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VLIV SUPLEMENTACE KREATINU NA KRÁTKODOBOU PAMĚŤ A INTERPRETACI GYMNASTICKÝCH PRVKŮ U REKREAČNÍCH SPORTOVCŮ (PILOTNÍ OVĚŘENÍ)

THE EFFECT OF CREATINE SUPPLEMENTATION ON SHORT-TERM MEMORY AND INTERPRETATION OF GYMNASTIC ELEMENTS IN RECREATIONAL ATHLETES (PILOT STUDY)

J. Suchý, M. Suk, & Š. Panská

Karlova Univerzita, Pedagogická fakulta, Katedra tělesné výchovy

Abstract

This pilot study aimed to evaluate the effect of a seven-day creatine or placebo supplementation on the interpretation and execution of gymnastic elements among healthy recreational athletes (n = 10, age: 22–25 years). During both the pre-test and post-test sessions, participants were given one minute to study ten described and printed gymnastic floor elements. They were then asked to verbally recall the elements and immediately perform them. Between the two testing sessions, participants supplemented daily with either 20 mg of creatine (n = 5) or a placebo—maltodextrin (n = 5). No significant differences were observed between the control and experimental groups during the pre-test. In the post-test, there were no statistically or practically significant differences in the number of recalled elements. However, the number of executed elements showed a statistically significant improvement ($p < 0.05$) in the creatine group compared to the control group. The practical significance (Cohen's d = 0.73) indicated a medium effect size. Seven-day creatine supplementation positively influenced the execution of gymnastic positions and elements but did not enhance their memorization.

Keywords: dietary supplements; creatine; memory; gymnastics

Souhrn

Pilotní ověření vlivu sedmidenní suplementace kreatinem nebo placebem na interpretaci gymnastických prvků u skupiny zdravých rekreačních sportovců (n = 10, věk: 22-25 let). Při vstupním i výstupním testování probandi jednu minutu studovali deset popsaných a vytištěných gymnastických prvků na prostných, které následně vyjmenovali. Po vyjmenování ihned prvky realizovali. Mezi vstupním a výstupním testem probandi sedm dnů suplementovali 20mg kreatinu (n = 5) nebo placeba – Maltodextrin (n = 5). U vstupního testování nebyly zjištěny žádné signifikantní rozdíly mezi kontrolní a experimentální skupinou. V rámci výstupního testu nebyly zjištěny statisticky ani věcně významné rozdíly v počtu vyjmenovaných cviků. V počtu realizovaných prvků u výstupního testu byl zjištěn statisticky významný ($p<0,05$) rozdíl vlivu kreatinu oproti kontrolní skupině. Věcná významnost (Cohenovo d: 0,73) pro počet realizovaných prvků byla na hodnotě středního efektu. Sedmidenní suplementace kreatinu měla efekt na počet realizovaných gymnastických poloh a prvků, nikoliv na jejich zapamatování.

Klíčová slova: doplňky stravy; kreatin; paměť; gymnastika

Introduction

The market offers a wide array of dietary supplements that claim to enhance athletic performance. For the purpose of this study, creatine monohydrate (CrM) was selected due to its popularity among athletes and its proven efficacy in numerous publications (e.g., Cooper et al., 2012; Escalante et al., 2022). Buford et al. (2007) report positive effects of CrM on both physical and mental performance.

Regular use of CrM can improve strength and anaerobic capacity (Cooper et al., 2012), and it is also used as a supplement in conventional medical treatments (Kreider & Stout, 2021).

CrM is widely available in sports nutrition stores and is relatively inexpensive compared to other forms of creatine (Cooper et al., 2012). Its price is determined by the fermentation of carbon- and nitrogen-containing raw materials, followed by isolation and purification. The final product is obtained through crystallization and drying, resulting in a powdered form (Castoldi et al., 2020).

Given these factors, CrM is a commonly preferred choice among athletes seeking an effective supplement for performance enhancement and muscle recovery (Wax et al., 2021). According to Kreider & Stout (2017), athletes use creatine not only as a short-term performance booster but also as a regular part of their training regimen.

