

Aerobic Exercise as the Fuel for Enhanced Creativity: A Review of Evidence

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ABSTRACT

Background: Creative thinking is considered as an ultimate form of human thinking, which is influenced by various biological and psychological factors. Literature reveals that bodily movements are associated with enhanced creativity in select professions. The present review aimed to summarize the effects of various forms of acute exercise on creative thinking processes.

Materials and methods: An electronic search of databases such as MEDLINE through PubMed, ProQuest, and Google Scholar was performed to retrieve appropriate reference literature. The period was set from inception till November 2021 to identify relevant English language peer-reviewed articles on exercise and creativity. Eight articles were selected for review after shortlisting from the relevant literature.

Results: Studies reveal that a wide range of participants (children and adults; athletes and non-athletes) benefited from acute exercise-induced enhanced creative thinking. Majority of the studies employed objective measurements of exercise-enhanced creativity. Various forms of exercise (walking, running, jogging, cycling, swimming, etc.) enhanced the creative thinking processes.

Conclusion: Though most forms of acute exercise enhanced the creative thinking processes, exercise forms that are aerobic in nature, involving a wide range of body movements, and performed for a longer period of time, had the most beneficial effects on creativity.

Keywords: Acute exercise, Cognition, Creative thinking, Physical activity, Psychological.

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INTRODUCTION

Creativity is one of the unique attributes of human thinking. Creative thinking is often considered instrumental in scientific innovations, artistic portrayals, and seeking solutions to existing problems.¹ Creativity is considered to the extent of ultimate gift or talent potential of a being leading to individual and the societal uplift.² Creative thinking, however, occurs due to the perturbation of stable cognitive algorithms, paving way for new, innovative thinking to occur.¹ The term “creativity” does not get confined due to a structured definition.

Creativity is postulated to occur due to the constant interaction between people and their environment.³ Hence, it can be clearly understood that environmental influences play a vital role in creative thinking. Some of such factors are music, exercise, ambient light, etc. Anecdotal literature shows that bodily movement is associated with enhanced creativity and overcoming mental obstacles, especially in artisans, musicians, etc.

The present narrative review attempts to summarize the effects of various forms of acute exercise on creative thinking processes. It also attempts to delineate the participant characteristics, exercise characteristics, measurement of creativity, and the possible reasons for enhanced post-exercise creative thinking.

MATERIALS AND METHODS

An electronic search of databases such as MEDLINE through PubMed, ProQuest, and Google Scholar was performed to retrieve appropriate reference literature. The period was set from inception till November 2021 to identify relevant English language peer-reviewed articles on exercise and creativity. We used the following combinations of free text terms such as: “aerobic exercise”, “creativity”, “creative thinking”, “exercise”, and “physical

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activity”. Two independent authors performed a liberal search of literature, and the final list of articles were selected based on mutual consensus. A total of 37 original research articles were initially shortlisted, and based on the reading of the abstracts and full-texts, 8 articles were selected for the review. For the present narrative review, we neither attempted computation of effect sizes nor performed a risk of bias assessment for included papers.

RESULTS

Participant Characteristics

A wide range of participants were studied for the effects of aerobic exercise on creativity. Most studies had examined by recruiting young adults: College and university students⁴⁻⁸ and university staff.^{5,7} One study differentiated the effects of exercise on creativity between trained cycling athletes and non-athletes.⁹ Few studies

have explored the effects of aerobic exercise on the creative thinking processes of children.^{10,11}

Exercise Characteristics

Various forms of exercise have been shown to initiate and sustain creative thinking both in the short-term and in the long-term.

Acute bouts of running,^{4,10} aerobic dance (Steinberg, et al.),⁵ aerobic exercise (jogging, swimming, fast walking, stair climbing, and working out in stationary bikes),⁶ cycling,⁹ and treadmill walking⁷ had significant positive influences on creative thinking. One recent study revealed that active play in children and adolescents improved their creative thinking processes.¹¹ Studies have found that as the intensity of aerobic exercise increased, convergent creative thinking diminished.⁹ The type, duration, intensity of exercise, and the participant characteristics are depicted in Table 1.

