer). One session of each method per week was done, totaling two weekly sessions.

In the circuit training method, multi-articular/multisegment, asymmetrical, and multi-plane exercises performed with base instability were used. This type of exercise, called functional exercise, provides stimuli to improve the musculoskeletal structures and provides balance to the muscles of the abdominal, lumbar, and pelvic regions, directly influencing proprioception, body/posture perception, balance, agility, and strength production<sup>(22)</sup>. Functional exercises aim to integrate physical capabilities and physiological systems through integrated and combined training<sup>(23)</sup>.

In order to obtain an improvement in functional strength and greater adherence to PEF, the exercises were applied according to the high-intensity interval training (HIIT) method<sup>(24)</sup>. The validated protocol used was the Tabata High Intensity Intermittent Training protocol<sup>(25)</sup>, adapting the intensity according to the capacity of the participants. Studies done with the application of this training method suggest expressive improvements in the aerobic and anaerobic capacity of practitioners<sup>(26)</sup>.

The exercises were applied as follows: the participants warmed up with a five-minute jog, followed by three minutes of stretching.

There were eight exercise stations:

- 1<sup>st</sup> station - free squats;
- 2<sup>nd</sup> station - jumping jacks;
- 3<sup>rd</sup> station - the supra abdominal exercise lying in dorsal decubitus with elevation of the trunk up to 45°;
- 4<sup>th</sup> station - individual medicine ball toss, up or down, and in pairs, one to the other;
- 5<sup>th</sup> station - jump rope;
- 6<sup>th</sup> station - back squat;
- 7<sup>th</sup> station - isometric abdominal plank;
- 8<sup>th</sup> station - shuttle race with touching cones ten meters apart from each other.

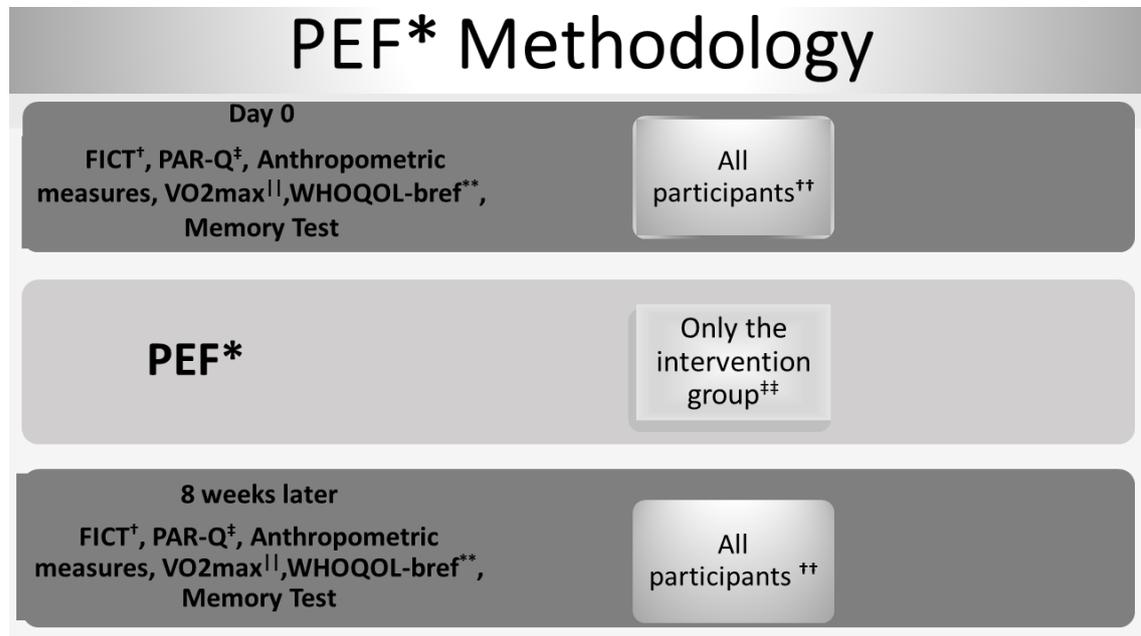
The eight stations were performed in sequence by the participants with 20 seconds of work and ten seconds of recovery interval, totaling approximately four minutes of circuit time. As the number of participants was larger than the number of stations, the exercises were repeated during the circuit so that everyone performed the same training load. In the exercise protocol, an auditory stimulus was used by means of music with the counting of the work and recovery times during the circuit. Every two weeks, one lap was increased in the circuit. Therefore, in the 3<sup>rd</sup> and 4<sup>th</sup> weeks, there were two laps; in the 5<sup>th</sup> and 6<sup>th</sup> weeks, three laps, and in the 7<sup>th</sup> and 8<sup>th</sup> weeks, four laps.

