Improving Cardiovascular Recovery From Stress With Brief Poststress Exercise

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Objective: While exercising before a stressor has been shown to limit the magnitude of stress responses, we test the use of exercise as a coping mechanism after the stressor, to limit the duration of the stress response. Design: After doing difficult mental arithmetic with harassment, male and female undergraduates (N = 102) either walked in place or sat still for 3 minutes, then all sat for a recovery period. Main Outcome Measures: Continuous blood pressure and heart rate monitoring was done throughout. Changes from an initial resting baseline were calculated. Results: During the manipulation, blood pressure for exercisers was higher than for controls, but soon after the tasks were completed the participants who had exercised had significantly lower systolic (SBP; M = 3.5 mmHg above prestress baseline, p < .01) and diastolic blood pressure (DBP; M = 0.3 mmHg above prestress baseline, p < .001) than those who had not exercised (SBP; M = 8.8 mmHg, DBP; M = 4.8 mmHg). Conclusion: Although exercising when angry adds to initial cardiovascular arousal, it improves recovery afterward. We discuss possible mechanisms for this effect.

Keywords: cardiovascular recovery, exercise, stress, misattribution of arousal, postexercise hypotension

Participation in regular aerobic exercise has long been associated with good health, and in particular with a decreased risk of cardiovascular disease. Longitudinal studies (Morris, Everitt, Pollard, Chave, & Semmence, 1980; Paffenbarger & Hale, 1975; Paffenbarger, Wing, & Hyde, 1995) have found that individuals with the highest occupational or leisure time energy expenditure have the lowest incidence of infarction and other signs of heart disease, including sudden death. One explanation for this association is that regular aerobic exercise can buffer cardiovascular responses to psychological stress. Investigators have demonstrated that fit individuals show a reduction in the magnitude (Anshel, 1996; Holmes & McGilley, 1987; Holmes & Roth, 1985; Light, Obrist, James, & Strogatz, 1987; Shulhan, Scher, & Furedy, 1986) and duration (Cox, Evans, & Jamieson, 1979; Sinyor, Schwartz, Peronnet, Brisson, & Seraganian, 1983) of cardiovascular responses to stressors in the lab.

Exaggerated blood pressure and heart rate responses to stress are associated with damage to the cardiovascular system (Barnett, Spence, Manuck, & Jennings, 1997; Jennings et al., 2004; Kamarck et al., 1997; Matthews et al., 2004; Matthews, Woodall, & Allen, 1993; see Light, Sherwood, & Turner, 1992, for a review). People who exhibit large cardiovascular responses are at risk for the development of hypertension and cardiovascular disease, and situations that lead to large responses may put people at risk (Krantz & Manuck, 1984, 1986; Lovatto & Wilson, 1992).

Initial studies stemming from the cardiovascular reactivity hypothesis focused on acute cardiovascular responses in the immediate presence of the stressor (cardiovascular reactivity). However, a number of more recent studies (Borghi, Costa, Boschi, Mussi, & Ambrosini, 1986; Gerin & Pickering, 1995; Haynes, Gannon, Orimoto, O’Brien, & Brandt, 1991; Steptoe & Marmot, 2005) suggested that recovery, or the duration of blood pressure elevation, in addition to the magnitude of the initial peak reaction, may contribute to cardiovascular illness.

Although the association of exercise and health has been most often studied with chronic aerobic exercise, taking place several days a week for weeks or months, some studies (Mondin et al., 1996; Moses, Steptoe, Mathews, & Edwards, 1989; Roth & Holmes, 1987) have indicated that psychological benefits of exercise training can occur independent of changes in aerobic fitness. This has led investigators to examine the role of a single session of aerobic exercise in reducing cardiovascular reactivity to a subsequent stressor. Although not unanimous, in general, this line of research has found blood pressure (Boone, Probst, Rogers, & Berger, 1993; Ebbesen, Prakash, Mills, & Green, 1992; Rejeski, Thompson, Brubaker, & Miller, 1992; Roy & Steptoe, 1991; Taylor & Katomeri, 2006; West, Brownley, & Light, 1998), but not heart rate (Duda, Sedlock, Melby, & Thaman, 1988; McGowan, Robertson, & Epstein, 1985; Roth, 1989) attenuation to a postexercise stressor (see Hamer, Taylor, & Steptoe, 2006, for a review and meta-analysis). More recent work has focused on other measures of cardiovascular reactivity, including peripheral vascular resistance (Hamer, Jones, & Boutcher, 2006) and sympathetic activity (Brownley et al., 2003).