Measurement of Creative Thinking

Almost all the studies on exercise and creativity employed objective measurements of improvements in creativity. The commonly employed tests for measure of creative thinking are mentioned in Table 2.

Effects of Aerobic Exercise on Creative Thinking

A landmark study by Gondola et al. proved that acute bouts of running lasting 20 minutes each facilitated creative thinking processes in healthy subjects.⁴ Since then, more studies have found positive influence of aerobic exercise on creative thinking processes.^{5-7,9-11} However, few studies have reported negative association between exercise and creativity.⁸

DISCUSSION

The present review of literature on the relationship between exercise and creativity has found certain important observations. A wide range of aerobic exercise interventions (walking, treadmill walking, running, aerobic workouts, aerobic dance, etc.) have proven beneficial in enhancing the creative potential. The positive influence of exercise is observed across age-groups, involving both children and young adults.^{5-7,9-11}

Moderators of Exercise-induced Enhancement of Creativity

Exercise Characteristics

Studies reveal that exercises that are aerobic in nature,^{4-7,9-11} which allowed a wide range of body movements like aerobic dance⁵ and performed over a longer period as noted in athletes,⁹ had positive influences on creativity. Such findings suggest that enhanced physical flexibility and an enduring physical fitness are key factors for exercise-enhanced creativity. Nevertheless, simpler forms of aerobic exercise, such as walking, improved convergent and divergent thinking processes. Incorporating active forms of play among children proved beneficial in promoting their creative thinking potential.¹¹

Biological Factors

Studies on neuroscientific basis of creativity have shown that both the left and right hemispheres are involved in the creative thinking process. Bilateral medial temporal lobes, bilateral rostralateral prefrontal cortex, insula, and temporopolar cortices are activated during creative generation and creative evaluation.¹²

Physical exercise mediates enhanced neurotransmission in select brain areas such as the prefrontal cortex and basal ganglia leading to enhanced cognitive abilities such as heightened arousal, cognitive control, increased planning, and reward perception.^{13,14} Such activation of select brain areas might underlie the beneficial effects of acute exercise on creativity.

Psychological Factors

Regular exercise is postulated to be linked with better memory, balanced emotional states, and creative thinking.⁸ Physical exercise has inherent components of self-will, initiation, sustained attention, and self-regulation, which in turn may influence the cognitive apparatus in the genesis of creative ideas.^{15,16}

The post-exercise enhanced mood states can be potent confounders in the post-exercise enhanced creativity. However, when studies attempted to discern this influence, they found that the creative thinking after a bout of exercise occurred "independent" of the mood state.⁵

Environmental Factors

Walking in the outdoor environment produced better cognitive outcomes when compared with walking indoors on a treadmill.⁷ This indicates that environmental factors can influence creativity enhancement by exercise.

Limitations

The present review focused more on acute bouts of aerobic exercise, and various forms of aerobic activity such as Zumba, martial arts, etc., were not reviewed. As noted in the recent review, the relationship between aerobic exercise and creative thinking is multifarious, with multiple different studies with different methodological concerns.¹⁷ The present review did not include the effects of chronic forms of physical activity (e.g., endurance or resistance exercise) on creativity.

CONCLUSION

Various forms of exercise have been shown to initiate and sustain creative thinking both in the short-term and in the long-term. Exercise forms that are aerobic in nature, involving a wide range of body movements, and continued for a longer period, have the most beneficial effects on creative thinking. Future studies should explore the moderating factors in exercise-induced better creative thinking, including environmental factors apart from the biological and psychological factors.

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Table 1: Effects of aerobic exercise on creativity—literature evidence