The other PEF method was team sports training through soccer. The interventions were made through

60-minute matches, divided into two 30-minute periods, with a five-minute recovery interval. This method was used in order to work on social relationships during sports practice and also to make the interventions more attractive, taking into account the studies that suggest

that outdoor sports practice, with sports such as soccer, can reduce drug addiction<sup>(27)</sup>.

The PEF was applied by a trained professional, with usual equipment for physical training and easy adaptation in case any of this equipment was missing (Figure 1).



\*PEF = Physical Exercise Program; <sup>†</sup>FICT = Free and Informed Consent Term; <sup>‡</sup>PAR-Q = Physical Activity Readiness Questionnaire; <sup>||</sup>VO2max = Maximum Oxygen Volume; <sup>\*\*</sup>WHOQOL-bref = World Health Organization of life; <sup>††</sup>All participants = Intervention group, who participated in the physical exercises, plus the control group, who did not participate in the physical exercises; <sup>††</sup>Intervention Group Only = Represents only the individuals who participated in the physical exercises

Figure 1 – PEF (Physical Exercise Program) Methodology

In a first step, all participants (n= 33) were submitted to the tests and evaluations for data collection, which were compared between the two groups at the end of the eight weeks of interventions.

After the participants answered the PAR-Q questionnaire and their mass measurements were taken, the Rockport walk test was applied to calculate the VO2<sub>max</sub>. Next, they were given the WHOQOL-bref form to be filled out, which evaluated their perception of QOL. Finally, the Hopkins Verbal Learning Test (HVLT) was applied, a test that evaluated, by means of indices and scalar values, the memory of the participants.

For data analysis, the calculations of the scores obtained from the WHOQOLbref questionnaire were made using Microsoft Excel software, from the proposed instrument, following the syntax established by the WHOQOL Group and elaborated to facilitate its realization<sup>(28)</sup>. The results were expressed as numerical means transformed into a scale from zero to 100 and percentage means. For the analysis of VO2max and body mass data, the Statistical Package for the Social Science (SPSS) software was used, and to verify the normality distribution of the data, the Shapiro-Wilk test was used.

To evaluate the effects of physical exercise in the different stages of the study, parametric data were compared with T-test and one-way ANOVA with repeated measures. Non-parametric data were compared using the Wilcoxon test and followed by the Kruskal-Wallis test. Pearson's Correlation was used to analyze the relationships between variables and the significance level of 5% ( $p \leq 0.05$ ).

In the Hopkins Verbal Learning Test (HVLT), the score for the Immediate Memory or Learning Trial and the Tardy Memory Trial was totaled by the raw score for each correct response. In the Late Recognition Trial, the score was obtained from the number of yes responses for the words correctly belonging to the initial list, minus the false positives, consisting of the yes responses for words that did not belong to the initial list. The raw scores and their respective percentages were considered for the classifications of the participants according to the scalar values of the test<sup>(20)</sup>.