Although these studies differ in their methodology, in terms of the characteristics of the exercise, the stressor, and the demographics of the sample, all put exercise before the stressor. This arrangement is useful for determining whether exercise can limit the magnitude of stress responses, but it does not explore the use of
exercise as a coping mechanism after the stressor, to limit the duration of the stress response. This is significant for two reasons. First, it seems possible that the health impact of a stressful event is not confined to the period when the stressor is present, but instead extends some time after when the person is thinking about and recovering from the episode. Research on the benefits of regular aerobic exercise has examined cardiovascular recovery, and the acute aerobic exercise literature could benefit from this addition as well. Second, insofar as it is impossible to plan to exercise before an unforeseen stressor—the investigators in these studies knew the stressor was coming, but the subjects did not—this approach has limited ecological value. Instead, it is more likely that people would use exercise as a coping mechanism after experiencing a stressor, such as going for a walk after an argument with one’s spouse. Thus, because both cardiovascular recovery may be an important adjunct to reactivity in the health-relevant aspects of psychological stress, and because exercising after a stressor captures more of a real-world coping strategy, this study investigates the potential benefits of poststress exercise on cardiovascular recovery.

The present investigation examined the effects of a single session of exercise, after a stressor, on cardiovascular recovery. The aim was to extend what is known about the benefits of exercise to a new domain, with important practical ramifications.

Method

Overview

Participants performed a serial subtraction task while being harassed by an experimenter. Participants were then randomly assigned, using a between-subjects design, into an experimental condition, in which the stressor was followed by 3 minutes of walking in place, or a control condition, in which participants sat still after the stressor. Another group of subjects walked in place without having done the math task. See Table 1 for a schematic of the study design. Blood pressure and heart rate were monitored during baseline, stressor, manipulation, and recovery periods.

Participants

Undergraduates at the University of California, San Diego (N = 102) participated for course credit (72 women, 30 men, age M = 20.01 years, SD = 2.03 years). No instructions were given prior to participation, other than a brief description of the study (i.e., “Your blood pressure will be measured while you perform several tasks.”). No participant reported being in poor health or on any medications that might influence cardiovascular readings. See Table 2 for baseline cardiovascular measures and demographic characteristics of the sample.

Procedure

Baseline. On the participant’s arrival, the experimenter (S.C.) explained that the participant’s blood pressure would be monitored during an arithmetic task and that some, but not all, participants would participate in a moderate exercise task as well. (All participants were informed about the prospect of exercising to control for any inflation in cardiovascular measures due to anticipation of the upcoming exercise task.) After giving informed consent, the participant was seated and fitted with the finger cuff of the blood pressure monitor. The experimenter explained that the participant would sit for a rest (baseline) period and then a different experimenter would administer a serial subtraction task, which would be followed by a brief activity period (possibly exercise), and a longer rest (recovery) period. To get a real time sample of what participants were thinking about, the experimenter also instructed the participant to record his/her thoughts during the rest periods by jotting down a few words whenever a knock (at Minutes 1, 2, 5, 4, 7, and 11) was heard at the door. A knock was chosen as a signal because it did not require the experimenter to be in the same room as the participant. The participants were cautioned to write just enough to cue their memory so that later, at the end of the study, they would be able to explain what they had been thinking about to the experimenter. The experimenter also emphasized that she alone (and not the person administering the math task) would read the results of these thought reports. This was important because the role of the person administering the math task was to provoke anger; our past studies suggest that some of the thoughts reported during recovery related to the provoker, and we did not want the participant to feel unable to record such thoughts. After instructing the participant to sit still during the 10 minutes of the rest period, the experimenter left the room.

Stressor task. After baseline, another experimenter, blind to the condition of the participant, entered the room and administered the mental arithmetic task. The participant was asked to count backward out loud by 13 s from 2,397. Thirty seconds into the task, the experimenter informed the participant that his/her counting was too slow and that the task should be started again, at a faster pace. Similar interruptions informing the participant of deficient performance continued approximately every 30 s for 3 minutes. Each response was scheduled and standardized, so that each participant heard the same criticism at the same time. This task has been shown to be an effective stressor in several studies (K. Allen & Blascovich, 1994; M. T. Allen, Obrist, Sherwood, & Crowell, 1987; Glynn, Christenfeld, & Gerin, 2002), and has the potential to evoke more than one emotion, including anger and embarrassment. After the stressor ended, the experimenter who conducted the math task left the room and the original experimenter re-entered, to explain the instructions for the manipulation.

