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Phosphatidylserine and caffeine attenuate postexercise mood disturbance and perception of fatigue in humans

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ABSTRACT

Phosphatidylserine (PS) may attenuate the adverse effects of physical fatigue. Therefore, we investigated the effects of a multi-ingredient supplement containing 400 mg/d PS and 100 mg/d caffeine (supplement [SUP]) for 2 weeks on measures of cognitive function (CF), reaction time (RT), and mood (MD) following an acute exercise stress. It is hypothesized that PS will maintain preexercise CF and RT scores, while attenuating postexercise fatigue. Participants completed 2 acute bouts of resistance exercise (T1 and T2) separated by 2-week ingestion of SUP or control (CON). Outcome measures were assessed pre- and postexercise. When collapsed across groups, a significant decrease in RT performance was seen in the 60-second reaction drill from pre- to postexercise at T1. All other RT tests were similar from pre- to postexercise at T1. Reaction time was not significantly changed by PS. When collapsed across groups, a significant increase in performance of the serial subtraction test was seen. A significant increase (8.9% and 7.1%) in the number of correct answers and a significant decrease (8.0% and 7.5%) in time to answer were seen from pre- to postworkout at T1 and T2, respectively. A significant increase in total MD score from pre- to postworkout was observed for CON but not for PS at T2. Phosphatidylserine significantly attenuated pre- to postexercise perception of fatigue compared to CON. Ingestion of SUP for 14 days appears to attenuate postexercise MD scores and perception of fatigue, but does not affect CF or RT, in recreationally trained individuals.

1. Introduction

Phosphatidylserine (PS) is an endogenously synthesized phospholipid. Phospholipid bilayers form the core structure of the membranes that surround mammalian eukaryotic cells. The distinct lipid composition defines the thickness, permeability, and fluidity of the membrane [1], regulating the properties of the proteins embedded within it [2] and the subsequent activation of cell signaling pathways for specific cellular processes [3]. Consequently, different tissues and different cell types have distinct phospholipid compositions. Despite its ubiquitous distribution, PS it is found predominantly in the

Abbreviations: 1-RM, 1-repetition maximum; CF, cognitive function; CON, Control; D2, Dynavision D2 Visuomotor Training Device; HPL, Human Performance Laboratory; ICC, intraclass correlation coefficient; MD, mood; POMS, Profile of Mood States Questionnaire; PS, phosphatidylserine; RT, reaction time; SEM, standard error of measurement; SST, serial subtraction test; SUP, supplement; T1, testing session 1; T2, testing session 2; TMS, total mood score.

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myelin of brain tissue [4] and appears to have a concomitant role in the activity of nerve cells [5]. Phosphatidylserine is the most effective phospholipid in the activation of classic isoforms of the enzyme protein kinase C [6], triggering the transcription, differentiation, proliferation, and regulation of nerve cells downstream of its activation [7]. In addition, it has been suggested that PS can affect the exocytosis of neurotransmitters through its calcium-dependent interaction with membrane-binding proteins, enhancing the fusion between synaptic vesicles and membranes to release neurotransmitters such as acetylcholine [8]. Consequently, the integration of supplemental PS into cell membranes may stimulate neural amplification, possibly augmenting both cognition and motor function [9,10].

