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Positive Effect of Physical Exercise on University Students' Creative Thinking

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This study aims to assess the relationship between engagement in physical exercise and the level of creative thinking among university students. A total of 120 students were recruited using stratified random sampling to ensure a diverse representation of academic disciplines and backgrounds. The sample was divided into two groups: a research group of 60 participants who engaged in a structured physical exercise program and a control group of 60 students who did not participate in any physical exercise. The Torrance Test of Creative Thinking-Verbal was used to evaluate the creative thinking indicator. Before initiating the experimental activities, a comprehensive questionnaire specifically designed to assess creative thinking abilities. T-test was used to compare the means of two independent groups to determine if the observed differences in their scores are statistically significant. Based on pre-test TTCT-V scores of both research and control groups do not significantly differ. The results of the study confirmed significant differences between the research and control groups by the post-test TTCT-V scores. This result indicates that the research group exhibited a higher level of cognitive flexibility, and an ability to shift between different ideas and approaches. In conclusion, this study confirms that physical exercise has a positive effect on university students' creative thinking during term time.

Keywords: physical exercises, creative thinking, TTCT-V, positive impact, students

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INTRODUCTION

The benefits of physical exercise are evident from both a physical and psychological perspective. A recent umbrella review (Singh et al., 2023) concluded exercise had a positive impact on both mental health and was effective in avoiding a number of chronic physical disroders. Drawing upon extensive research, it becomes increasingly evident that the significance and indispensability of physical exercise for university students are profound. Numerous studies have consistently highlighted the multifaceted benefits that regular physical activity brings to students' lives, extending far beyond mere physical health (Lindwall & Hassmén, 2004; Andreea, 2018; Zhang, 2021). Factors such as enhanced cognitive function and learning efficiency as well as bolstering mental well-being and resilience, the holistic impact of exercise on university students is vast and far-reaching (Ranjbar et al., 2015; Margulis et al., 2021; Botagariev et al., 2021). Physical exercise serves as a cornerstone for promoting overall health and vitality among students, contributing to improved cardiovascular health (Karpov et al., 2021), better weight management (Das & Evans, 2014), and enhanced immune function (Simpson et al., 2015). Moreover, engaging in regular physical activity has been shown to positively influence students' self-perception (Lazarević et al., 2017), confidence levels, and body image, fostering a more positive relationship with oneself (Şanlier et al., 2016; Gillen, 2015).

Beyond the physical realm, exercise plays a pivotal role in optimizing cognitive function and academic performance. Research indicates that physical activity stimulates the release of neurotransmitters and growth factors in the brain, promoting neuroplasticity and enhancing cognitive abilities such as memory, attention, and executive function (Hwang, 2021). Engaging in physical activity triggers the release of endorphins and other mood-regulating neurotransmitters, leading to a natural uplift in mood and reduction in stress levels. Additionally, exercise provides a constructive outlet for releasing pent-up tension and negative emotions, promoting emotional resilience and psychological well-being (Yunusovich et al., 2022).

It is widely acknowledged that university students frequently spend considerable amounts of time in sedentary positions, whether it be during lectures, study sessions, or engaging in academic pursuits. Self-reported data reveals that, on average, university students spend approximately 7.29 of waking hours per day in sedentary activities (Castro et al., 2020). Other researchers have corroborated the findings, indicating a wide range of sedentary time (ST) among university students, spanning from 0.75 to 14.35 hours per day. The mean ST, as measured by domain-specific questionnaires, was recorded at 11.10 hours per day, while accelerometers yielded a slightly lower mean ST of 10.69 hours per day (Moulin et al., 2021). The analyzed studies affirm that the significance and importance of exercise for university students are substantial. It appears that engaging students in physical activities poses a significant challenge. While students may spend significant time sedentary, it does not necessarily follow that they are not active; however, many students still fail to meet the recommended guidelines for weekly exercise, which can negatively impact overall health and well-being despite periods of physical activity.

Today, a pivotal aspect of higher education involves fostering students' creative thinking abilities. Creative thinking has a direct and profound impact on students' future careers, learning capabilities, and overall engagement in various activities (Aladwan et al., 2023). A considerable number of researchers have dedicated their efforts to exploring the importance of fostering creative thinking among university students (Ritter et al., 2020; Soh, 2017;). To date, research exploring the correlation between creative thinking and engagement in physical exercise among university students remains limited. While extensive literature exists on the individual benefits of both creative thinking and physical activity, there is a notable gap in understanding how these two factors may interact within the context of higher education.