<i>Sl. no.</i>	<i>Study authors</i>	<i>Study title</i>	<i>Form of exercise assessed in the study</i>	<i>Aim</i>	<i>Sample</i>	<i>Exercise characteristics</i>	<i>Study design/Analyses</i>	<i>Tests for creativity</i>	<i>Inference</i>	<i>Implied mechanisms</i>
1.	Gondola and Tuckman, 1985	Effects of a systematic program of exercise on selected measures of creativity	Running	To assess the effects of a controlled exercise program on creative thinking	Co-Ed students N = 23	20-minutes running 16 sessions	A comparison study with the control group	Alternate uses, remote consequences, obvious consequences	Significant differences found for alternate uses and remote consequences, which yielded more divergent measures, which suggests a strong influence on creativity No significant differences were found in obvious consequences (a measure of access to memory storage)	
2.	Steinberg et al., 1997	Exercise enhances creativity independently of mood	Aerobic workout OR Aerobic dance	To establish whether post-exercise creative thinking was attributable to improved mood	University students and staff N = 63	25-minutes aerobic workout/ aerobic dance For the control group, 25-minutes of emotionally neutral video	A comparison study with the control group Study comparison group N = 31 Control group N = 32 For both groups, measures of mood were taken pre- and post-experiment, and creativity tests were taken post-experimental session	Mood adjective checklist consisting of positive and negative mood adjectives Torrance's unusual uses test	Mood and creativity were improved by physical exercise independently of each other A significant improvement was found on the flexibility measure of creativity Aerobic dance was perhaps marginally more effective than aerobic workout	

<p>3. Herman-Tofler and Tuckman, 1998</p>	<p>The effects of aerobic training on children's creativity, self-perception, and aerobic power</p>	<p>Aerobic exercise (low to medium impact)</p>	<p>To examine whether an aerobic conditioning program vs regular physical exercise differed in their effects on creativity, self-perception, and aerobic power</p>	<p>Third grade students N = 52</p>	<p>Study group– Aerobic exercise (one session per week for 8 weeks, each session included 5 minutes of stretching, followed by 25 minutes of low to medium impact aerobics and ended with brief stretching) Control group– Traditional physical education</p>	<p>A comparison study with the control group</p>	<p>The pre- and post-testing methods and instruments used in this study are as follows:</p> <ul style="list-style-type: none"> • <i>Aerobic power:</i> Time to complete 800 m run • <i>Creativity:</i> Torrance test of creative thinking (TTCT) • <i>Self-perception profile:</i> Which examines the following domains: <ul style="list-style-type: none"> – Perceived athletic competence – Perceived social acceptance – Perceived physical appearance – Perceived behavioral conduct – Perceived global self-worth 	<p>A significant increase on figural creativity was observed in an aerobic exercise program compared to regular physical exercise program</p> <p>There was no significant difference in other factors in comparison between AE program and regular PE program</p>
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Table 1: (Contd...)

Sl. no.	Study authors	Study title	Form of exercise assessed in the study	Aim	Sample	Exercise characteristics	Study design/Analyses	Tests for creativity	Inference	Implied mechanisms
4.	Blanchette et al., 2005	Aerobic exercise and creative potential: Immediate and residual effects	Aerobic workout	To check the effect of acute aerobic exercise on creative potential	College students, N = 60	30-minutes aerobic exercise Self-selected from one of the following: Jogging, swimming, fast walking, stationary bikes, and stair climbing	Three regimens: Regimen A: Test performed before exercise Regimen B: Test performed immediately after exercise Regimen C: Test performed after 2.30 hours lag after aerobic exercise The 60 participants were randomly assigned to different permutations of regimen combination (i.e., ABC, ACB, BAC, BCA, CAB, and CBA) These were compared within each subject	Torrance test of creative thinking	Aerobic exercise significantly impacted the creative processes of the participants, and these effects were shown to endure over a 2-hours period	
5.	Clozato et al., 2013	The impact of physical exercise on convergent and divergent thinking	Cycling	To check whether creativity in convergent- and divergent- thinking tasks is affected by acute moderate and intense physical exercise	Two groups: Athletes (BMI = 22.3) = 48; Non-athletes (BMI = 22.2) = 48	<ul style="list-style-type: none"> Rest Moderate cycling (Level 8) Intense cycling (Level 16) 	Comparison study Athletes vs non-athletes	Remote association task (Convergent thinking) Alternate uses test (Divergent thinking)	Athletes performed better in convergent thinking in the moderate and intense exercise conditions than during rest Intense exercise impaired convergent thinking in non-athletes compared to moderate exercise and rest conditions No group differences for divergent thinking tasks	

