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Comparison of Anxiolytic Effects of Acute Exercise in Older Versus Younger Adults

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Abstract

Although the anxiolytic effect of acute exercise is well established, there is little understanding regarding whether this effect differs across age. The purpose of this investigation was to compare anxiolytic effects of acute exercise in older versus younger volunteers. Older ($n = 32$, aged 59-75 years) and younger ($n = 45$, aged 18-30 years), aerobically fit volunteers were assessed. On 3 consecutive days, participants ran/walked for 60 min at 65% to 75% of heart-rate reserve. The Spielberger State-Trait Anxiety Inventory (Form Y1) was administered 5 min before and 20 min after each exercise bout. Mean state anxiety before and after exercise was analyzed by repeated measures age-by-gender-by-time ANOVA. A significantly greater anxiolytic effect of exercise in the older versus younger participants was found for the mean data ($p < .001$), as well as each of the 3 individual days. The results suggest greater anxiolytic effects of vigorous acute exercise in older compared to younger adults.

Keywords

age; anxiety reduction; STAI; physical activity

The anxiolytic effect of acute exercise has been well documented (Bahrke & Morgan, 1978; Garvin, Koltyn, & Morgan, 1997; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). However, one noteworthy gap in our understanding is whether this effect varies across age. Most experimental studies have focused on young adults.

An earlier meta-analysis found that the average effect size (ES) for reduction in self-reported anxiety following acute exercise in adults above 45 years was less than half of that observed in participants aged 30 years (Petruzzello et al., 1991). Moreover, ESs for reductions in psychophysiological indices of anxiety in the older adults were 25% to 50% of those observed in the younger age groups. A more recent meta-analysis of the effect of acute exercise on psychological variables in older adults (>60 years) found a mean ES of only 0.06 (Arent, Landers, & Etnier, 2000).

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However, more recent experimental studies have found anxiolytic effects of acute exercise in seniors with ESs ranging from 0.18 to 0.63 (McAuley, Blissmer, Katula, & Duncan, 2000; Watanabe, Takeshima, Okada, & Inomata, 2000; Wininger, 2002). These effects seem comparable to those observed in younger adults.

The most valid comparisons of age differences in the anxiolytic effect of acute exercise are likely to be derived from studies that directly compare this effect between younger and older subjects. We are aware of only one such study. In contrast with meta-analysis results, Hatfield, Goldfarb, Sforzo, and Flynn (1987) found that cycling exercise elicited more than twice the reduction in anxiety among older ($n = 7$, 66 ± 5.9 years; $ES = 0.80$) versus younger subjects ($n = 9$, 26 ± 2.5 years, $ES = 0.38$).

In light of accumulating epidemiologic evidence linking exercise with improved health and longevity (Church, LaMonte, Barlow, & Blair, 2005; LaMonte & Blair, 2006; Manini et al., 2006) and the demographics of our aging, mostly sedentary senior population, comparisons of psychological responses to exercise across age could have important implications for exercise promotion and adherence among older adults. Indeed, evidence suggests that stress/anxiety reduction is one of the primary incentives for exercise (Buckworth & Dishman, 2002). Whereas older adults might enjoy the greatest health benefits of exercise, including attenuation of age-related impairments in physical and cognitive function, many older adults are reluctant to exercise, often focusing on potential negative outcomes (e.g., falling) and assuming that psychological benefits can be enjoyed only by young individuals. Demonstrating similar psychological benefits of exercise in older and young adults could help debunk these assumptions, and potentially could help reduce reliance on pharmacologic treatments, which are particularly risky in older adults (Bolton et al., 2008).

The aim of the present study was to compare the anxiolytic effect of acute exercise in older (aged 59-75 years) versus younger (aged 18-30 years) aerobically fit adults. These groups provided a clear age delineation, although avoiding some health complications and risks of exercise which become increasingly prevalent in people above 75 years of age. The study was ancillary to a complex 5-day laboratory protocol.