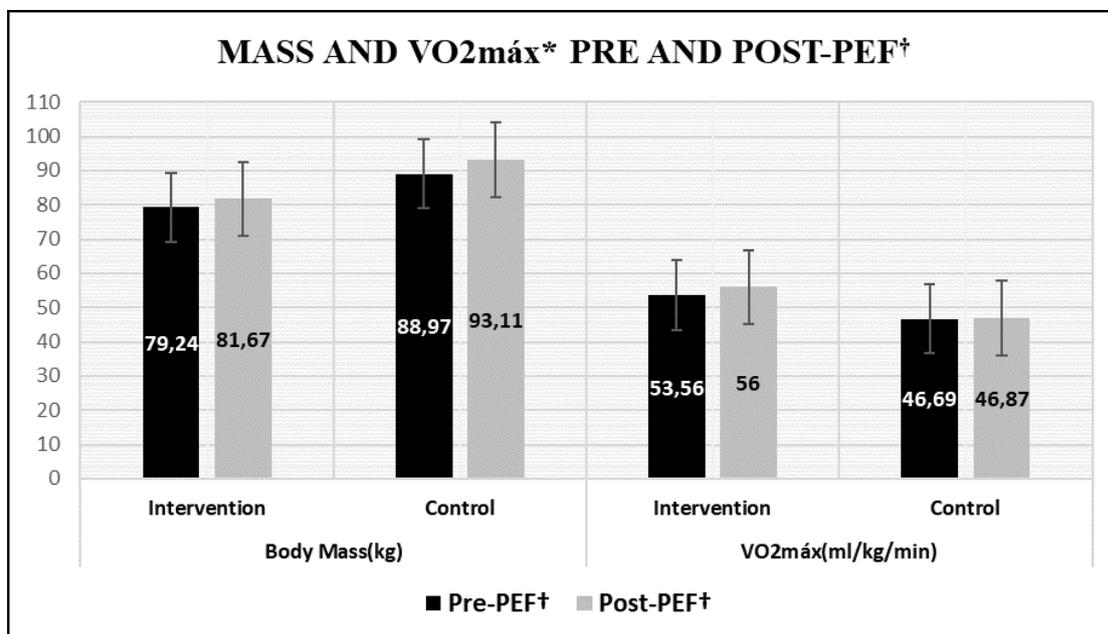
## Results

In the intervention group, the mean age of the participants was 35.42 ( $\pm 4.03$ ) and, in the control group, was 40.14 ( $\pm 8.07$ ), the difference was approximately

11.76% greater in the control group. Approximately 93% of the total participants in both groups received some type of social or corporate benefit for subsistence; 69% of the control group and 60% of the volunteer group were engaged in some type of paid activity prior to starting treatment; 35% of the volunteer group and 26% of the control group were in a stable relationship, and 58% were treatment recidivists. The level of education of the majority of the participants in both groups, approximately 75%, was incomplete High School. Approximately 83% were using alcohol and one other substance. Of the participants, 63% were using alcohol and crack; 13%, alcohol and cocaine; 7%, alcohol and marijuana; 8% were alcohol only users, and approximately 9% of the participants reported using other psychoactive substances.

All participants said they had used some illicit substance during their lives.

The first data collected from the study participants were body mass and VO<sub>2</sub>max. Both groups took body mass (kg) and VO<sub>2</sub>max test (ml/kg/min) before and after the PEF interventions. The mean masses of the intervention group that participated in PEF were 79.24 ( $\pm 2.24$ ) pre-PEF and 81.67 ( $\pm 2.38$ ) post-PEF, and the mean VO<sub>2</sub>max was 56.56 ( $\pm 1.01$ ) pre-PEF and 56 ( $\pm 0.98$ ) post-PEF. In the group that did not participate in PEF, the control group, the mean mass was 88.87 ( $\pm 3.94$ ) pre PEF and 93.11 ( $\pm 4.53$ ) post PEF, and mean VO<sub>2</sub>max was 46.69 ( $\pm 1.83$ ) pre PEF and 46.87 ( $\pm 2.08$ ) post PEF. The results represent the mean  $\pm$  standard error (Figure 2).