<p>6. Oppezzo and Schwartz, 2014</p>	<p>Give your legs: The positive effect of walking on creative thinking</p>	<p>Walking (4 experiments)</p>	<p>Undergraduate psychology students (N = 48)</p>	<p><i>Experiment 1:</i> Indoor treadmill walking (seated followed by walking) Pace: Self-selected comfortable speed</p>	<p>Within-subject comparison</p>	<p>GAU task followed by CRA task</p>	<p>Most of the participants benefited from walking compared with sitting, and the average increase in creative output was around 60%</p> <p>Creativity was more in those who sat after treadmill walking (Walking has a residual effect on creativity even after seated)</p> <p>Walking outdoors led to improved creative performance on the GAU</p> <p>Walking enhanced analogical creativity</p> <p>Walking, rather than being outdoors, enhanced novel, high-quality analogous descriptions</p>
			<p>Community college psychology students (N = 48)</p>	<p><i>Experiment 2:</i> Indoor treadmill walking Three conditions were compared (Sit-tread, Sit-sit, Tread-sit)</p>	<p>Within-subject and between-subject comparisons</p>	<p>Only GAU</p>	
			<p>University students (N = 40)</p>	<p><i>Experiment 3:</i> Outdoor Walking Four conditions were compared (sit-sit, sit-walk, walk-sit, walk-walk)</p>	<p>Within-subject and between-subject comparisons</p>	<p>Only GAU</p>	
			<p>Adults employed in university (N = 40)</p>	<p><i>Experiment 4:</i> Outdoor walking vs Outdoor moving 40 were randomly assigned to four groups (conditions): Sitting inside (SitIn) vs walking on a treadmill inside Walking vs Sitting in a moving wheelchair outside (SitOut) vs Walking outside (WalkOut)</p>	<p>Between-subject comparisons</p>	<p>Generate analogies for three prompts:</p> <ul style="list-style-type: none"> • A robbed safe • A light bulb burning out • A budding cocoon 	

(Contd...)

Table 1: (Contd...)

Sl. no.	Study authors	Study title	Form of exercise assessed in the study	Aim	Sample	Exercise characteristics	Study design/Analyses	Tests for creativity	Inference	Implied mechanisms
7.	Frith and Loprinzi, 2018	Experimental effects of acute exercise and music listening on cognitive creativity	Treadmill walking	To evaluate independent influences of exercise or music stimuli on verbal creative performances in the laboratory environment	One group 32 students Three 15-minutes, randomized experimental conditions; Treadmill walking, self-selected music, or a seated control period; completed	15-minutes walk on treadmill Pace: 3 miles per hour or more Perceived exertion: 6–20 (Borg's Scale)	Within-subject comparison	Four creativity tasks (three tests of divergent thinking and one test of convergent thinking)	No differential effect of acute exercise or passive music listening on creative thinking performance	
8.	Piya-Amornphan et al., 2020	Physical activity and creativity of children and youths	Active play	To explore the correlation between physical activity and creativity in children and youths	Students of different age-groups (6–17 years) N = 1447	Activities such as play, sports, recreation, and leisure activity were provided to students	Between-subject comparisons	Test for creative thinking-drawing Production (TCT-DP)	The positive correlation between the TCT-DP score representing enhanced creativity with more active play was noticed in adolescents but not found in participants aged 6–13 years. Active play was found to be associated with time spent with family and peers in all age-groups	

Table 2: List of tests used to measure the effects of exercise on creative thinking

<i>Sl. no.</i>	<i>Name of the test</i>
1	Alternate uses test (Gondola and Tuckman, 1985; Oppezzo and Schwartz, 2014; Clozato et al., 2013; Frith and Loprinzi, 2018)
2	Remote association task (Clozato et al., 2013; Frith and Loprinzi, 2018)
3	Torrance's test of creative thinking (TTCT) (Herman-Tofler and Tuckman, 1988; Blanchett et al., 2005)
4	Torrance's unusual uses test (Steinberg, 1997)
5	Obvious consequences test (Gondola and Tuckman, 1985)
6	Remote consequences test (Gondola and Tuckman, 1985)
7	Compound remote-association test (Oppezzo and Schwartz, 2014)
8	Realistic problem generation test (Frith and Loprinzi, 2018)
9	Realistic presented problem (RPP) test (Frith and Loprinzi, 2018)
10	Test for creative thinking-drawing production (TCT-DP) (Piya-Amornphan et al., 2020)

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