We did not anticipate any difference in the anxiolytic effect of exercise between older and younger adults. Older and younger adults have demonstrated similar responses to other anxiolytic stimuli. Moreover, potential psychosocial mechanisms (e.g., self-efficacy) mediating anxiolytic effects of exercise have not differed between older and younger adults (Focht, Knapp, Gavin, Raedeke, & Hickner, 2007) and are liable to be less different in highly fit individuals.

Method

Participants

Older adults (59-75 years) and younger adults (18-30 years) were assessed. Eligibility criteria included reported participation in aerobic exercise 3 days/week, for 20 min/day, at 60% maximal effort. Exclusion criteria consisted of the presence of 2 major risk factors for coronary artery disease (American College of Sports Medicine, 2006).

Procedure

Medical screening included fasting assessment of plasma lipids and glucose, a physical examination and interview, and assessment of abnormal heart responses to a physician-supervised incremental treadmill test to volitional exhaustion (VO₂ peak). Maximal heart rate reached at VO₂ peak was used to prescribe the subsequent experimental exercise bout.

Prior to participation in the study, written informed consent was obtained from each participant, as approved by the Institutional Review Board. Participants consented to participate in a 5-day laboratory protocol (described below). Included in the consent was a statement that the study would include assessment of anxiety, which is the focus of the present report.

Laboratory Protocol—The 5-day laboratory protocol was designed to examine the influence of exercise or bright light on the circadian system. Participants were randomized to either exercise or bright light treatment. The present report is limited to exercise-related data. Each participant stayed in a studio-apartment room and followed a 90 min “ultrashort” sleep–wake cycle (Kline et al., 2007), involving 60 min wake intervals in dim light (<50 lux) and 30 min sleep intervals in darkness, repeated around-the-clock throughout the 5-day period. The 90-min schedule was interrupted to administer the treatments (see below). Food and drink were available *ad libitum* (excluding caffeine and alcohol). The protocol included around-the-clock collection of urinary and saliva samples and completion of numerous questionnaires. During the wake periods, participants were free to watch television, read, etc. Exercise was not permitted, except as described below.

Exercise treatments: The laboratory protocol required the participants to walk/run on a treadmill for 60 min at 65% to 75% of heart rate reserve (HRR) for 3 consecutive days, always during the middle 3 days/nights of the 5-day protocol. Exercise intensity was maintained by monitoring heart rate with a heart rate monitor. An electric fan helped cool the participants during the exercise. With one exception, each participant spent at least 50 min in the designated HRR zone. One participant stopped exercising after 45 min on one of the days due to ankle soreness. His data were included in the analysis. The 60-min exercise bouts were performed at one of 8 randomly assigned times-of-day or -night but were performed at the same time-of-day/night each day for each individual, that is, centered at 0100, 0400, 0700, 1000, 1300, 1600, 1900, or 2200 hr. The 90-min ultrashort sleep–wake schedule was interrupted to allow the exercise bout, as well as wakefulness for 30 min before and 30 min after the exercise. Since extensive analysis indicated that there was no significant influence of time-of-day or circadian time on baseline State-Trait Anxiety Inventory (STAI) or on responses to exercise, data were collapsed across all times of testing.

Anxiety Assessment—Anxiety was assessed with Spielberger’s STAI (Form Y1; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) at 5 min before and 20 min following all three exercise bouts. Participants were given standardized instructions prior to completing the STAI questionnaire (Spielberger et al., 1983). The STAI is the best-validated anxiety questionnaire (Spielberger et al., 1983) and the most widely used anxiety measure in exercise studies.

A single postexercise interval of 20 min was chosen because some evidence had suggested greater anxiolytic responses at this time versus immediately post exercise (O'Connor, Petruzzello, Kubitz, & Robinson, 1995). Moreover, questions have been raised about the validity of the STAI for detecting anxiolytic effects during and immediately following exercise because some of the somatic signs of anxiety measured by the STAI could reflect physiological responses to exercise (Ekkekakis, Hall, & Petruzzello, 1999). However, there has been no dispute that a reduction in STAI observed 20 min post exercise is a valid indication of anxiety reduction. Longer postexercise intervals would have introduced the confound of sleep at 30 to 60 min post exercise, and more frequent postexercise STAI assessment would have increased the risk that responses at one time point might have influenced subsequent responses (Morgan, 1997).

