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The Effect of Creatine Monohydrate Consumption on Men's Cognitive Function with Anaerobic Exercise

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Abstract

Introduction: Creatine monohydrate is a supplement used to accelerate the recovery process, increase muscle mass, and affect the cognitive function of its consumer. **Objectives:** This study aimed to determine the effect of consuming creatine monohydrate on male cognitive function with anaerobic exercise. **Method:** The methodology used in this study is by conducting experiments involving 12 participants aged between 20-45 years old with anaerobic exercise routines. The participants were asked to consume creatine monohydrate 5 gr/day for 20 days. Assessment of cognitive function was conducted on day 0 and day 21 using the XpressO by MoCA instrument, and the data were analyzed using a dependent paired t-test. **Result:** The average age, weight, height, and body mass index of the participants were 31.2±7.6 years old, 80.9±14.6kg, 170.6±5.1cm, and 27.8kg/m^2 respectively. Significant increase in cognitive function on day 21 compared to day 0 was shown respectively by 46.75±9.8 and 32.33±9.7 *($p=0.024$; $p<0.05$)*. **Conclusion:** Creatine monohydrate consumption with a dose 5 gr/day for 20 days has an effect on the increase of male cognitive function with anaerobic exercise.

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INTRODUCTION

In recent years, supplement use among athletes and individuals has increased. Consuming supplements as a companion to physical activity aims to improve performance in sports. One supplement whose use has increased in recent years is creatine monohydrate. This supplement has seen sales increase from 50 million dollars in 1996, 400 million dollars in 2001 and increasing to 520 million dollars in 2021 (Reports, 2024; Bamberger, 1998; Metzl et al., 2001).

Creatine monohydrate is a supplement used to reduce fatigue, speed up the energy recovery process and increase strength and muscle mass (Dolan et al., 2019). The dose of creatine monohydrate is divided into two phases, namely the loading phase with a dose of 20 gr/day with four doses divided over 5-7 days of use and a continuation phase at a dose of 3-5 gr/day (Dolan et al., 2019). Creatine monohydrate is known to affect cognitive function in users. Creatine monohydrate facilitates more stable adenosine triphosphate (ATP) in the brain area, so it can affect cognitive performance abilities (Dolan et al., 2019). Creatine has the ability to cross the blood-brain barrier. However, the absorption is not as much as in skeletal muscle tissue (Forbes et al., 2022).

This study was combined with anaerobic exercise because creatine is a widely used supplement for individuals engaging in anaerobic exercise, such as weightlifting (Buford et al., 2007). This study aimed to examine other effects of creatine consumption beyond its primary known benefit of improving anaerobic performance. Therefore, the combination of creatine and anaerobic research was chosen to explore the potential effects of creatine on other cognitive, physiological, or biochemical aspects that may have been understudied.

Several previous researchers found evidence regarding the effects of consuming creatine monohydrate on cognitive function. In research by Astorino et al (2020), using 26 participants who consumed 5 gr of creatine monohydrate/day for 16 weeks, it had an effect of increasing performance on cognitive function. In study Borchio et al (2020), consuming 20 gr of creatine monohydrate/day for 7 days had a positive effect on the differentiation task test (DTT) and Corsi block test (CBT). In Turner et al (2015) study, consumption of creatine monohydrate was 20 gr/day for 7 days, provides increased attention and corticomotor increases in cognitive function. However, previous studies have never studied the effect of consuming creatine monohydrate on cognitive function at a dose of 5 gr/day for 20 days, which is the usual dose consumed by men with anaerobic exercise.

Cognitive function can be assessed by visual assessment, naming, attention, language, abstraction, short memory, and orientation (Julayanont et al., 2013). Cognitive function can be assessed by visual assessment, naming, attention, language, abstraction, short-term memory and orientation (Julayanont et al., 2013). This assessment can use the Montreal Cognitive Assessment (MoCA) tool. MoCA is a paper assessment of cognitive function. This tool cannot be used by people with subjective cognitive disorders, for example individuals who feel a decrease in cognitive function but the detection results are normal. So, it can be used to assess

cognitive function with MoCA which is modified to become XpressO by MoCA (Klil-Drori et al., 2024).

Based on the background above, this research was conducted to see the effect of consuming creatine monohydrate supplements at a dose of 5 gr/day for 20 days on the cognitive function of men who do anaerobic exercise using the XpressO by MoCA instrument.