CrM is well tolerated and considered a safe dietary supplement (Kreider & Stout, 2017). When taken in recommended doses, no serious side effects have been reported, even among pregnant women (Guingand et al., 2020). Only minimal information has been published regarding potential adverse effects of CrM supplementation. Athletes often consume up to 20 g/day for several days, followed by 5 g/day for weeks or months (Turner et al., 2015). Users typically report no adverse effects, except for weight gain. In studies involving football players who took creatine or placebo during training, no increased incidence of cramps was observed in the experimental group compared to the control group (Williams et al., 1999). Some healthy participants in relevant studies reported gastrointestinal issues and muscle cramps. Smith et al. (2023) state that controlled studies have not found conclusive evidence linking creatine supplementation to muscle dysfunction. For athletes, it is important to ensure adequate intake of water and electrolytes, as these are likely the most common causes of muscle cramps.

For the purposes of this research, short-term memory is defined according to James (1890). McMorris et al. (2017) suggest that creatine supplementation may increase brain creatine stores, contributing to improved memory, particularly in older adults. Rae et al. (2003) investigated the effects of creatine on cognitive functions, especially working memory and abstract reasoning in vegetarians. Oral creatine supplementation over six weeks had a statistically significant ($p < 0.05$) positive effect on working memory, as measured by Raven's Advanced Progressive Matrices, which require rapid information processing. These findings suggest that creatine may positively influence processes related to thinking speed and mental agility.

Gymnastics is a complex and technically demanding sport that requires a high level of coordination, balance, and flexibility (Leone et al., 2017). These demands make gymnastics an ideal sport for studying the impact of movement on neuroplasticity. Floor routines consist of a series of elements performed on a specially sprung 12×12 meter surface without any apparatus (FIG, 2025). These routines combine acrobatic, dance, jump, turn, and balance elements, performed with musical accompaniment in women's categories. In men's categories, music is not used, and routines focus more on strength skills and technically challenging acrobatic elements. The most commonly used elements in floor routines include various combinations of handsprings, somersaults, jumps, and turns, smoothly connected to demonstrate the difficulty and appeal of the performance (ČGF, 2017).

Objectives

A pilot study to verify the effect of seven-day creatine monohydrate (CrM) supplementation (dose: 20 grams/day) on short-term memory through verbal recall and subsequent execution of gymnastic positions and elements in a floor routine among recreational athletes.

Methodology

The effect of CrM on the memorization of gymnastic positions and elements was examined using a randomized, single-blind, placebo-controlled experiment.

Participants: a homogeneous group of physically fit students ($n = 10$, age: 22–25 years) from the Faculty of Education, Charles University (PedF UK). Participants were randomly assigned using the "first–second" method into an experimental group ($n = 5$), which received powdered CrM, and a control group ($n = 5$), which received a placebo identical in appearance, taste, and texture (maltodextrin). Only the study authors were aware of group assignments. Participation required completion of course requirements in gymnastics within the Physical Education and Education program at PedF UK.

The study was approved by the Ethics Committee of the KTV PedF UK on September 2, 2024 (ref. no. 17/2024). At the beginning of the study, participants' health eligibility was verified, and

they were informed about the research procedure, signing an informed consent form. They were also instructed to immediately report any adverse effects of CrM supplementation or other health issues to the principal investigator and/or their physician.

During both the pre-test and post-test, participants studied printed examples of gymnastic positions and elements for one minute: standing position, kneeling, straddle stance, forward roll, dive roll, handstand, shoulder stand, backward roll, round-off, and cartwheel (Havel & Hnízdil, 2010). After one minute, each participant was asked to verbally recall all ten positions and elements in the given order. Immediately after listing the last remembered element, they performed the positions and gymnastic elements on the floor.

Assessment focused on correctly recalling the specified positions and elements in the exact order presented in the printed material. The evaluation of the gymnastic routine was based on the number of elements performed correctly and sequentially, ending when the participant could no longer continue with the next listed element. Execution technique was not assessed. These procedures ensured consistent evaluation of memory performance across all participants.

