Blanchette, David M., Ramocki, Stephen P., O'del, John N., and Casey, Michael S. (2005), Aerobic Exercise and Cognitive Creativity: Immediate and Residual Effects, *Creativity Research Journal*, 17(2&3), 257-264.

Aerobic Exercise and Creative Potential: Immediate and Residual Effects

ABSTRACT

The potential effects of aerobic exercise on creative potential were explored both immediately following moderate aerobic exercise and after a two hour lag. Sixty college students participated in an experiment consisting of three regimens varying the time when a Torrance Test of Creative Thinking was taken in relation to exercise completion. The results supported the hypotheses that creative potential will be greater upon completion of moderate aerobic exercise than when not preceded by exercise (immediate effects), that creative potential will be greater following a two hour lag time following exercise than when not preceded by exercise (residual effects), and that creative potential will not be significantly different immediately following exercise than after a two hour lag time following exercise (enduring residual effects). Limitations and implications for future research were discussed.

INTRODUCTION

The positive impact of aerobic exercise on physiological functions, particularly cardio-pulmonary processes and structures, has been extensively studied and validated. Yet only recently has the potential benefit of aerobic exercise on mental processes and structures been addressed. One potential benefit of aerobic exercise that has received particularly little attention is that of its potential effects on creativity.

Some recent research on creativity has investigated factors that may be influential in facilitating creativity, such as physical environment (McCoy & Evans, 2002), curiosity (Kashdan & Fincham, 2002), television (e.g., Valkenburg & van der Voort, 1994), relaxation (Khasky & Smith, 1999), and reward (e.g., Eisenberger & Rhoades, 2001). Contextual determinants of creativity in organizations that have been studied include work environment (Stokols, Clitheroe, & Zmuidzinas, 2002), goals (Shalley, 1991), rewards (e.g., Hennessey & Amabile, 1998), and deadlines (Amabile, Hadley, & Kramer, 2002). Much of this work has investigated influences on motivation to engage in creative organizational behavior. Some studies have addressed affect, such as moodÕs effect on creativity (e.g., George & Zhou, 2002). However, very little work has investigated physiological factors that may influence creative potential. To add to this scant literature, this study investigates aerobic exerciseÕs impact on creative potential.

EXERCISE AND COGNITIVE FUNCTIONING

The relationship between exercise and the physical processes of the human body is relatively well understood. The benefits of physical exercise and the subsequent enhancement of physical task performance is a familiar concept. What remains less clear, however, is the existence of a relationship between aerobic exercise and aspects of cognitive functioning, more specifically, creativity.

Clarke (1958) reviewed seven studies and found that all the

results supported hypotheses of exerciseÕs enhancement of cognitive functioning. Tomporowski and Ellis (1986) reviewed 27 studies and concluded that general exercise produces short-term facilitative effects on cognitive tasks, but that the results of the studies are conflicting and equivocal. Etnier et al.Õs 1997 review of nearly 200 studies and reviews also noted a general consensus of mixed results. The authorsÕ meta-analysis concluded that exercise has a small positive effect on cognition, and that individual instances of exercise are unlikely to be very influential, whereas long-term exercise programs producing fitness gains are more likely to impact cognitive functioning.

As suggested by many of the studies and reviews, the historical work on the relationship between exercise and cognitive functioning has yielded conflicting results, which may at least partially be accounted for by the broad spectrum of factors being addressed in these studies. The broad term of cognitive functioning incorporates a range of concepts under its umbrella, and the operationalization of constructs employed has varied widely in these works. For example, the construct of ÒexerciseÓ varies by duration, type, and intensity. Exercise has been operationalized as Òacute bouts,Ó or single instances of physical activity-based arousal, or fitness, a product of long-term exercise. Different types of aerobic exercise (e.g., jogging and dancing), and anaerobic exercise (e.g., weight lifting and isometrics), have been tested, and fitness has been characterized by several different measures. The intensity of an individual instance of exercise has varied from a few seconds to the point of exhaustion, and further there has been little consistency or definition regarding the level of arousal the exercise produces in the subjects. As for dependent variables, a wide range of cognitive functioning measures have been utilized, such as arithmetic function performance, reaction time, intelligence tests and surrogates for intelligence (e.g., academic performance), memory tests, and many others. It is unlikely that all forms of cognitive functioning are alike, and therefore different effects on cognitive functioning are possible.