Stress/exercise experimental condition. Following the stressor, participants in the stress/exercise experimental condition performed a 3-minute seated walking in place task, which involved raising the left and right leg alternately to a specified height (25 centimeters) in time to a metronome (120 beats per minute). This procedure has been found to reliably elevate blood pressure in previous studies (Glynet al., 2002). Of more importance is that
this task in isolation also leads to rapid blood pressure recovery, so that any sustained elevations in blood pressure during the recovery period, following the stressor and then the exercise task, are unlikely to be due to the exercise, but to the stressor. Although actual walking or running is a more likely form of exercise in the real world, this task enabled the participant to maintain an erect posture, and to maintain the position of the arm, relative to the heart.

**Stress/no exercise control condition.** Participants in the stress/no exercise control condition did not exercise. However, to determine whether any effects of the exercise could be due to the metronome used in that condition being distracting in itself, half of the participants (stress/metronome task) tapped the index finger of their dominant hand to the same metronome beat for 3 minutes. The remaining participants (stress/no task) sat still, in silence, for 3 minutes.

**No stress/exercise control condition.** A no stress/exercise control condition, added later, assessed the effect of exercise alone, without the stressor present. During the stressor period, participants sat for 3 minutes in silence. Although the participants in this condition were not randomly assigned with the other participants, they were drawn in the same way from the same participant pool, and were identical in basic demographic characteristics.

**Recov ery.** In both the control and experimental conditions, at the end of the 3-minute manipulation, the experimenter asked the participant to sit still for a final rest period, only jotting down a few words when a knock was heard at the door. The experimenter then left the room, knocking on the door at the five standardized times. After 15 minutes, the experimenter returned, removed the finger cuff and interviewed the participant about the thought reports. The participant then completed several questionnaires and was debriefed.

**Subjective Measures**

At the end of the recovery period, all participants rated, on 7-point Likert-type scales, “How difficult was the arithmetic task?” (1 = *not at all difficult* to 7 = *very difficult*), and “How stressful was the arithmetic task?” (1 = *not at all stressful* to 7 = *very stressful*). Participants were also asked “How often did you think about the arithmetic task during the last 15 minutes?” (1 = *no time at all* to 7 = *the whole time*), “How stressful was the arithmetic task?” (1 = *not at all stressful* to 7 = *very stressful*), and “How often did you think about the arithmetic task during the last 15 minutes?” (1 = *no time at all* to 7 = *the whole time*).

**Recording of Physiological Measures**

Systolic and diastolic blood pressure and heart rate were recorded with an Ohmeda Finapres 2300 blood pressure monitor (Finapres Medical Systems, Amsterdam). Using the Peñaz method, this instrument measures beat-to-beat pressures from an inflatable finger cuff worn on the third finger of the nondominant hand. The Finapres has proven to be a useful alternative to intra-arterial blood pressure measurement in laboratory testing (Imholtz, Settels, & Meiracker, 1990) and clinical practice (Gorback, Quill, & Lavine, 1991; Weiling, Harkel, & Lieshout, 1991). It is also able to track intra-arterial readings during abrupt changes of blood pressure (Parati, Casadei, & Groppelli, 1989). The Finapres enhances reliability by collecting a large number of readings (Gerin, Pieper, & Pickering, 1993).

**Data Reduction and Analysis Procedures**

The beat-to-beat pressures from the Finapres were combined into minute averages across the experimental session. The cardiovascular dependent measures were change scores, computed using the difference between the minute averages for the period of interest and the mean of the pretask baseline measurements. These means were computed using the pulse-based technique, in which equal weight is assigned to heart beats, rather than time intervals, resulting in greater weight given to the periods when the pulse is elevated (Glynn, Christenfeld, & Gerin, 1997). Raw change scores,
rather than residualized change scores, were used (Llabre, Spitzer, & Saab, 1991).

We verified the initial equivalence of groups by comparing the mean of the pretask baseline measurements with a separate one-way analysis of variance (ANOVA) for each of the cardiovascular measures. Manipulation and treatment effects were analyzed by comparing the mean change score for each period with a separate one-way ANOVA for each of the cardiovascular measures. An alpha level of .05 was used in the analysis.

Results

Baseline Measures

There was no significant difference between conditions during the baseline period for any of the cardiovascular measures, all Fs (2, 99) < 1.21, all ps > .30.