In accordance with Turner et al. (2015), participants consumed 20 grams of CrM or placebo (maltodextrin) each morning for seven days. Compliance was monitored via SMS and follow-up questioning during the post-test. The same gymnastic positions and elements were used in the post-test but presented in a different order.

To assess differences between groups and between pre- and post-tests, a paired t-test and Cohen's d were used, with effect sizes defined as 0.2 (small), 0.5 (medium), and 0.8 (large) (Hendl, 2004).

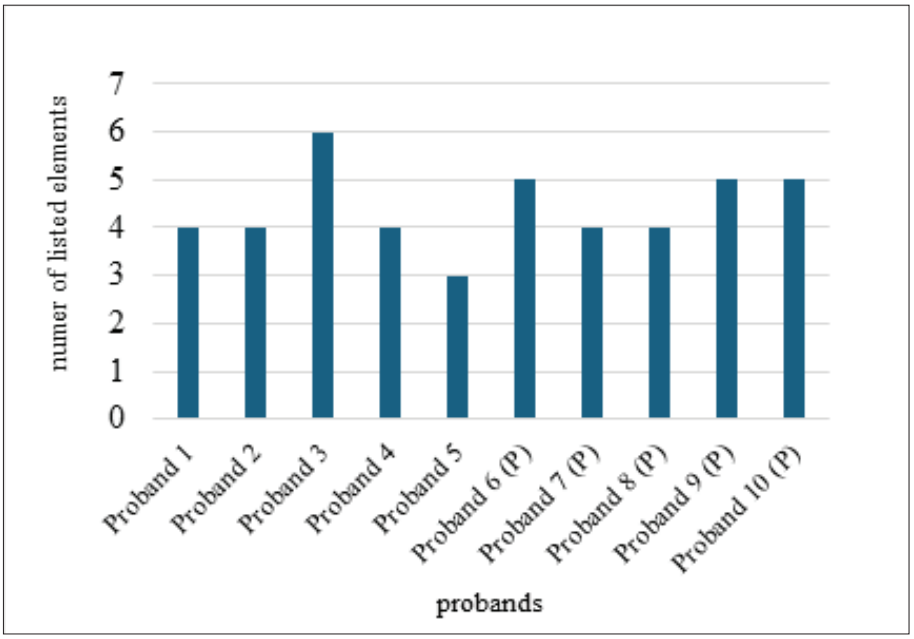
The research was supported by the Cooperatio project at PedF UK.

Results

The pilot study was conducted in accordance with the planned design. None of the participants reported any health issues or adverse effects during the week of CrM or placebo supplementation.

In the initial test involving verbal recall of gymnastic positions and elements, no practically significant difference was found between participants who later supplemented with CrM or placebo (Cohen's $d = 0.36$), indicating a small effect. Statistical significance assessed by t-test also showed no significant difference between groups ($p > 0.05$) (see Graph 1).

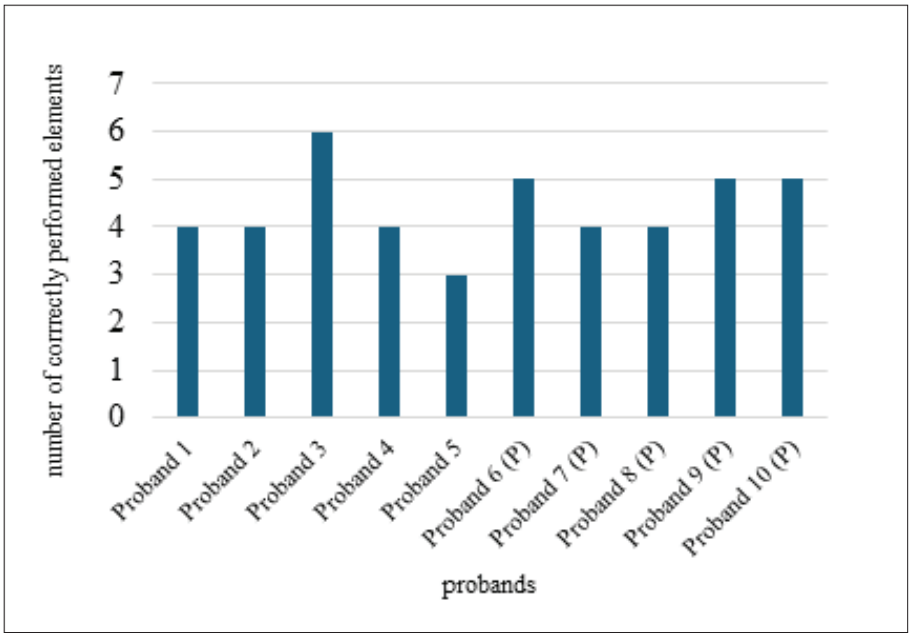
Graf 1./ Graph 1.
Vstupní testování – prvek/poloha, po kterém proband ukončil vyjmenování gymnastických poloh a prvků (P = placebo)./ Initial testing - exercise after which the proband completed the list of exercises (P = placebo).