EXERCISE AND CREATIVITY

Creativity is a much sought after and encouraged thought process. (Sutton, 2001) Creativity is informally considered, for instance, to play a key role in the initial attractiveness, and sustained competitiveness, of many organizations. Research on this aspect of cognitive functioning has often found a positive relationship between physical exercise and creativity. Gondola and Tuckman (1985) tested the effects of an exercise program, measuring differences at the completion of the program before an individual bout of exercise. The study therefore tested fitness rather than acute exercise and reported small but significant gains in creativity measures of Alternate Uses (spontaneous flexibility) and Remote Consequences (originality), but no significant differences for Obvious Consequences (different ideas). Gondola (1986) replicated this study and added tests of acute (single exercise) bouts, and found that both acute and long-term exercise conditions produced significant gains in all three of these creativity measures. Gondola (1987) tested another form of acute aerobic activity (dance), and found significant effects for all three measures of creativity.

Steinberg et al. (1997) found that acute bouts of aerobic exercise (in an exercise class) produced small but significant effects on creative processes on one of three measures of the Torrance test. Ramocki (2002) extended these findings in testing the effects of various forms of aerobic exercise for physically fit vs. unfit groups. Physically fit subjects engaged in vigorous exercise for one hour and were tested using Torrance-type test forms. The performance gains of the fit subjects following exercise were generally larger, though not always to the point of statistical significance, than those of the unfit subjects, who did not exercise. One possible explanation for these findings, as suggested by the literature on exercise effects on cognitive processes as well as current recommendations of the medical community for individual

instances of exercise, is that the one hour period of vigorous exercise created a fatigue level that swamped the main effects of the study. That is, the debilitating effects of fatigue may have mitigated the enhancing effects of arousal.

The few studies relating exercise to creativity processes have generally found positive effects, though varying in strength. However, no studies were found that tested whether such effects are enduring. While establishing the impact of aerobic exercise on creative potential is a potentially important issue, from a pragmatic perspective such effects may be little more than a curiosity if those effects do not last long enough to provide some practical benefits in terms of creative output.

CURRENT STUDY

The literature suggests that creativity is a product of ordinary cognitive processes, which to some extent may be influenced and facilitated. (e.g., Bink & Marsh, 2000; Ward, Smith, & Vaid, 1997) The current study investigates whether aerobic exercise is a potentially influential factor on creativity. The results of research on the impact of exercise on cognitive processes in general have been predominantly positive but equivocal. The research investigating the impact of one potential factor, aerobic exercise, on creativity processes has been sparse, and the results are mostly positive but of small magnitude.

The current study has two major objectives. The first is to investigate aerobic exerciseÕs immediate effects on creative potential. The beneficial effects of physiological arousal (e.g., Tomporowski & Ellis, 1986) and attention narrowing (e.g., Kahneman, 1973), as well as previous work on exercise effects on cognitive processes generally and creativity specifically, lead to the expectation that aerobic exercise should positively impact creative potential. Addressing some of the possible methodological shortcomings identified in the exercise and creativity research relating to exercise duration and exercise program structure further

supports this expectation. This suggests the following hypothesis:

> H1: Creative potential will be greater upon completion of moderate aerobic exercise than when not preceded by moderate aerobic exercise.

The second major objective is to initiate investigation of the pragmatic issue relating to the endurance of aerobic exercise effects on creative potential, if any. Previous research has addressed the immediate effects of individual instances of exercise or the long-term effects of fitness, but has not addressed whether the effects of individual instances of exercise are transient or enduring. Essentially, prior research has investigated how aerobic exercise affects creativity processes up to the point immediately following the cessation of exercise, but has not addressed whether such effects may endure over time. This suggests the following hypothesis:

> H2: Creative potential will be greater two hours after the completion of moderate aerobic exercise than when not preceded by moderate aerobic exercise.

Further, it is expected that creativity effects will occur at the conclusion of aerobic exercise, and that residual effects will be substantial. The question is whether these residual effects may dissipate to some degree as the time following the completion of moderate aerobic exercise increases. This suggests the following hypothesis:

> H3: Creative potential will not be significantly different upon completion of moderate aerobic exercise than two hours after the completion of moderate aerobic exercise.