Stress Manipulation Check

The serial-subtraction task was effective as a stressor for all conditions, with average task increases of 22.8 mmHg systolic blood pressure, 14.5 mmHg diastolic blood pressure, and 13.7 beats per minute (bpm) heart rate. There was no significant difference between conditions in the cardiovascular measures during the stress manipulation, all Fs (1, 76) < 0.45, all ps > .50.

Effect of Exercise on Blood Pressure and Heart Rate

In the stress/exercise condition, at the end of the exercise period blood pressure and heart rate were elevated compared to the end of the math stressor, and compared to the levels of the participants in the stress/no exercise and no stress/exercise control conditions. Systolic blood pressure was 39.4 mmHg above baseline (11.9 mmHg higher than at the end of the math task, 29.9 mmHg higher than the stress/no exercise condition, and 8.5 mmHg higher than the no stress/exercise condition). Diastolic blood pressure was 21.7 mmHg above baseline (3.9 mmHg higher than at the end of the math task, 18.9 mmHg higher than the stress/no exercise condition, and 5.5 mmHg higher than the no stress/exercise condition). Heart rate was 37.0 bpm above baseline (22.3 bpm higher than at the end of the math task, 40.7 bpm higher than the stress/no exercise condition, and 5.3 bpm higher than the no stress/exercise condition).

Effect of Experimental Condition on Blood Pressure and Heart Rate Recovery

For ease of comparison, the last 10 minutes of the recovery period was used in the analysis of cardiovascular recovery. This was a post hoc decision, as we were looking for the point at which the blood pressure measures for all conditions had leveled off, allowing a stable comparison across groups. This is also a conservative measure, as the stress/no exercise control condition had 3 additional minutes to recover. Participants in the stress/no exercise condition were sitting still for 3 minutes whereas those in the stress/exercise condition and no stress/exercise condition exercised; the manipulation period for these participants was, in effect, the beginning of their recovery period.

Within the stress/no exercise control condition, there were no significant differences in any of the cardiovascular measures between participants who finger tapped and those who did not. Therefore, these two groups were combined for the recovery analysis. It is worth noting that, although differences were not significant, those participants who finger tapped had slower recuperation, suggesting the metronome by itself did not enhance recovery, and was, if anything, actually more arousing than distracting.

There was a significant effect in improving recovery of having exercised on both systolic blood pressure, \( F(2, 99) = 4.35, \ p < .05, \ \eta^2 = 0.08 \) (see Table 3 and Figure 1) and diastolic blood pressure \( F(2, 99) = 6.38, \ p < .005, \ \eta^2 = 0.11 \) (see Table 3 and Figure 2) during the last 10 minutes of the recovery period. A post hoc Tukey honestly significant difference (HSD) showed a significant difference in systolic blood pressure between the stress/exercise and stress/no exercise conditions, \( p < .05 \), with exercising after stress returning systolic blood pressure closer to baseline than not exercising after stress. Diastolic blood pressure followed the same pattern (\( p < .01 \)).

Although participants who exercised after the stressor (stress/exercise) had significantly \( (p < .05) \) higher systolic and diastolic blood pressure during the exercise manipulation than participants who exercised without having first experienced the stressor (no stress/exercise), there were no significant differences in recovery between the two conditions \( (p < .90) \).

There were no significant differences in heart rate between conditions, \( F(2, 99) = 3.06, \ p > .05 \) (see Table 3 and Figure 3). Slight spikes in the heart rate data during the recovery period, just visible on the figure, coincide with the thought sampling signals (at Minutes 1, 2.5, 4, 7, and 11).

Self-Report

Stressor. There were no significant differences between conditions in how difficult participants found the math task, \( F(1, 76) = 0.06, \ p > .80 \). The average response was 5.3 on a 7-point Likert-type scale in which 7 was most difficult. Nor were there significant differences between conditions in how stressful participants found it, \( F(1, 76) = 0.11, \ p > .74 \). The average response was 5.0 on a 7-point Likert-type scale in which 7 was most stressful.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Systolic BP</th>
<th>Diastolic BP</th>
<th>Heart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>M  SD</td>
<td>M  SD</td>
</tr>
<tr>
<td>Stress/exercise( ^a )</td>
<td>3.5 9.7</td>
<td>0.3 6.6</td>
<td>2.1 3.5</td>
</tr>
<tr>
<td>No stress/exercise( ^b )</td>
<td>3.6 11.7</td>
<td>1.1 7.0</td>
<td>1.4 4.4</td>
</tr>
<tr>
<td>Stress/no exercise( ^c )</td>
<td>8.8 7.8</td>
<td>4.8 4.9</td>
<td>0.1 3.2</td>
</tr>
<tr>
<td>Stress/metronome task</td>
<td>9.9 8.3</td>
<td>5.4 5.6</td>
<td>0.8 2.8</td>
</tr>
<tr>
<td>Stress/no Task</td>
<td>7.6 7.2</td>
<td>4.2 4.2</td>
<td>-0.6 3.4</td>
</tr>
</tbody>
</table>

Note. BP = blood pressure.