\*VO<sub>2</sub>max = Maximum Oxygen Volume; †PEF = Physical Exercise Program

Figure 2 - Participants' mass and VO<sub>2</sub>max\* data

The average increase in body mass after PEF, compared to the average pre-PEF in the intervention group was 2.31 kg ( $\pm 0.62$  kg) ( $p=.002$ ), being lower compared to the control group, average 4.28 kg ( $\pm 0.84$ ) ( $p=.001$ ). The intervention group showed a mean increase in VO<sub>2</sub>max of 2.52 ml/kg/min ( $\pm 3.12$ )

( $p=.000$ ), being higher than the mean increase shown in the control group, which was 0.07 ml/kg/min ( $\pm 2.67$ ) ( $p=.922$ ) (Figure 2).

In the participants' perception of QOL, the data collected showed the following differences in means and Standard Error (SE) as shown in Table 1.

Table 1 - Pre-PEF\* and post-PEF\* difference in the domains of the WHOQOL-bref<sup>f</sup>. Ponta Grossa, PR, Brazil, 2018

<b>Control</b>	<b>Pre-PEF*</b>	<b>SE<sup>‡</sup> (+/-)</b>	<b>Post- PEF*</b>	<b>SE<sup>‡</sup> (+/-)</b>	<b>Dif.<sup>§</sup> %</b>	
Physical Domain	57,65	3,28	59,44	1,89	1,79	3,10%
Social Domain	52,38	5,05	58,33	4,37	5,95	11,36%
Psychological Domain	62,80	3,13	67,56	1,81	4,76	7,58%
Environment Domain	57,37	4,13	62,95	2,53	5,58	9,73%
<b>Intervention</b>	<b>Pre-PEF*</b>	<b>SE<sup>‡</sup> (+/-)</b>	<b>Post- PEF*</b>	<b>SE<sup>‡</sup> (+/-)</b>	<b>Dif.<sup>§</sup> %</b>	
Physical Domain	55,64	2,13	63,72	1,62	8,08	14,52%
Social Domain	54,39	4,48	67,54	3,76	13,16	24,18%
Psychological Domain	62,06	2,25	74,78	1,81	12,72	20,50%
Environment Domain	60,20	2,14	74,51	2,15	14,31	23,77%

\*PEF = Physical Exercise Program; <sup>f</sup>WHOQOL-bref = World Health Organization Quality of Life-Bref; <sup>‡</sup>SE = Standard Error; <sup>§</sup>Dif. = Difference between the groups

The “%” column of Table 1 compares the performance of the participants in the two groups before and after the PEF interventions.

The Physical domain, in the control group, presented, on average, a positive difference of 1.79 ( $\pm 2.77$ ) between the pre-PEF (57.65  $\pm 3.28$ ) and post-PEF (59.43  $\pm 1.89$ ), however, without presenting a statistically significant difference ( $p=0.53$ ). In the intervention group, this difference was statistically significant ( $p=0.007$ ). The PEF participants reported, on average, a positive difference of 8.08 ( $\pm 2.64$ ) between pre-PEF (55.64  $\pm 2.13$ ) and post-PEF (63.72  $\pm 1.62$ ).

In the Social Domain, on average, the control group reached a positive improvement of 5.95 ( $\pm 3.75$ ) in the period between pre-PEF (52.38  $\pm 5.05$ ) and post-PEF (58.33  $\pm 4.37$ ), and this difference was not statistically significant ( $p = 0.14$ ). Whereas, in the intervention group, the difference in the Social Domain was statistically significant ( $p \leq 0.001$ ) between the

pre-PEF moment (54.39  $\pm 4.48$ ) and the post-PEF moment (67.54  $\pm 3.76$ ).

The Psychological Domain, in the control group, obtained an average difference of 4.76 ( $\pm 2.62$ ) between pre-PEF (62.80  $\pm 3.13$ ) and post-PEF (67.56  $\pm 1.81$ ). This difference in data, although positive, was statistically insignificant ( $p = 0.092$ ). The mean difference of 12.72 ( $\pm 1.84$ ) in the Psychological Domain of the intervention group showed statistically significant values in the difference between the means ( $p \leq 0.0001$ ) in the period between pre-PEF (62.06  $\pm 2.25$ ) and post-PEF (74.78  $\pm 1.81$ ).