The relationship between physical activity and creative thinking has garnered significant interest in research. Engaging in regular physical activity can stimulate various cognitive processes that contribute to creativity. Physical activity increases blood flow to the brain, promoting the growth of new neurons and improving overall brain function (Oppezzo & Schwartz, 2014). This enhanced brain health can lead to improved cognitive abilities, including creative thinking. Also, exercise is known to reduce stress and anxiety, which can hinder creativity. By improving mood and providing a mental reset, physical activity can create a more conducive environment for creative thought (Bidzan-Bluma & Lipowska, 2018; Alkharusi et.al., 2019).

Different forms of exercise, especially those that are rhythmic or require coordination, can encourage divergent thinking, a key component of creativity. Activities like dancing or team sports may foster innovative ideas and problem-solving skills. Engaging in outdoor and nature based physical activity can further enhance creativity (Kimura et al., 2023). Teachers who organize physical education classes and other exercise activities have the ability to tailor these programs to meet specific requirements and engage students effectively (Nemeth et.al., 2024). In this regard, the relationship between physical activity and creative thinking is multifaceted, involving physiological, psychological, and social dimensions. Encouraging regular exercise can therefore be an effective strategy to enhance creativity in individuals.

In the current era of scientific advancement and modern technology, the demand for physical activity is increasingly recognized as essential for overall health and well-being. As sedentary lifestyles become more common due to the proliferation of technology, the importance of regular physical activity is highlighted not only for physical fitness but also for cognitive functioning and mental health. Studies confirm addiction to substances, digital devices, smartphones, and computers are on the rise across all age groups and demographics (Karakose et.al., 2022; Tutubas et.al., 2023). The increasing dependence on smartphones across various age groups has been associated with rising levels of addiction, leading to sedentary behavior and a lifestyle characterized by physical inactivity. This phenomenon highlights the need for further investigation into the implications of smartphone use on health, as prolonged engagement with digital devices can contribute to negative outcomes such as decreased physical activity, increased risk of obesity, and various mental health issues. Understanding these trends is essential for developing effective interventions to promote a more active lifestyle and mitigate the adverse effects of excessive

smartphone use. (Paradakis et.al., 2021; Paradakis, 2023). The aforementioned trends highlight the urgent need to promote physical activity among students. Increasing physical engagement can yield significant positive outcomes, including enhanced physical health, improved mental well-being, and enhanced academic performance. Regular physical activity is associated with better cardiovascular health, increased strength and endurance, and a reduced risk of chronic disease. Moreover, it can alleviate symptoms of anxiety and depression, boost mood, and enhance cognitive functions such as memory and concentration.

This study holds significant implications for educational practices and student well-being. Findings may encourage educational institutions to incorporate more opportunities for physical activity into curricula, fostering an environment conducive to creative thinking and holistic development. By demonstrating a positive correlation between physical exercise and creative thinking, the research could advocate for policies that prioritize physical activity as a critical component of student life. Ultimately, this study contributes to the broader fields of educational psychology and cognitive science by illuminating the interplay between physical health and cognitive performance, thereby offering practical recommendations for enhancing creativity among university students. Therefore, the aim of this investigation is to assess the relationship between engagement in physical exercise and the level of creative thinking among university students.

Based on the research purpose the following two hypotheses were formulated:

Hypothesis 1. The pretest creative thinking scores of control and research groups do not significantly differ.

Hypothesis 2. The post-test creative thinking scores of control and experimental groups significantly differ and the post-test creative thinking scores will be significantly greater in experimental groups than control groups.

METHOD

Sample

A total of 120 students enrolled in Bachelor's degree programs at Samarkand State University were randomly selected for the study (see Figure 1).

The average age of students was 19±2.7 years old. Participants were chosen from faculties not specializing in physical education and sports and excluded those who were classified as high-performance athletes. To maintain gender balance, the selection process involved choosing 60 female students and 60 male students.