There are six possible outcomes of these three hypotheses. If all three hypotheses are rejected, this suggests that there are no

significant immediate or residual effects of aerobic exercise on creativity. If H1 is rejected, H2 supported, and H3 rejected, this suggests that aerobic exercise has no significant immediate effects but significant lag effects on creativity. If H1 is rejected, and H2 and H3 supported, this suggests that that the results are confounded, for if immediate effects are greater than residual effects, and residual effects are greater than control levels, then immediate effects should be greater than control levels unless artifacts are present. If H1 is supported, and H2 and H3 are rejected, this suggests that aerobic exercise has significant immediate effects but no significant residual effects on creativity. If H1 and H2 are supported, and H3 is rejected, this suggests that aerobic exercise has significant immediate effects and significant residual effects but at significantly dissipated levels on creativity. The support of all three hypotheses suggests that aerobic exercise has significant immediate effects and significant and enduring residual effects. These alternative interpretations are presented in Table 1.

Table 1: Permutations and Interpretations of Hypotheses

Permutations				Interpretations
H1	H2	H3		
X	X	X	Support	Aerobic exercise has no sign
			immediate or	
			Reject	residual effects on creativity.
No Effects				
H1	H2	H3		
	X		Support	Aerobic exercise has no sign
			immediate	
X	X		Reject	effects, but has significant residual effe
				creativity.

Lag Effects Only

H1 H2 H3 Confounded results: if imm
effects are
X X Support greater than residual effects, and residual
X Reject effects are greater than control levels, then
immediate effects should be greater than co
Confound levels unless artifacts are present.

H1 H2 H3
X Support Aerobic exercise has sign
immediate
X X Reject effects, but no residual effects on creativity.
Immediate Effects Only

H1 H2 H3
X X Support Aerobic exercise has sign
immediate
X Reject effects, and significant residual effects but at
Significantly dissipated levels on creativity.
Immediate Effects,
Enduring Residual Effects

H1 H2 H3
X X X Support Aerobic exercise has significant imm
Reject effects, and significant and enduring residual
effects on creativity.
Immediate Effects,
Dissipating Residual Effects

There are two secondary potential outcomes of the study. The first is to investigate whether the reputed optimum level of aerobic exercise for physiological benefits will also elicit psychological benefits. Taken together, the three hypotheses address whether instances of aerobic exercise reputedly optimal for producing physiological benefits also produce psychological benefits, such as enhancing cognitive creativity processes and potentially outputs.

The second secondary potential outcome is to investigate whether potentially enduring effects have practical applications for creative productivity, such as divergent thinking. If residual effects are relatively transient, it is unlikely that such effects will aid creative productivity given the typical transition time between exercise and work environments. However, if residual effects endure in excess of this transition time, then these residual effects are more likely to benefit creative productivity in work environments.

METHODOLOGY

Participants

Sixty college students volunteered to participate in the study. In a confidential initial questionnaire, each subject reported gender, age, weight, academic major, GPA, and exercise history, including number of hours of exercise in a typical week, type of exercise done for typical workouts, and length of time (years) engaging in regular workouts. All volunteers were accepted for participation, and received compensation at the end of the study.

There were 30 men and 30 women in the study, ranging in age from 18-27 (average @20). The participants came from a wide variety of academic disciplines, including education, computer information systems, psychology, physical education, and business, and had GPAs commensurate with the college norms. All

subjects reported being physically fit and experienced exercisers and signed a medical waiver form as conditions for participation.

Procedure

This study consisted of three regimens. In Regimen A, a version of the creativity instrument was completed without any prior exercise that day. In Regimen B, a version of the creativity instrument was completed immediately after a thirty minute period of aerobic exercise. In Regimen C, a version of the creativity instrument was completed two hours after a thirty minute period of aerobic exercise. Each participant completed each of the three regimens.

The sixty participants were randomly assigned to different permutations of regimen completion (i.e., ABC, ACB, BAC, BCA, CAB, CBA). Thus, each regimen permutation included ten subjects. Participants were allotted ten minutes to complete all or as much as they could of each version of the creativity measure.

Exercise protocols were primarily aerobic in nature, with controls for exercise type, duration, and intensity. Weight lifting, an anaerobic form of exercise, was allowed for a short time at the beginning of the exercise period if desired (very few elected to do so), as long as at least the entire latter half of the session was aerobic. The aerobic exercises participants chose included jogging, swimming, fast walking, stationary bikes, and stair climbing.