The Environment Domain presented results in mean differences in the control group of 5.58 ( $\pm 2.91$ ) between the two moments, pre-PEF (57.37  $\pm 4.13$ ) and post-PEF (62.95  $\pm 2.53$ ), showing no statistically significant difference ( $p \leq 0.078$ ). In the intervention group, the difference was 14.30 ( $\pm 2.46$ ), statistically significant ( $p \leq 0.0001$ ), in the period between pre-PEF (60.20  $\pm 2.14$ ) and post-PEF (74.51  $\pm 2.35$ ).

### Hopkins Verbal Learning and Testing (HVLТ-R)

Tables 2 and 3 show the HVLТ-R test results of the intervention and control groups, respectively.

Table 2 - Performance of the intervention group according to the pre-established classifications by the Hopkins Verbal Learning and Test (HVLТ-R). Ponta Grossa, PR, Brazil, 2018

Pre-PEF*		Intervention group			Post-PEF*		
Classification	Total of subjects	%	CF <sup>†</sup>	Classification	Total of subjects	%	
CF <sup>†</sup>	Deficient			Deficient			
	Limited	3	15.79	Limited			
	Lower mean	13	68.42	IM <sup>‡</sup>	Lower mean	11	57.89
	Higher mean	3	15.79	Higher mean	8	42.11	
IM <sup>‡</sup>	Higher			Higher			
	Deficient			Deficient			
	Limited	5	26.32	Limited	1	5.26	
	Lower mean	6	31.58	TM <sup>§</sup>	Lower mean	7	36.84
	Higher mean	7	36.84%	Higher mean	10	52.63	
TM <sup>§</sup>	Higher	1	5.26	Higher	1	5.26	
	Deficient			Deficient			
	Limited			Limited			
R <sup>  </sup>	Lower mean	2	10.53	R <sup>  </sup>	Lower mean		
	Higher mean	10	52.63	Higher mean	7	36.84	
	Higher	7	36.84	Higher	12	63.16	

\* PEF = Physical Exercise Program; <sup>†</sup>CF = Cognitive Functions; <sup>‡</sup>IM = Immediate memory; <sup>§</sup>TM = Tardy memory; <sup>||</sup>R = Recognition

Table 3 - Control group performance according to the pre-established classifications by the Hopkins Verbal Learning and Test (HVLТ-R). Ponta Grossa, PR, Brazil, 2018

Pre-PEF*		Control Group			Post-PEF*		
Classification	Total of subjects	%	CF <sup>†</sup>	Classification	Total of subjects	%	
CF <sup>†</sup>	Deficient			Deficient			
	Limited	2	10.53	Limited	1	5.26	
	Lower mean	10	52.63	IM <sup>‡</sup>	Lower mean	11	57.89
	Higher mean	2	10.53	Higher mean	2	10.53	
IM <sup>‡</sup>	Higher			Higher			
	Deficient			Deficient			
	Limited	1	5.26	Limited			
	Lower mean	8	42.11	TM <sup>§</sup>	Lower mean	8	42.11
	Higher mean	4	21.05	Higher mean	5	26.32	
TM <sup>§</sup>	Higher			Higher	1	5.26	
	Deficient			Deficient			
	Limited			Limited			
R <sup>  </sup>	Lower mean	1	5.26	R <sup>  </sup>	Lower mean		
	Higher mean	9	47.37	Higher mean	8	42.11	
	Higher	4	21.05	Higher	6	31.58	

\*PEF = Physical Exercise Program; <sup>†</sup>CF = Cognitive functions; <sup>‡</sup>IM = Immediate memory; <sup>§</sup>TM = Tardy memory; <sup>||</sup>R = Recognition

The “%” column of Tables 2 and 3 compares the performance of the participants in the two groups before and after the PEF interventions.