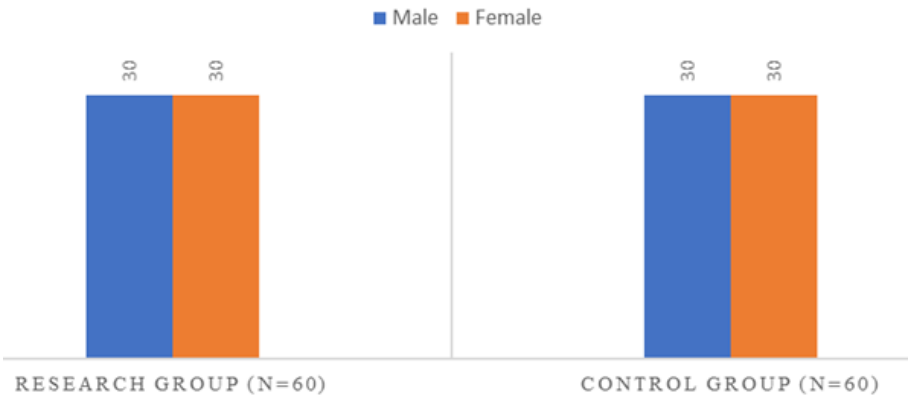

Figure 1
Involved participants to the research process by gender categories (n = 120)

Procedure

All participants were duly informed about the content and purpose of the research study. Written consent was obtained from each study participant prior to their involvement in the research. Following the informed consent process, the sample group was divided into two groups: the research group (RG) and the control group (CG). The research group (RG) comprised participants who followed our intervention, while the control group (CG) consisted of students who did not engage in physical exercises. The specific sample sizes for each group were 60 for the research group and 60 for the control group.

Two researchers continuously monitored the control group to ensure that the students did not engage in any exercise during the study. While, university lecturers organized physical education classes and exercise for the research group.

The Torrance Test of Creative Thinking-Verbal (TTCT-V)

Torrance Test of Creative Thinking-Verbal (TTCT-V) was used to evaluate the creative thinking indicator of the students (Torrance, 1974). Before initiating the experimental activities, a comprehensive questionnaire specifically designed to assess the creative thinking abilities of the students was administered. This questionnaire included various items and tasks aimed at evaluating different aspects of creativity, such as divergent thinking, problem-solving skills, originality, and fluency of ideas. The questionnaire was carefully crafted to provide detailed insights into the creative potential of each participant, serving as a baseline measure for the subsequent analysis of the effects of the experimental interventions.

Practical Approach

During a three-month period, the research group (RG) engaged in regular physical exercise for a minimum of three times a week, focusing primarily on fitness, table tennis, volleyball and specially designed team games. The duration of each exercise

session ranged from 45 to 90 minutes. Physical exercise was organized around students' timetables (Table 1).

Table 1
Research design

Groups	Pre-Test	Experimental Implementation	Post-Test
RG	measurement	Designed approach (exercises)	measurement
CG		Usual approach (non exercises)	

Ethical Considerations

Before participants were asked to sign the consent forms, they were provided with a comprehensive document outlining the study's objectives, potential limitations, and any associated risks. The document also detailed the methodology, procedures, and anticipated activities. Participation was entirely voluntary, and confidentiality was rigorously maintained. To protect participant privacy, all personal data provided were anonymized using unique identification numbers. Furthermore, any physical documents containing sensitive information were securely stored in locked filing cabinets. Electronic data were stored on university computers protected by passwords to prevent unauthorized access. These precautions were implemented to ensure the confidentiality and security of participant information throughout the study. Local Ethical Committee of Samarkand State University approved this study.

Data Analysis

T-test was used to compare the means of two independent groups (Research vs Control) to determine if the observed differences in their scores are statistically significant. A significance level of $p<0.05$ was used as a threshold level for all statistical analyses, with significant results denoted by asterisks: ***p <0.001, **p <0.01, *p <0.05.

FINDINGS

The findings obtained during the study have confirmed both hypotheses.

Testing *"Hypothesis 1".*

Based on *"Hypotesis 1"* the pre-test TTCT-V scores of both research and control groups do not significantly differ.

Initially t-tests were conducted to examine pre-test differences. There were no significant difference on any of the subscales found prior to the intervention. See table 2 for a comparison of scores between groups pre intervention (fluency: t-0.063, $p\geq0.267$; originality: t-0.059, $p\geq0.476$; flexibility: t-0.023; $p\geq0.320$). In summary, the pre-test scores for the TTCT-V subtests - fluency, originality, and flexibility show that there were no significant differences between the research and control groups. The p-values for all three subtests indicate that the initial creative abilities of participants in the research and control groups were comparable before the intervention began. These findings suggest that both groups were on an equal footing in terms of creative thinking skills at the start of the experiment, *"Hypothesis 1"* is supported.