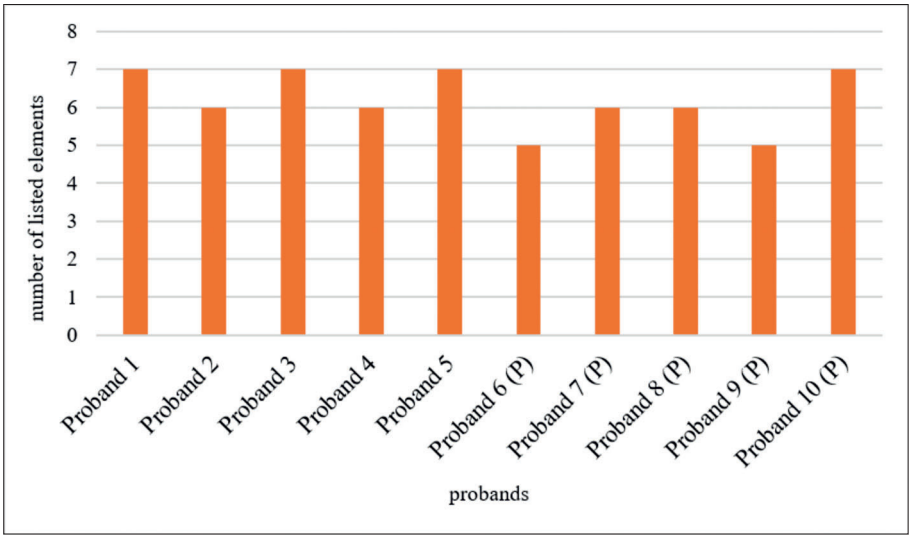
In the second part of the initial test, which involved performing the listed positions and elements, it became evident that combining movement and memory was considerably more demanding than verbal recall alone. The practical significance of the number of correctly performed sequential positions and elements, assessed by Cohen's d, was 0.14, indicating a very small effect size between the experimental and control groups. Statistical analysis (t-test) did not reveal a significant difference ($p > 0.05$).

These results confirm that both groups had comparable abilities during the initial measurement in terms of recalling and performing the selected gymnastic positions and elements in the correct sequence (see Graph 2).

Graf 2./ Graph 2.
Vstupní test – počet interpretovaných gymnastických prvků (P = placebo)./ Initial testing - number of gymnastic elements performed (P = placebo).