The control group showed an increase in the learning curve of approximately 5.26% of subjects in the *lower mean* ( $\pm 0.57$ ) ( $p=1.00$ ) in the Immediate Memory cognitive function and in the *higher mean* ( $\pm 9.50$ ) ( $p=0.39$ ) in the Late Memory function. In the cognitive function of Cognition, the largest increase was in the *higher* rating ( $\pm 0.57$ ) ( $p=0.25$ ), approximately 10.53%.

In the intervention group, the learning curve averages showed a superior improvement over those of the control group. In the Late Memory function, the increase in the upper mean ( $\pm 2.40$ ) ( $p=0.56$ ) was approximately 15.79%. In the cognitive functions Immediate Memory, lower mean item ( $\pm 1.00$ ) ( $p=0.42$ ), and Recognition, higher item ( $\pm 1.66$ ) ( $p=0.42$ ), this improvement in the upward curve was even greater, with an increase of approximately 26.32%.

## Discussion

Individuals who use psychoactive substances often have insufficient nutritional intake because of the effect of the drugs, as well as their self-care behavior. When these individuals are in treatment, their caloric intake is high. As the control group does not exercise with the same intensity and frequency as the intervention group, there is the possibility of a greater gain in body mass by accumulation of fat mass. Thus, it is possible that the intervention group had a lower accumulation of adiposity, a result in accordance with the studies that reported a significant reduction in the increase in fat percentage through moderate to vigorous physical exercise<sup>(29)</sup>. It is worth noting that the group of individuals who did not adhere to PEF was already a group with higher body mass. This is because there is a multiplied prevalence of increased obesity in individuals with sedentary behavior and ingestion of unhealthy foods<sup>(30)</sup>.

The VO<sub>2</sub>max values achieved corroborate the results obtained in previous research, which showed a significantly greater gain in peak VO<sub>2</sub>max and an improvement in cardiorespiratory capacity in subjects who participated in a PEF<sup>(31)</sup>. These results contribute to a better perception of QOL among individuals in treatment.

In the perception of QOL, the increase in body mass without the improvement in physical conditioning may be the preponderant factor of the lower perception of the person evaluated in relation to his/her physical condition<sup>(10)</sup>. Participation in a PEF can significantly improve an individual's perceived fitness level and self-esteem by up to approximately 31%<sup>(32)</sup>. This improvement in perception is due to the increase in well-being as a result of the facilitation that physical exercise promotes in the execution of daily tasks<sup>(33)</sup>.

The difference shown between the two groups in the Social Domain is probably due to the capacity that sports have to influence the behavior of a society<sup>(34)</sup>. Sporting activities provide opportunities for positive social interaction, because they promote relationships in which solidarity and inclusive support actions are identified, which stimulate the perception of individual well-being and a sense of belonging, as well as improve the integral health of individuals<sup>(35)</sup>.

The results in the Psychological Domain are supported by previous research which has stated that moderate physical exercise has a major positive influence on mood and sleep in individuals and that a 30-minute program is sufficient to improve mood and sleep quality, thus contributing to the prevention of the incidence of mental illness<sup>(36)</sup>. Physical exercise has a strong impact on psychological well-being, positive affect, and stress control in individuals leaving sedentary lifestyles<sup>(37)</sup>. Evidence from epidemiological data also suggests that exercise can reduce symptoms of anxiety disorders, stress-related disorders, and panic disorder. They also suggest that exercise can be used as an effective option in mental health treatment, as people who exercise improve their psychological well-being<sup>(38)</sup>.

Negative results in the Environment Domain are common and are caused by the temporary deprivation of liberty during the initial period of abstinence, a fact that occurs in treatment carried out in a therapeutic community<sup>(39)</sup>. The greater difference in the intervention group may have been influenced by the application of PEF, which had the vast majority of training sessions applied in an open environment, outdoors, which, according to studies, provides a reduction of the fissure, the main cause of mood swings, abandonment of treatment and consequent relapse<sup>(27)</sup>.