METHOD

The material used in this study was creatine monohydrate supplement (Matrix Provus) with distribution permit number 022882000200100

This study was conducted at a fitness center in Pontianak using a total sampling method that met the inclusion criteria of this study, namely male, aged 20-45 years, doing anaerobic exercise (weight lifting for muscle mass building), used a moderate intensity range (30% – 70%), with 10 – 12 repetitions and a rest time between sets of > 1 minute (Buchanan et al., 2023). The movement involves the main muscle groups, namely pectoralis (chest press), deltoids (shoulder press), back (bent over row), triceps (triceps extension), biceps (biceps curl), legs (squat). The exercise is done 3-6 times a week with each exercise lasting 60-90 minutes, were not taking multivitamins, and had taken creatine monohydrate but had stopped taking it for 5 weeks were part of this study. Respondents are allowed to refuse this research. All respondents must sign an informed consent form.

This research is an observational study with an experimental design for 20 days. Respondents consumed creatine monohydrate supplements at a dose of 5 gr/day for 20 days which were then assessed on day 0 and day 21 using the XpressO by MoCa instrument. Data collection was carried out with the consent of the respondents at the Pontianak City Fitness Center. This research has been declared to have passed ethical review by the Ethical Review Division of the Faculty of Medicine, Tanjungpura University, with No: 15937 /UN22.9/PT.01.04.2024

Cognitive function assessment was carried out using the XpressO by MoCA instrument. There are nine questions in this instrument with an average completion time of 7 minutes. The highest points in this instrument are 100 with sequential class ranges <43 (bad); 43-71 (medium); >71 (good).

Descriptive techniques in this research were used to describe the sample. Shapiro Wilk was used to see the normality of the data and analyze the homogeneity test. Next, the data was analyzed using a paired t-test with a confidence level of 95% and an alpha level of $P<0.05$ for statistical significance. All data collected was analyzed using SPSS software version 23. All data was analyzed on day 0 and day 21.

RESULT AND DISCUSSION

This study found 12 respondents who met the inclusion criteria. This number is considered low due to the difficulty in finding suitable respondents, therefore the number of respondents used was only 12 people (very limited). All respondents in this study were male with the respondents' exercise being anaerobic (weight lifting to build muscle mass). On average, respondents did anaerobic exercise five times a week. The youngest respondent was 20 years old and the oldest was 45 years old. The respondents' weight range was 56 kg - 117 kg. The tallest respondent was 185 cm and the smallest was 165 cm. The respondents' occupations in this study varied, including civil servants, private employees, and students.

Table 1. Respondent Characteristics (n=12)

Characteristics	Mean±SEM
Age (years)	31.2±2.2
Weight (kg)	80.9±4.2
Height (cm)	170.6±1.4

The average age of respondents calculated at the start of this study was 31.2 ± 2.2 years. The average body weight of respondents calculated at the time of the research was 80.9 ± 4.2kg. The average height of respondents in this study was 170.6 ± 1.4cm. The average body mass index (BMI) obtained from the calculation results is 27.8kg/m^2

A total of 12 respondents consumed creatine monohydrate at a dose of 5 gr/day for 20 days. Measurement of cognitive function in respondents was carried out before consuming creatine monohydrate with a washout period of 5 weeks aimed at normalizing creatine levels in the tissue and was re-measured after consuming creatine for 20 days. Measurement of cognitive function was carried out on day 0 and re-measured on day 21. Cognitive function was measured using the XpressO by MoCA instrument.

The data that has been obtained, namely data from day 0 and day 21, will be tested for Shapiro Wilk normality with values for day 0 p = 0.053 and day 21 p = 0.093 and a homogeneity test of p = 0.731. These results meet the requirements for significant normality with a p-value <0.05. So the data is analyzed using parametric statistical methods such as the paired t-test (figure 1).