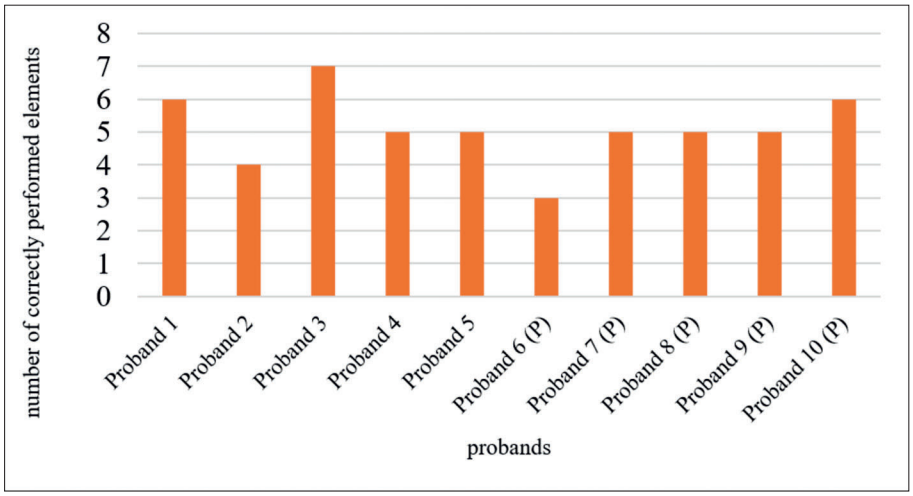
Graf 3./ Graph 3.
Výstupní testování – poloha/prvek, po kterém proband ukončil vyjmenování gymnastických poloh a prvky (P = placebo)./ Exit testing - exercise after which the proband completed the list of exercises (P = placebo).



After seven days of CrM or placebo supplementation, all participants underwent post-test evaluation in the same gymnasium where the initial testing had been conducted. Prior to the start of the test, each participant confirmed that they had taken their assigned supplement—either CrM or placebo—every morning for the full seven-day period (see Graph 3).

During the post-test evaluation of short-term memory, assessed through verbal recall of gymnastic positions and elements, Cohen's d was 0.00—indicating no practical effect between the groups. This finding was further supported by the t-test, which showed no statistically significant difference ($p > 0.05$). These results suggest that CrM supplementation had no impact on the memorization of the specified elements compared to the placebo group (see Graph 4).

Graf 4./ Graph 4.
Výstupní testování – počet realizovaných gymnastických cviků (P = placebo)./ Exit testing - number of gymnastic elements performed (P = placebo).



Tabulka 1./ Table 1.
Výsledky jednotlivých účastníků v pre a post testu (P = placebo), základní popisná statistika./ Results of Individual Participants in the Pre-Test and Post-Test (P = placebo), Basic Descriptive Statistics.

Probands/results	Pre-test Number of correctly listed elements	Pre-test Number of correctly performed elements	Post-test Number of correctly listed elements	Post-test Number of correctly performer elements
Proband 1	4	7	7	6
Proband 2	4	5	6	4
Proband 3	6	8	7	7
Proband 4	4	4	6	5
Proband 5	3	5	7	5
Proband 6 (P)	5	6	5	3
Proband 7 (P)	4	7	6	5
Proband 8 (P)	4	7	6	5
Proband 9 (P)	5	5	5	5
Proband 10 (P)	5	6	7	6
Average	4,40	6,00	6,20	5,10
SD	0,84	1,25	0,79	1,10
Variation range	1,00	2,00	1,00	0,75

In the post-test evaluation of gymnastic position and element execution, the practical significance (Cohen's d = 0.73) indicated a medium effect of creatine supplementation on neuroplasticity compa-

red to the control group. Participants in the experimental group achieved a statistically significant ($p < 0.05$) higher number of correctly performed positions and elements than those in the control group. These findings suggest that the CrM-supplemented group demonstrated a more pronounced improvement in the ability to accurately execute gymnastic positions and elements in the correct sequence compared to the placebo group (maltodextrin).

Discussion

Throughout the pilot study, participants reported no adverse effects related to the daily supplementation of 20 g of CrM. This positive finding aligns with previously published studies (Kreider et al., 2017; Smith et al., 2023).

A possible explanation for the beneficial effects of creatine on memory lies in its role in energy production within the brain. Creatine is essential for ATP synthesis, which serves as the primary energy source for brain cells. Higher levels of creatine in the body lead to increased energy availability for synaptic transmission, which may enhance cognitive function (Branch, 2003). The execution of gymnastic positions and elements tested short-term memory through movement, requiring the activation of additional brain centres beyond those involved in verbal recall. This factor may have influenced the test outcomes.