It is also likely that the significant improvement identified in the intervention group is due to exercise's ability to provide a sense of well-being through psychological effects that act directly on mental health<sup>(40)</sup>. The effects of alcohol and other drug use produce deficits in the cognitive processes of memory and learning that may extend over a longer time during treatment<sup>(6)</sup>.

Along with physical impairments, cognitive impairments are the greatest influencers of the perception of QOL and one of the most frequent reasons for complaints among sedentary individuals. This negative perception of QOL is improved proportionally according to the occurrence of improvement in physical conditioning<sup>(41)</sup>. Another possibility for the differences between the two groups is the incidence of long-term sequelae from repetitive traumatic brain injuries from alcohol and other drug use, which can lead to disorders such as depression, impulsivity, and aggressive behavior<sup>(42)</sup>.

In time, exercise has several mental health benefits that enable individuals to cope more easily with the

stressors that arise during withdrawal from treatment. It improves positive mood acutely and, over time, increases feelings of vigor and reduces tension, fatigue, and confusion. Decreases symptoms of social anxiety and the risks of depression, which can lead to poor treatment outcomes, without stimulating the side effects common to psychiatric drugs<sup>(43)</sup>. These benefits may have been responsible for the wide range observed between the two groups with regard to perceived QOL.

Based on the data, it is possible to state that a PEF contributes significantly to the perception of QOL of alcohol and other drug users in rehabilitation. It can also be responsible for reducing psychological factors that are often associated with relapse, such as depression and anxiety, increasing self-esteem and promoting a sense of well-being.

The HVLT-R memory tests provided expressive results of changes in immediate, delayed, and posterior recognition memory in the participants' evaluations.

Both groups showed improvements in learning memory (Immediate Memory), information retention memory (Late Memory), and late recognition of information (Recognition). The improvement shown in both groups may have been caused by moderate neurogenesis that, during withdrawal, promotes adaptive changes in memory circuits<sup>(44)</sup>. The difference in memory improvement results between the two groups, although not yet entirely clear to the researchers, may be linked to improved cardiac vascular fitness<sup>(45)</sup>.

Studies highlight that the effects of a PEF on brain plasticity provide changes in cognition and well-being. The structural and functional changes in the brain induced by a PEF<sup>(46)</sup> are beneficial during treatment and contribute to the adherence to the rehabilitation process. Physical exercises have the ability to stimulate the processes of behavioral changes triggered by the facilitating effects produced by the release of neurotrophic factors, such as the peripheral Brain-derived Neurotrophic Factor (BDNF), which would explain the greater difference achieved in the intervention group compared to the control group in all tests. Another important issue that needs attention is the proportional relationship between improved cardiovascular fitness<sup>(47)</sup> with the improvement in learning and memory. According to studies, just one session of moderate aerobic exercise can already be responsible for significant improvements in memory and cognitive flexibility<sup>(48)</sup>. However, it is important that factors such as intensity, frequency, duration of PEF, and the biological individuality of the individual be variables taken into consideration when prescribing the training routine. These variables may be responsible for determining success or failure in achieving structural and neurofunctional benefits through physical exercise<sup>(49)</sup>.

## Study limitations

The study was conducted in only one therapeutic community for alcohol and other drug users with exclusively male subjects, making it impossible to investigate the effects of physical exercises on women and also to compare them with other models of therapeutic programs. Another limiting factor is the difficulty of adherence of this type of population to the proposed programs, which reduced the possibility of a longer period of study.

## Conclusion

The application of PEF positively influenced the improvement of cardiorespiratory capacity by approximately 4.56%; in the perception of QOL, by up to 21% approximately in the Environment Domain and an improvement of approximately 16% in the memory of alcohol and other drug users in treatment who participated in the study.

It is concluded that a PEF structured with the necessary care, which meets and respects the individual characteristics and physical limitations of this population, presents itself as a therapeutic strategy that can contribute positively expressive in the rehabilitation process of the individual user of alcohol and other psychoactive substances.

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