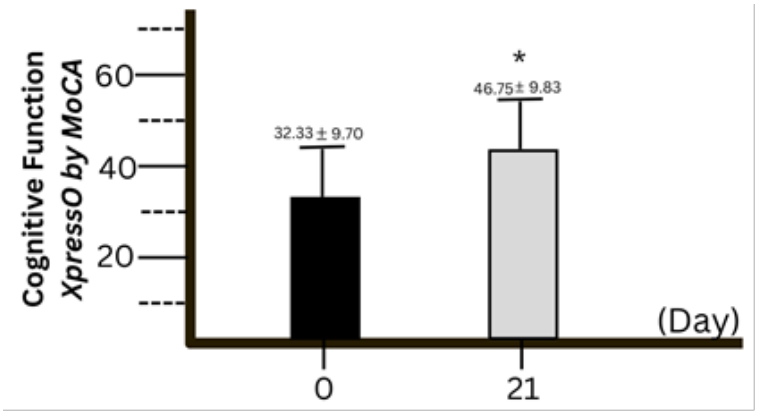

Figure 1. Respondents cognitive function on day 21 compared to day-0 (* = p<0.05)

Cognitive function measurements were carried out in a quiet place so that respondents could concentrate. The instrument used to measure respondents' cognitive function was XpressO by MoCA. The assessment begins with short memory type questions and is followed by executive function type questions. There are nine questions in XpressO by MoCA with an average processing time of 7 minutes. The measurement results show a significant difference between day 21 and day 0 with a p value of 0.024 (p<0.05) (Figure 1).

These results indicate that the duration of consumption of 5 gram of creatine monohydrate/day for 20 days with anaerobic exercise can improve cognitive function more quickly compared to previous research (Astorino et al., 2020; Kalman et al., 2021). In the study of Astorino et al (2020), which used 26 respondents during exercise "strength training" by consuming 5 gr/day of creatine monohydrate for 16 weeks experienced an increase in cognitive function. In line with these results, in research by Kalman et al (2021), which used 24 respondents reported that consuming 5 gr/day of creatine monohydrate for 28 days in weight training and aerobic exercise had improved cognitive function. These results indicate that consuming 5 gr/day of creatine monohydrate in anaerobic training for the first 20 days had provided an increased cognitive function

Research on creatine monohydrate with cognitive function was also carried out on respondents without exercise. In the study by Rae et al (2003) which used 45 respondents, it was reported that consumption of creatine monohydrate 5 gr/day for 6 weeks showed an increase in cognitive function. The latest study by Sandkühler et al (2023) used 123 respondents, showed an increase in cognitive function with consuming creatine monohydrate as much as 5 gr/day for 6 weeks. In Toniolo et al (2017) research using 35 respondents who consumed 6 gr/day for 6 weeks can have the effect of increasing cognitive function. This research shows that consuming creatine monohydrate 5 gr/day is not only used by athletes to increase strength and muscle mass, but can also be consumed by non-athlete individuals to increase cognitive function (Dolan et al., 2019). So that further researchers can use non-athlete respondents with a dose of 5 gr/day for 20 days to see the effect on cognitive function.

Apart from the duration of consumption of creatine monohydrate, cognitive function is also influenced by the daily dose. Several studies show that consuming 20 gr/day for 7 days can improve cognitive function (Turner et al., 2015; Roelands et al., 2020; McMorris et al., 2007). This shows that the effect on cognitive function can be seen in a shorter time but at higher doses. However, regarding side effects, the use of creatine monohydrate does not cause damage to the kidneys and liver if used according to the recommended dose (de Guingand et al., 2020).

Assessment of cognitive function should include the concepts of thinking, reasoning, observing, imagining and remembering (Julayanont et al., 2013). Assessment of cognitive function has many instruments such as MoCA and MMSE. In this study, the measurement of cognitive function used XpressO by MoCA which aims to see short-term memory, executive function and time to digest a problem (Klil-Drori et al., 2024). In the study of Ciesielska et al (2016), comparing the MoCA and MMSE instruments on respondents with mild cognitive impairment, the results showed that the MoCA instrument had better detection in assessment than MMSE. The use of the MoCA instrument was also carried out in the studies of Astorino et al (2020) and Liz et al (2015) to see the effect of creatine monohydrate consumption on cognitive function. The MoCA instrument was modified into XpressO by MoCA and had similar assessment results for cognitive function (O'Driscoll et al., 2017). XpressO by MoCA has the advantage of being able to be used regardless of respondent education, digital assessment and free (O'Driscoll et al., 2017). So the use of the XpressO by MoCA instrument in this study can represent the value of respondents' cognitive function after consuming creatine monohydrate.

This study also show that changes in cognitive function in respondents who consumed creatine monohydrate were not affected by age. Table 2 data shows an increase in cognitive function in three different age ranges (Depkes RI., 2009). Respondents in this study were dominated by the age range of 17 - 25 years (n = 3) with an increase in cognitive function of 69.81%, followed by respondents with an age range of 26 - 35 years (n = 6) and 36 - 45 years (n = 3), which were 41.51% and 26.86% respectively.