Given that this was a pilot study, the small sample size presents a limitation for generalizing the results and increases the risk of random influences. Due to resource constraints, we were unable to use advanced technologies (e.g., EMG, electrodes, or other devices measuring brain wave activity) for a more precise assessment of CrM's effects. The use of such equipment could provide deeper insights into neural synapses and the degree of brain wave stimulation.

Another limitation was the absence of daily physical verification of morning CrM or placebo intake. As a result, we relied on verbal confirmation of correct timing. We attempted to mitigate this limitation through ongoing communication with participants via SMS.

Upon reviewing the study design, we believe that more detailed participant guidelines during the experiment could have improved the reliability of the results. For example, participants should have been instructed to maintain adequate sleep, avoid excessive alcohol consumption, and refrain from intense physical activity.

In this pilot study, participants supplemented with 20 g of CrM or placebo for seven days. The duration was based on Turner et al. (2015), who investigated the effects of seven-day CrM supplementation on neuropsychological test performance in normoxic and hypoxic conditions. Rae et al. (2003) supplemented 5 g of CrM or placebo for six weeks and found a positive effect on working memory and intelligence. Hultman et al. (1996) reported that CrM levels return to baseline approximately five weeks after supplementation ends.

Participant performance may also have been influenced by physical fitness, stress levels, and prior experience with similar tasks. These potential confounding factors were minimized by requiring all participants to have passed a gymnastics course that included a floor routine. None of the participants had previously competed in gymnastics. During testing, we aimed to create a positive atmosphere through verbal and nonverbal communication and motivation.

Conducting the pilot study with a heterogeneous group could have led to greater variability in results. However, we believe the homogeneous sample provided more accurate outcomes. Participants were tested individually, which contributed to the validity of the results and allowed for detailed analysis of individual performance.

We selected the floor routine due to its coordination demands, making it an interesting model for studying motor skills. The chosen gymnastic positions and elements were based on gymnastics literature (e.g., Havel & Hnízdil, 2010) and focused on key skills such as balance, coordination, strength, and technical execution. Each element contributes to the technical proficiency required for success in competitive gymnastics. The floor routine does not require specialized equipment, and the standard gymnastics floor was replaced with a gymnastics carpet, facilitating the study's implementation.

In evaluating the execution of positions and elements, we focused solely on correct sequencing. Based on the study's progression, we consider the selected positions and elements to be appropriately chosen. Their suitability was confirmed in relation to the participants' gymnastics abilities. It would be interesting to assess the technical execution of the elements as well (FIG, 2025), for example by

involving a gymnastics expert or judge, which would allow for the inclusion of performance quality in the final evaluation.

This pilot study provides new insights into the effects of CrM on cognitive and motor performance. The results suggest potential applications in optimizing training programs aimed at improving performance in coordination-intensive sports. Future research could explore the effects of creatine on cognitive functions in other contexts, such as its impact on processing complex music-movement compositions or demanding movement patterns involving apparatus.

Conclusion

The aim of this pilot study was to determine whether CrM is a suitable dietary supplement for enhancing memory, assessed through verbal recall and subsequent execution of a gymnastics floor routine among recreational athletes (n = 10).

Initial results showed no significant differences between the experimental (n = 5) and control groups (n = 5) in the number of recalled positions and elements or their execution (Cohen's d = 0.36, $p > 0.05$).

After seven days of morning supplementation with CrM (20 g/day) or placebo (20 g/day, maltodextrin), no significant difference was found in the number of recalled positions and elements. However, members of the experimental group performed a statistically significantly higher number of positions and elements than those in the placebo group ($p < 0.05$). The results demonstrated a medium effect size (Cohen's d = 0.73) of creatine on neuroplasticity compared to the control group in the number of executed gymnastic elements.

The findings of this pilot study suggest that, with appropriate dosing, CrM may enhance athletic performance in coordination-intensive sports.

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Mgr. Šárka Panská, Ph.D.
Univerzita Karlova
Pedagogická fakulta, Katedra tělesné výchovy
250 01, Královická 915
Brandýs nad Labem
sarka.panska@pedf.cuni.cz