Duration was addressed by time of exercise. This study sought to test the effects of approximately moderate levels of aerobic exercise. Since there is no definitive research defining exactly what constitutes Òmoderate levelsÓ of exercise, particularly in their impact on cognitive processes, a conservative approach in being consistent with the popular recommendations of health professions was selected. Therefore, the exercise session lasted thirty minutes.

Exercise intensity was operationalized by pulse rate. Pulse rates taken immediately at the cessation of exercise verified that subjects were within the pulse rates guidelines suggested by health

professionals for moderate workouts, i.e., approximately double resting rates (Pulse rates averaged 140 for Regimen B, and 141 for Regimen C).

The lag time of two hours for Regimen C was selected because it not only ensured full recovery from exercise, in terms of returning to base pulse rates, but also mimicked typical transition times from exercise to productivity behaviors. That is, for most people, two hours after exercise allows adequate time to get to and engage in work and other productive activities.

Some controls relating to the questionnaire variables age, gender, weight, GPA, weekly exercise time, and number of years exercising were applied. Also, the pulse rate one minute after the completion of exercise was compared to the pulse rate at the completion of exercise to form a Òpulse dropÓ as a measure of physical condition, consistent with recent medical research (e.g., Cole et al., 1999). This information provided data for examining potential external effects and interactions.

The dependent variable of creative potential (in particular divergent thinking) was measured by Figural Tests A and B (ÒThinking Creatively with PicturesÓ) of the Torrance Tests of Creative Thinking (1962,1966). The reason for investigating this particular form of creativity with this particular instrument is that not only is pictorial imagination central to many human tasks, but it has many applications to creative productivity. Further, this particular instrument has been commonly used in research and been well validated (e.g., Chein, 1982; Curnow & Turner, 1992; Hinkle, Tuckman, & Samson, 1993; Steinberg et al., 1997).

Three distinct yet similar versions consisted of four pictures to be completed by the participant. To aid in operationalizing the construct, a scoring guide (Torrance, Ball, & Safter, 1992) was provided by the testing service to assist the evaluators in scoring responses. Creative potential in these instruments is operationalized by the constructs of fluency, originality, abstractness of titles, elaboration, and resistance to premature closing. Additionally, evidence of creative strengths, captured in a

set of thirteen criterion-referenced measures (emotional expressiveness, storytelling articulateness, movement of action, expressiveness of titles, synthesis of incomplete figures, unusual visualization, internal visualization, extending or breaking boundaries, humor, richness of imagery, colorfulness of imagery, fantasy), was incorporated. Consistent with the scoring guide, all measures were summed to form a composite score.

Each member of the research team independently scored the instruments. Each individual instrument had been coded and randomized so that scorers did not know which response came from which participant. Each of these four scorers scored all of these anonymous instruments in random order. Inter-rater reliability was high with Pearson Correlation medians of .818 (range .766-.886) for H1, .850 (range .789-.870) for H2, and .826 (range .781-.917) for H3.

RESULTS

Each hypothesis was evaluated using a two-sample t-test. Hypothesis 1 predicted that the creative potential of the treatment condition would be greater than of the control condition, i.e., when the subjects completed an aerobic exercise session they would immediately demonstrate greater creative potential than when they did not participate in an aerobic exercise session. This hypothesis was strongly supported, with $t\ (118df) = 4.08$, $p = .000$.

Hypothesis 2 predicted that when the subjects completed an aerobic exercise session and waited two hours before testing they would demonstrate greater creative potential than when they did not participate in an aerobic exercise session. This hypothesis was also strongly supported, with $t\ (118df) = 3.11$, $p = .001$.

Hypothesis 3 predicted that when the subjects were tested immediately after an aerobic exercise session they would not demonstrate significantly different levels of creative potential than

when they were tested two hours after completing an aerobic exercise session. This hypothesis was supported, with t (118df) = 1.15, p = .251.

A series of regression analyses were run in an attempt to determine if any external constructs would contribute to the explanation of the significant main effects resulting from hypotheses 1 and 2 (as hypothesis 3 was essentially a comparison of main effects from hypotheses 1 and 2). Interactive variables were also tested. Only the pulse drop external variable for the hypotheses 1 regression achieved significance, with weak explanatory power. No interactive terms approached statistical significance. Table 2 reports the regression results for these external and interactive terms.