Table 2
Comparison of Pre-Test TTCT-V scores of research and control groups (n=120)

TTCT-V Subtests	Groups	N	Mean	SD	T test	p value
Fluency	Research	60	14.2	0.34	0.063	≥0.267
	Control	60	14.1	0.36		
Originality	Research	60	9.47	0.24	0.059	≥0.476
	Control	60	9.76	0.41		
Flexibility	Research	60	13.33	0.38	0.023	≥0.320
	Control	60	13.86	0.36		

Testing *"Hypothesis 2"*

Table 3 presents the comparison of post-test TTCT-V scores between the experimental group and the control group. The findings confirmed significant differences between the research and control groups by the post-test TTCT-V scores (fluency: t-1.028, $p \leq 0.005$; originality: t-1.019, $p \leq 0.005$; flexibility: t-1.135, $p \leq 0.005$). This result indicates that the research group exhibited a higher level of cognitive flexibility, an ability to shift between different ideas and approaches. The significant difference suggests that exercise was effective in enhancing participants' ability to think flexibly and adaptively in creative problem-solving scenarios.

Table 3
Comparison of Post-test TTCT-V scores of research and control groups (n=120)

TTCT-V Subtests	Groups	N	Mean	SD	T test	p value
Fluency	Research	60	17.39	0.41	1.028	≤0.018*
	Control	60	15.24	0.73		
Originality	Research	60	12.36	0.35	1.039	≤0.023*
	Control	60	10.45	0.81		
Flexibility	Research	60	18.11	0.40	1.135	≤0.014*
	Control	60	14.37	0.52		

DISCUSSION

This study focused on examining the impact of physical exercise on students' creative abilities. The findings confirmed that physical activity, such as fitness, table tennis, volleyball, and specially designed team games, positively influence students' creative thinking scores.

Effectiveness of Physical Exercise on Creative Thinking

The results of this study indicate a notable improvement in creative thinking skills among university students who engaged in physical exercise compared to those who did not. This finding aligns with a growing body of literature suggesting that physical activity has a beneficial impact on cognitive functions, including creativity. It is important to indicate that effective use of physical exercise during the academic year at universities can positively effects students' creative thinking. Our results align with previous studies, which confirmed the positive effect of physical exercise on students' creativity. Previous research suggests physical exercise can impact, harmonious development, motor abilities, intelligence, and creative potential of students (Lupu,

2012). In addition, studies also confirm that physical education classes have a positive effect on students learning capacities (Kim, 2015; Chen, 2024). In this context, our research findings are consistent with and reinforce the conclusions of previous studies.

Enhancement of Fluency, Originality, and Flexibility

Significant improvements were recognised in all three core components of creative thinking as measured by the TTCT-V: fluency, originality, and flexibility.

The ability to generate a large number of ideas was significantly enhanced in the exercise group. This result suggests that physical exercise may stimulate the cognitive processes involved in idea generation. Increased blood flow and neurogenesis, stimulated by regular physical activity, could contribute to a higher volume of ideas being produced. Yoga and/or aerobic exercise was linked to estimated enhancements in verbal fluency compared to sedentary adults (Nocera et al., 2020). Yoga and aerobic exercise may be effective methods for boosting cognitive function in older adults.

Participants who engaged in physical exercise also demonstrated a significant increase in originality. This enhancement implies that exercise might foster a more divergent thinking process, allowing students to produce more novel and unique ideas. Despite this, studies have highlighted that the effects of physical exercise on cognitive and creative performance may vary depending on individual characteristics (Rominger et al., 2019). They emphasized that personal traits, such as baseline fitness levels, personality, and genetic factors, could influence how effectively physical exercise impacts each person's cognitive outcomes. This suggests that the benefits of exercise might not be uniform across all individuals and that personal differences should be considered when evaluating the impact of physical activity on cognitive functions.