\( ^a n = 26. \) \( ^b n = 24. \) \( ^c n = 52. \)

\( * p < .05. \) \( ** p < .01. \)
Rumination. There was not a significant difference in how much participants reported thinking, during the recovery period, about the stressor, $F(1, 76) = 0.21, p > .65$. The average response was 3.5, in which 7 indicated that they were thinking about the stressor the whole time. There was a significant difference in how much participants reported thinking about the manipulation (sitting in silence, finger tapping, or walking in place), $F(1, 76) = 9.24, p < .005$. Participants who did exercise reported thinking more about the manipulation ($M = 2.6$) than participants who did not exercise ($M = 1.8$), in which a 7 indicated that they were thinking about the manipulation the whole time.

Thought sampling. Participants in the stress/exercise condition reported fewer emotional thoughts about the math task (i.e., “I’m so bad at math,” “I feel dumb,” “I hate the number 13”) than participants in the stress/no exercise control condition, achieving marginal statistical significance, an average of .40 and .80 emotional thoughts per person, respectively, $F(1, 76) = 2.88, p < .10$. Over 25% of participants in the stress/exercise condition wrote about going to the gym or the need to exercise more often, compared to 3% of participants in the stress/no exercise control condition, $F(1, 76) = 9.97, p < .005$. Participants who exercised wrote about going to the gym and the need to exercise more often, compared to those who did not exercise, in which a 7 indicated that they were thinking about the manipulation the whole time.

It is notable that, although exercising after a stressor adds to initial cardiovascular arousal, it goes on to facilitate cardiovascular recovery afterward.

The existing literature on acute aerobic exercise does not offer a clear explanation for why exercise should promote recovery, although there are several possibilities. Exercise may work by distracting participants from thoughts of the stressor (Bahrke & Morgan, 1978; Raglin & Morgan, 1987). It is also possible that exercise could have produced a hypotensive aftereffect. Or, the exercise could have altered the way people thought about the stressor, by misattribution of arousal.

Discussion

Although exercising before a stressor has been shown to limit the magnitude of stress responses, we tested the use of exercise as a coping mechanism after the stressor, to limit the duration of the stress response. To our knowledge, this is the first study of its kind to examine the effects of poststress exercise on cardiovascular recovery. Although the blood pressure of the participants in the exercise condition was far higher, during the exercise, than the blood pressure of the participants who did not exercise, soon after the tasks were completed the participants who had exercised had significantly lower systolic and diastolic blood pressure than participants who had sat still. It is notable that, although exercising after a stressor adds to initial cardiovascular arousal, it goes on to facilitate cardiovascular recovery afterward.

The existing literature on acute aerobic exercise does not offer a clear explanation for why exercise should promote recovery, although there are several possibilities. Exercise may work by distracting participants from thoughts of the stressor (Bahrke & Morgan, 1978; Raglin & Morgan, 1987). It is also possible that exercise could have produced a hypotensive aftereffect. Or, the exercise could have altered the way people thought about the stressor, by misattribution of arousal.

Although distraction has been found to be effective in reducing stress-associated elevations in blood pressure during rumination
(Glynn et al., 2002), it is not a sufficient explanation for the efficacy of exercise in prior experiments. Roth, Bachtler, and Fillingim (1990) had female participants bicycle or sit still for 10 minutes. During this period, half of the participants in each condition performed a difficult mental arithmetic task. Scores on the Profile of Mood States (McNair, Lorr, & Droppelman, 1992) indicated that the exercising participants, regardless of task exposure, reported less tension and more vigor than participants who did not exercise. That is, participants, who could not have been distracted from the stressor during exercise because the stressor was concurrent with the exercise, still reported less anxiety than participants in the stressor-alone condition. Furthermore, in our study, the benefits of exercise on cardiovascular levels do not occur during the exercise, when it should be distracting but blood pressure and heart rate are at their highest, but only after the exercise has ended.