Table 2. Age range in cognitive function outcomes

Range Age (n)	Day 0 (Mean±SD)	Day 21 (Mean ±SD)	Percentage (%)
17 – 25 (3)	21.00±20.07	35.66±44.41	69.81
26 – 35 (6)	47.33±41.07	67.00±24.51	41.51
36 – 45 (3)	13.66±14.15	17.33±14.01	26.86

The age range 36 – 45 years has a lower percentage increase compared to other age ranges. Previous research shows that elderly respondents can also improve cognitive function after consuming creatine monohydrate (Astorino et al, 2020; de Guingand et al., 2020; Liz et al., 2015). Other research shows that younger respondents can also improve cognitive function

after consuming creatine monohydrate (Turner et al., 2015; Rae et al., 2003; Sandkühler et al., 2023). The results of this study revealed that age was not a factor in changes in cognitive function in respondents who consumed creatine monohydrate.

This study also looked at the influence of BMI on respondents' cognitive function. Body Mass Index (BMI) in this study follows the classification rules of the World Health Organization (WHO). BMI values <18.5 (underweight); 18.5 – 22.9 kg/m2 (normal weight); 23 – 24.9 kg/m2 (overweight); 25 – 29.9 kg/m2 (obesity 1); >30 kg/m2 (obesity 2) (Ismail CT, 2000). BMI respondents were only in the normal weight class (n=2), obesity 1 (n=8) and obesity 2 (n=2).

Table 3. BMI range on cognitive function outcomes

BMI Range (n)	Day 0 (Mean±SD)	Day 21 (Mean±SD)	Percent Increase (%)
< 18,5 (0)	-	-	-
18,5 – 22,9 (2)	30,5±16,26	52,5±47,37	72,13
23 – 24,9 (0)	-	-	-
25 – 29,9 (8)	38,8±38,94	51,7±34,80	33,24
>30 (2)	8,0±2,82	21,0±21,2	162,50

The highest BMI range was found at >30, which showed an increase in cognitive function of 162.50%, followed by the range of 18.5–22.9 kg/m2 and 25–29.9 kg/m2 with values of 72.13% and 33.24%, respectively. These results indicate that the increase in cognitive function after consuming creatine monohydrate is not affected by BMI. This is due to the mechanism of action of creatine monohydrate, which is able to pass through the blood-brain barrier cells without being affected by an individual's body mass. Previous research also supports that differences in high and low BMI do not affect an individual's cognitive function (Cournot et al., 2006; Momtaz et al., 2018)

A diet high in creatine combined with the consumption of creatine monohydrate supplements can increase creatine levels in the body (Rae et al., 2003; Benton et al., 2011; Merege-Filho et al., 2017). However, several journals have shown that consuming foods high in creatine without taking creatine monohydrate supplements has no effect on cognitive function (Solis et al., 2014; Solis et al., 2017). This is due to the low levels of creatine from foods, such as meat, which is 25 µmol/L compared to 800 µmol/L from a 5g creatine monohydrate supplement (Kreider et al., 2022). Consequently, the researchers do not consider the effect of consuming foods high in creatine to affect cognitive function in respondents. As a result, a limitation of this study is that the researchers did not pay attention to the high or low creatine intake from the respondents' foods. Hence, further research needs to group them according to the type of food consumed. Furthermore, the large number of variables related to respondents' education and occupation limits this study. In other words, future researchers could stratify respondents based on education, occupation, and high- or low-creatine dietary intake to examine the effect of creatine monohydrate consumption on cognitive function.

To date, there have been many studies showing the benefits of consuming creatine in athletes, such as increasing muscle mass. It is known that the doses given in the research also varied. From research that has been carried out, a dose of 5 gram of creatine monohydrate for 20 days has had the effect of improving cognitive function in men with anaerobic exercise.

The results and discussion sections contain a discussion of age and BMI in relation to cognitive function, while the research questions do not. Perhaps the BMI data and age distribution could be displayed in the respondent data section. Then, in the discussion, it could be added that cognitive function is influenced by several factors, including BMI and age, so that this article appears well-organized and coherent from the background to the conclusion.

CONCLUSION

We found that there was an increase in cognitive function after consuming creatine monohydrate 5 gr/day for 20 days in men with anaerobic training. Further studies with larger populations are needed to strengthen these findings.

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