Table 2: Statistical Analyses of Main Effects for Hypotheses 1 and 2

	Hypotheses 1		Hypotheses 2	
External Variables:	t-value	p-value	t-value	p-value
Pulse Drop	2.91	(.005)	-0.78	(.439)

Years Exercising	1.94	(.058)	1.47	(.148)	
Weight	-1.41	(.164)	-0.62	(.541)	
Age	0.81	(.424)	0.19	(.850)	
Gender	1.41	(.164)	0.10	(.923)	
GPA	-0.82	(.413)	-0.74	(.464)	
Hours Weekly Exercise	-1.06	(.294)	-0.54	(.589)	
Adjusted R-Square	.131		0.00		

Notes:
-Pulse drop is measured positively, i.e., decrease in pulse value was recorded as a positive integer.
-All two-way interactions were examined. No interaction coefficients achieved statistical significance.

DISCUSSION

The H1, H2, and H3 supported outcomes are consistent with the ÒImmediate Effects, Enduring Residual EffectsÓ result permutation described in Table 1. This is the strongest possible outcome in terms of supporting both the immediate and residual effects of aerobic exercise on creative potential.

Instances of aerobic exercise significantly impacted the creative processes of the participants, and these effects were shown to endure over a two hour period. This not only supports the proposition that aerobic exercise may positively impact creative potential and adds to the literature in doing so, but introduces a new element in the discussion of exercise and creativity, that of residual effects. This temporal issue may have ramifications for the utility of aerobic exercise beyond physical health benefits.

This study is far from definitive, as its intent was to establish the viability of premises and baselines for further investigation. While efforts were taken to reduce potential biases, the fact that this was an exploratory study necessarily leads to some limitations.

As the precise physiological mechanisms underlying aerobic exerciseÕs effects on creative processes are unknown, this study reports correlations between aerobic exercise and creative output rather than forwarding causal mechanisms underlying creative processes. While initial results in this field indicate that exercise may produce changes in the brain or brain environment, and that these changes may have a positive effect on performance capabilities (Collardeu et al., 2001; Dustman, Emmerson, & Shearer, 1994; Hassman et al., 1994), neuropsychological research is extremely invasive and costly, and beyond the constraints of this study.

Nearly all participants were of traditional college age. Other works have supported the notion that aerobic exercise effects on creativity may transcend the effects of age (e.g., Herman-Toffler & Tuckman, 1998; Hinkle, Tuckman & Sampson, 1993; Palmer, 1995). Though prior research on creativity has shown a

generalization of cognitive effects across age, the narrow range of ages in this study did not allow for a good test of age interactions.

Also, due primarily to liability issues, only self-identified physically fit students were selected for the study. Rigorous physiological measures of fitness were not employed, as fitness was inferred from self-reported exercise histories and pulse drop data. The relatively narrow range of fitness levels and rudimentary fitness measures may have precluded a more powerful assessment of fitness interactions.

Participants engaged in thirty minutes of aerobic exercise that elevated pulse rates to approximately 140 on average, which was assumed, based on current ideas of cardiovascular conditioning, to constitute moderate levels of exercise. However, these levels have been established by the medical community with the primary objective of improving cardiovascular health, and very little evidence exists as to whether this level of physical arousal is ÒmoderateÓ regarding neurophysiological effects.

Ideally, multiple lag times would have been tested, and greater controls of activities during lag times enacted (subjects were directed to engage in normal but not exercise-related activities during the lag), but these ideals were beyond the constraints of the study. As such, this two hour lag time should be viewed as an initial rather than comprehensive level of investigation.

An argument may be made that allowing subjects to choose their own form of aerobic exercise potentially introduced a confound in that different activities may create different levels of energy expenditure. However, the decision was made to provide an exercise protocol that was reflective of real exercise behaviors. Further, all subjects were experienced exercisers and therefore knew how to ÒpaceÓ themselves using their normal exercise protocols for a moderate workout. This had the added benefit of reducing potential problems caused by muscle specificity, where forcing all subjects to engage in identical forms of exercise would have resulted in differing levels of energy expenditure depending

on previous experience with the exercise form. Pulse rates taken at the cessation of exercise verified the moderation of exercise, as described in the methodology section.

An effort was made to code the tests of participants to inhibit rater scoring bias, but there may be an issue that having the experimenters evaluate the tests was inherently biasing. However, the provided scoring instrument minimized the opportunities for subjective interpretation, and the high levels of inter-rater reliability further argue against significant rater bias.