The potential neural benefit has led to investigations examining the effects of PS supplementation on cognition, reaction time (RT), and acute physiological response to both physical and mental stress [11–17]. Acute ingestion of a multi-ingredient supplement containing 50 mg PS in combination with several other nutrients (α-glycerophosphocholine; choline bitartrate; vitamins B3, B6, and B12; folic acid; L-tyrosine; anhydrous caffeine; acetyl-L-carnitine; and naringin) has been shown to maintain RT to both visual and auditory stimuli and focus, following a high-intensity bout of exhaustive exercise [12]. In addition, supplementation with 400 mg/d of PS for 14 days has been shown to significantly increase cognitive function before and 60 minutes postexercise in resistance-trained college-aged men [17], whereas 200 mg/d of PS for 6 weeks in healthy men has been shown to significantly attenuate β-1 power (an indicator of activation associated with cognitive task demands and higher neurophysiological function in right hemispheric frontal brain regions) before and after induced mental stress [11]. Dosages of 800 mg/d PS for 10 days have been reported to significantly blunt the adrenocorticotropic and cortisol response to exercise [16], and supplementation with 750 mg/d for 10 days has been shown to increase time to exhaustion in both runners [13] and cyclists [14]. In contrast, there are several studies that were unable to support any cognitive or ergogenic benefit from PS ingestion. Kingsley and colleagues [15] reported that 750 mg/d for 10 days was not effective in attenuating markers of muscle damage, inflammation, or oxidative stress following prolonged downhill treadmill running. Baumeister and colleagues [11] reported that, following 42 days of supplementation with 200 mg/d of PS, no improvements in cognitive task performance following a mental stress were observed. Other investigators reported no effect on memory or other cognitive functions in older individuals with memory complaints supplemented with 300 or 600 mg/d PS [18]. Consequently, the efficacy of PS remains equivocal.

The differences in these studies may be related to the level of fatigue associated with the protocol. It appears that studies that involved a fatiguing exercise protocol demonstrated a potential ergogenic role for PS, whereas studies that did not exhaust their participants remained equivocal. Considering the apparent role of fatigue on the efficacy of PS, the purpose of this study was to examine the effects of a multi-ingredient supplement on measures of cognitive function, RT, and mood following an acute exhausting resistance exercise protocol. We anticipated declines in cognitive function, RT, and mood state from pre- to postexercise. Therefore, it was hypothesized that these declines would be attenuated through supplementation with PS and caffeine. Specifically, we hypothesized that 14 day of supplementation with PS and caffeine would maintain preexercise cognitive function and RT scores following resistance exercise, and attenuate postexercise fatigue level. To test this hypothesis, we used a double-blind, randomized, controlled trial in which 21 healthy recreationally trained men and women consumed either a multi-ingredient supplement containing 400 mg/d PS and 100 mg/d caffeine, or control for 14 days. Analysis of cognitive function, RT, and mood state was quantified through an objective measure using the serial subtraction test (SST), Dynavision D2 (D2), and Profile of Mood States Questionnaire (POMS) respectively.

2. Methods and materials

2.1. *Participants*

Twenty-two healthy participants (18 men, 4 women) volunteered to participate in this randomized, double-blind, controlled study. One participant was excluded because of nonadherence to the supplementation protocol. Twenty-one participants completed the study (17 male, 4 female; age: 22.5 ± 3.4 years; height: 1.76 ± 1.0 m; weight: 77.6 ± 12.6 kg; body fat: 14.6% ± 6.6%). Following an explanation of all procedures, risks, and benefits associated with the experimental protocol, each participant gave his or her written informed consent to participate in this study. The research protocol was approved by the University of Central Florida Institutional Review Board. All volunteers had at least 6 months of resistance training experience before the initiation of the investigation. Volunteers were not permitted to use any additional nutritional supplementation before and during the investigation. Screening for supplementation use was accomplished via a health questionnaire filled out during volunteer recruitment.

2.2. *Experimental protocol*

Participants reported to the Human Performance Laboratory (HPL) on 2 separate occasions. The study's protocol is depicted in Fig. 1. Each testing session was separated by 2 weeks. Volunteers were instructed to refrain from any strenuous physical activity for 72 hours before testing. In addition, participants were instructed not to drink or eat for 2 hours before each trial. During the first testing session (T1), participants performed a standardized warm-up consisting of 10 minutes of cycling and warm-up sets in both the squat and bench press exercise at 40% to 60% of his/her tested 1-repetition maximum (1-RM). Immediately following the warm-up, participants completed tests of RT (D2) and cognitive function (SST) and a mood survey (POMS). Immediately following these assessments, participants performed an acute bout of resistance exercise. The reaction, cognition, and mood assessments were administered in identical fashion immediately following the resistance training session. Participants were then randomly provided either the supplement (SUP) or control (CON) to ingest for the next 14 days. Participants then returned to the HPL at the end of the 2-week supplement period (T2) and