The greatest improvement was observed in flexibility, reflecting an enhanced ability to shift between different ideas and perspectives. This is crucial for effective problem-solving, critique and innovation. Further, studies also confirmed that the improvement in flexibility might be attributed to the cognitive and emotional benefits of exercise, such as reduced stress and enhanced executive function (Bollimbala et al., 2023; Ángel Latorre-Román et al., 2021). In addition, other studies have pointed out that thinking is one of the basic aspects in education system. While students' critical thinking abilities, especially, interpretation, analysis, evaluation, inference, explanation, and self-regulation require development through education systems. (Basri et. al., 2019). Our study corroborates the findings of earlier research, reinforcing the validity and reliability of those results. Specifically, the data we collected and analyzed align closely with the conclusions drawn in previous studies, thereby providing further evidence that supports their accuracy. By confirming these earlier findings, our research contributes to a more comprehensive understanding of the subject and highlights the continued relevance of the established theories and methodologies used in previous investigations.

Mechanisms Linking Physical Exercise and Creativity

The positive effects of physical exercise on creative thinking can be attributed to several underlying mechanisms:

1. Increased Brain Function. Physical exercise has been shown to promote neurogenesis and improve brain plasticity, particularly in areas associated with cognitive functions and creativity (Hötting & Röder, 2013; Gregory et al., 2012). Enhanced brain function and connectivity can lead to improved cognitive performance, including creativity.

2. Improved Mood and Stress Reduction. Exercise is known to reduce stress and improve mood through the release of endorphins and other neurotransmitters. A more positive emotional state and lower stress levels can create a conducive environment for creative thinking by reducing cognitive constraints and enhancing mental flexibility (Ludyga et al., 2020).

3. Enhanced Cognitive Function. Regular physical activity improves overall cognitive function (Jedrziewski et al., 2007), including attention, memory, and problem-solving skills. These cognitive improvements can contribute to better creative thinking by facilitating the generation of novel ideas.

4. Social Aspects of Physical Activity. Physical activity has been demonstrated to facilitate social connectedness which has been shown to enhance cognitive processes (Wray et al., 2020). Engaging in physical activity not only fosters social interactions and strengthens relationships but also creates a positive feedback loop that further stimulates cognitive functioning, potentially leading to improved mental health and overall well-being.

Implications for University Students and Educational Practices

The findings of this study have important implications for university students and educational institutions. Integrating physical exercise into the daily routines of students could be a simple yet effective strategy to enhance their creative thinking abilities (Siedentop & Van der Mars, 2022). Educational institutions might consider incorporating regular physical activity into curricula or offering exercise programs to support students' cognitive and creative development. Universities have various opportunities to attract students to be physically active. These include sports clubs, organized activity days, exercise sessions, and other initiatives. By promoting a vibrant culture of fitness, universities can encourage student participation and foster a sense of community.

Moreover, promoting physical exercise as part of a holistic approach to student well-being can improve not only academic performance but also overall health and stress management (Kokko, 2014). Encouraging students to participate in physical activities, such as sports, fitness classes, or recreational activities, can foster both their physical and psychological growth.

LIMITATION

This study's focus on a specific university may limit the diversity of perspectives and experiences. Also, the duration of the physical exercise program may not have been long enough to observe sustained changes in creative thinking. Long-term studies could provide a better understanding of the lasting effects of physical activity on creativity.

CONCLUSION

This study confirms that physical exercise has a positive effect on university students' creative thinking. This was evidenced by improvements in fluency, originality, and flexibility. These findings highlight the importance of incorporating physical exercise into students' routines and suggest that educational institutions should promote physical activity to support and enhance cognitive and creative development.

Future Research Directions

While the current study offers valuable insights, several areas warrant further exploration to build on these findings.

One promising direction is the implementation of longitudinal studies to investigate the long-term effects of regular physical exercise on creative thinking. By assessing whether the benefits of exercise are sustained over time, researchers can better understand its impact on academic and professional success.

Additionally, examining the effects of various types of physical activities on creativity could yield important insights. A comparative analysis of aerobic exercises, strength training, and flexibility workouts may reveal which forms of physical activity are most beneficial for enhancing creative thinking. Furthermore, incorporating nature-based exercise could potentially further enhance students' creative capacities, highlighting the role of the environment in physical activity.

Individual differences also merit exploration. Understanding how factors such as baseline fitness levels, gender, or personality traits influence the relationship between physical exercise and creativity could help in tailoring interventions to maximize effectiveness for diverse student populations.

Finally, conducting mechanistic studies will be crucial for uncovering the specific cognitive and neurobiological mechanisms through which physical exercise enhances creativity. Investigating changes in brain activity, neurotransmitter levels, and cognitive processes, enables researchers to deepen our understanding of how exercise influences creative thinking.

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