There was some concern that having participants engage in three separate instances of testing might create the possibility of learning effects where test performance was enhanced as a result of prior experience with the tests. However, this was not found to be the case, as an analysis of order effects for all permutations did not find any significant differences. Stated differently, the performance on the Regimen B test was just as likely to be highest whether it was the first taken, second taken, or last taken. Another possibility here is that the residual effects of exercise might influence creativity performance on subsequent tests taken after the test following an earlier session of exercise. Normally, exercisers do not engage in aerobic workouts on consecutive days, and workouts often are separated by multiple days. For Regimen A, exercise was not permitted on the testing day. However, the time between instances of aerobic exercise was not otherwise controlled. It is possible that previous instances of exercise engaged in outside of the experiment may have produced residual effects that influenced creativity scores on the test instruments. Yet as these instances were highly variable and measured on the scale of days rather than hours, they were thought to be likely of minimal effect. More importantly, perhaps, the randomization of regimen orders would effectively Òwash outÓ any extended residual effects.

IMPLICATIONS

The finding that aerobic exercise may positively impact creative

potential, and that these effects may extend for some period of time, has important ramifications for theoreticians and practitioners. Of course, since this study is exploratory, the results should be replicated and extended. Theoretical constructs underlying aerobic exerciseÕs effects on creative potential should be elaborated. Possibilities include explanations relating to physiological arousal and/or psychological phenomena (self-esteem or efficacy, etc.). Different time lags should be tested to better understand the residual effects of aerobic exercise. Testing different forms, durations, and intensities of aerobic exercise, as well as anaerobic exercise, would facilitate the generalization of findings. Using other measures of creativity, and testing other types of creativity, may lend further validity to the results. Testing possible interactive factors such as fitness levels, demographics, culture, etc., would add conceptual clarity to the issue.

This studyÕs results suggest that orthodox aerobic workouts have potential benefits in aiding creativity processes. This not only adds to the general utility of exercise to individuals, thereby providing greater impetus to exercise, but potentially provides tangible improvements to creative productivity. This implies that not only may individuals realize greater gains from aerobic exercise, but organizations may potentially benefit as well. For example, fostering environments that encourage aerobic exercise for employees may yield increases in creative output and innovation in product development, promotion, operations management, and many other areas.

REFERENCES

Amabile, T. M., Hadley, C. N., and Kramer, S. J. (2002). Creativity Under the Gun. *Harvard Business Review* 80(2): 52-61.

Bink, M. L., and Marsh, R. L. (2000). Cognitive Regularities in Creative Activity. *Review of General Psychology* 4(1): 59-78.

Chein, M-f. (1983), Creative Thinking Abilities of Gifted Children in Taiwan, Republic of China. *Bulletin of Educational Psychology* 15(June): 97-110.

Clarke, H. H. (1958). Physical Fitness Benefits: A summary of research. *Education* 78: 460-466.

Cole, C.R., Blackstone, E.H., Pashkow, F.J., Snader, C.E., and Lauer, M.S. (1999). Heart-Rate Recovery Immediately after Exercise as a Predictor of

Mortality. *The New England Journal of Medicine* 341: 1351-1357.

Collardeu, M., Brisswalter, J., Vercruyssen, F., Audiffren, M., and Goubault, C. (2001). Single and Choice Reaction Time During Prolonged Exercise in Trained Subjects: Influence of carbohydrate availability. *European Journal of Applied Psychology* 86: 150-156.

Curnow, K.E., and Turner, E.T. (1992). The Effect of Exercise and Music on the Creativity of College Students. *Journal of Creative Behavior* 26(1): 50-52.

Dustman, R. E., Emmerson, R., and Shearer, D. (1994). Physical Activity, Age, and Cognitive-Neuropsychological Function. *Journal of Aging and Physical Activity* 2: 143-181.

Eisenberger, R. and Rhoades, L. (2001). Incremental Effects of Reward on Creativity. *Journal of Personality and Social Psychology* 81(4): 728-741.

Etnier, J. L., Salazar, W., Landers, D. M., Petruzzello, S. J., Han, M. and Nowell, P. (1997). The Influence of Physical Fitness and Exercise Upon Cognitive Functioning: A meta-analysis. *Journal of Sport & exercise Psychology* 19: 249-277.