Instead of distraction, a physiological mechanism may be at work. Some studies have found that, following a single session of exercise, there is a transient reduction in resting blood pressure (see Kenney & Seals, 1993, for a review). This postexercise hypotension (PEH) has been found to persist for several hours after exercise, and can lower the blood pressure of hypertensive individuals into the normal range for much of the day following exercise, even in the presence of work-related stress (Brownley, West, Hinderliter, & Light, 1996). However, although PEH has been found within hours after exercise, it is not usually found minutes after, and more recent work has begun to examine sympathetic contributions to reduced reactivity, including reductions in catecholamine response (Brownley et al., 2003; Peronnet, Massicotte, Paquet, Brisson, & de Champlain, 1989). There is reason to think that, in our study, postexercise hypotension is not responsible for the quick recovery. The exercise task by itself did not cause blood pressure to recover below baseline levels. Instead, blood pressure returned rapidly and precisely to preexercise levels. Glynn et al. (2002), using an exercise task identical to that used in this study, found the same effect. Moreover, the participants who exercised in the absence of the stressor and participants who exercised after the stressor showed effectively identical recovery (despite the latter having significantly greater cardiovascular arousal at the start of the recovery period). If any postexercise hypotension was simply masking the lingering effects of the psychological stressor, then these two groups should be very different. Instead it appears that the rapid recovery people show from exercise replaces the slow recovery they show from an emotional stressor when participants do both.

A more subtle psychological process may also be at work. Exercising after a stressor could have the effect of interfering with the arousal-anger-rumination process. Interfering with people’s poststress anger, or rumination, may be sufficient to break the feed-forward process in which anger, angry thoughts, and autonomic activation sustain each other long after the actual anger-provoking event, and thus may improve blood pressure recovery (Glynn et al., 2002). Instead of simply distracting people from emotional thoughts, exercise may reduce the emotional nature of the thoughts, by providing an alternative attribution for the arousal produced in response to the anger-provoking stimulus (Loftis & Ross, 1974; Nisbett & Schachter, 1966; Ross, Rodin, & Zimbardo, 1969; Schachter, 1964; Schachter & Singer, 1962; Storms & Nisbett, 1970). Insofar as individuals can credit some, if not all, of their arousal to positive invigoration from exercise rather than

Figure 2. Average diastolic blood pressure (DBP) change from baseline score (per minute) across the experimental session.

![Figure 2](image-url)
negative tension from a stressor, it is possible that exercise following a stressor can reduce stress responses.

Study Limitations

Because the exercise in this experiment started almost immediately after the stressor, it remains to be addressed how long after an event exercise can continue to be an effective form of stress management. This is an important question, because often a lag is unavoidable. After an argument with one’s spouse, one still needs time to put on a pair of sneakers before going for a walk, and one might need to wait hours to exercise after a crisis at work.

The current study suggests that even brief exercise can be effective, and it needs to be explored whether longer exercise works similarly, as well as whether other forms of exercise, differing in intensity and form, would also work. Nevertheless, although the exercise task used in this study was very brief and very light relative to other studies, these properties make it advantageous from a public health perspective. We chose to standardize the exercise task in terms of its form and duration, rather than its intensity. That is, one could adjust the exercise task for each individual so that it produces the same increases in heart rate or percentage of maximal oxygen uptake. In this study, instead of holding the response constant, we held the stimulus constant. This method is more easily replicated and, as with the shorter duration of exercise, perhaps more easily adoptable by the public. However, future studies that employ real-world exercise, such as walking or running, would further contribute to the literature.

Although the math task was an effective stressor, both in terms of self-report and cardiovascular measures, it is unknown if these results could generalized to other stressful situations (i.e., not just those that invoke anger or embarrassment, but perhaps grief or fear).

The present study was not designed to test the various potential mechanisms underlying the effects of exercise on stress recovery. Rather, it was designed to test whether exercise could improve stress recovery, as it has been shown to do with stress reactivity. Potential mechanisms are suggested and debated, but this was not the focus of the study. Future work that is designed to test the various potential mechanisms underlying this effect is needed.

In conclusion, while research to date has looked at the impact of exercising before a stressor, this investigation demonstrates that exercising after a stressor can also limit the duration of cardiovascular arousal. Furthermore, within the framework of the cardiovascular reactivity hypothesis, this study has shown that interventions that follow a stressor, even those whose acute effect is to raise blood pressure, can still be effective in limiting the duration of cardiovascular responses, and thus have the potential to promote health.

References