George, J. M. and Zhou, J. (2002). Understanding When Bad Moods Foster Creativity and Good Ones DonÕt: The role of context and clarity of feelings. *Journal of Applied Psychology* 87(4): 687-697.

Gondola, J. C. (1986). The Enhancement of Creativity Through Long and Short Term Exercise Programs. *Journal of Social Behavior and Personality* 1(1): 77-82.

Gondola, J. C. (1987). The Effects of a Single Bout of Aerobic Dancing on Selected Tests of Creativity. *Journal of Social Behavior and Personality* 2(2): 275-278.

Gondola, J. C., and Tuckman, B. W. (1985). Effects of a Systematic Program of Exercise on Selected Measures of Creativity. *Perceptual and Motor Skills* 60: 53-54.

Hassmen, P., Blomstrand, E., Ekblom, B., and Newsholme, E. A. (1994). Branched-Chain Amino Acid Supplementation During 30-km Competitive Run: Mood and cognitive performance. *Nutrition* 10(5): 405-410.

Hennessey B. A., and Amabile, T. M. (1998). Reward, Intrinsic Motivation, and Creativity. *American Psychologist* 53(6): 674-675.

Herman-Toffler, L. R., and Tuckman, B. W. (1998). The Effects of Aerobic Training on ChildrenÕs Creativity, Self-Perception, and Aerobic Power. *Sports Psychiatry* 7(4): 773-790.

Hinkle, J.S., Tuckman, B.W., and Sampson, J.P. (1993). The Psychology, Physiology, and Creativity of Middle School Aerobic Exercises. *Elementary School Guidance & Counseling*, 28(2), 133-145.

Kahneman, D. (1973). *Attention and Effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kashdan, T. B. and Fincham, F. D. (2002). Facilitating Creativity by Regulating Curiosity. *American Psychologist* 57(5): 373-374.

Khasky, A. D. and Smith, J. C. (1999). Stress, Relaxation States, and Creativity. *Perceptual & Motor Skills* 88(2): 409-416.

McCoy, J. M. and Evans, G. W. (2002). The Potential Role of the Physical Environment in Fostering Creativity. *Creativity Research Journal* 14(3/4): 305-316.

Palmer, A. C. (1995). The Effects of Aerobic Exercise on Cognitive Ability and Creativity in Senior Citizens. Unpublished Dissertation

Ramocki, S. P. (2002). Creativity Interacts with Fitness and Exercise. *The Physical Educator* Late Winter: 8-17.

Shalley, C. E. (1991). Effects of Productivity Goals, Creativity Goals, and Personal Discretion on Individual Creativity. *Journal of Applied Psychology* 76(2): 179-185.

Steinberg, H., Sykes, E. A., Moss, T., Lowery, S., LeBoutillier, N., and Dewey, A. (1997). Exercise Enhances Creativity Independent of Mood. *British Journal of Sports Medicine* 31(3): 240-245.

Stokols, D., Clitheroe, C., and Zmuidzinas, M. (2002). Qualities of Work Environments That Promote Perceived Support for Creativity. *Creativity Research Journal* 14(2): 137-147.

Sutton, R. I. (2001). The Weird Rules of Creativity: You know how to manage for efficiency and productivity, but if itÕs creativity you want, chances are youÕre doing it all wrong. *Harvard Business Review* Sept.: 94-103.

Tomporowski, P. D. and Ellis, N. R. (1986). Exercise Effects on Cognitive Processes: A review. *Psychological Bulletin* 99(3): 338-346.

Torrance, E. P. (1962,1966). *Thinking Creatively with Pictures,*

Figural Booklets A and B. Scholastic Testing Service, Inc., Bensenville, Illinois.

Torrance, E. P., Ball, O. E., and Safter, H. T. (1992). *Torrance Tests of Creative Thinking: Streamline scoring guide figural A and B.* Scholastic Testing Service, Inc., Bensenville, Illinois.

Valkenburg, P. M. and van der Voort, T. H. A. (1994). Influence of TV on Daydreaming and Creative Imagination: A review of research. *Psychological Bulletin* 116(2): 316-339.

Ward, T. B., Smith, S. M., and Vaid, J. (Eds.). (1997). *Creative Thought: An investigation of conceptual structures and processes.* Washington, D.C.: American Psychological Association.