Data Analysis—To avoid floor effects, an a priori decision was made to exclude cases for which baseline STAI were <25, which is approximately one standard deviation below population norms for both younger and older adults (Spielberger et al., 1983). Data were averaged across the 3 days of assessment and analyzed by repeated measures ANOVA, comparing responses by age group and sex. ESs were also calculated.

Results

Three younger and 16 older participants were excluded from the analysis due to low baseline STAI levels (<25), which averaged 21.78 and 20.69, respectively. Baseline STAI level did not differ significantly across days.

The number of younger and older participants included in the analysis was 45 and 32, respectively (Table 1). The older participants were aged 59 to 75 years (66.6 ± 4.5 years) and highly aerobically fit for this age group. The younger participants were aged 18 to 30 years (23.4 ± 3.8 years) and of average fitness.

Mean STAI data are depicted in Figure 1. There was no significant difference in baseline STAI levels between younger and older participants. A significant main time effect, $F(1, 73) = 27.94$, $p < .001$, and a significant age-by-time interaction, $F(1, 73) = 14.72$, $p < .001$, was found, indicating greater postexercise reduction in mean STAI for the older versus younger participants. The corresponding ESs for the older and younger participants were, respectively, 1.11 and 0.15. Greater anxiolytic effects of exercise in older versus younger participants were also found separately for each of the 3 days of assessment. However, no significant gender, gender-by-time, or gender-by-age effect was found.

The age differences persisted following a post hoc analysis, in which 33% of both the young and older adults with relatively low baseline STAI were excluded. Moreover, the age difference persisted after inclusion of all of the data, $F(1, 104) = 12.38$, $p = .001$.

We did not regard the bright light treatment as a control treatment because of well-established mood-promoting effects of bright light. Nonetheless, we conducted post hoc comparisons with bright light, which elicited modest, and quite similar, reductions in STAI in the older (2.4 ± 1.1) and younger participants (2.3 ± 0.5). There was no significant difference in anxiolytic effects of exercise versus bright light. However, there was a

significant treatment by time-by-age code interaction, $F(1, 159) = 8.74, p = .004$, demonstrating that the age-group difference in anxiolytic response was unique to exercise.

Discussion and Conclusions

The results indicate significantly greater anxiolytic effects of vigorous acute aerobic exercise in the older versus younger participants. Corresponding ESs varied by more than sevenfold. Moreover, in daily comparisons, the anxiolytic effect of exercise was significantly greater in the older versus younger adults on all 3 experimental days. These data contrast with meta-analysis results but are consistent with the results of Hatfield et al. (1987) comparing anxiolytic effects of acute exercise in older versus younger adults.

There were several limitations of the present study which raise questions about the generalizability of the findings. First, a control group was not possible in this ancillary study. However, dozens of previous studies demonstrating anxiolytic effects of exercise have made it commonplace to forgo control conditions in studying various aspects of the anxiolytic effect of exercise (Kjos & Etnier, 2006; Hatfield et al., 1987; O'Connor, Bryant, Veltri, & Gebhardt, 1993; O'Connor et al., 1995; Trine & Morgan, 1997). We do not believe that postexercise reductions in anxiety can be readily attributed to behavioral artifacts in the study, such as "demand" or expectancy effects (Morgan, 1997). That similar age differences were not found following the bright-light treatment suggests that the results cannot be explained by an age-group difference in response set. It seemed that the subjects viewed completion of the STAI as a small part of a complex study and that they were unaware of the research hypothesis of this ancillary study.

The greater anxiolytic response to exercise versus bright light in the older participants might be explained by age-related declines in visual sensitivity due to macular degeneration, cataracts, and other eye problems.

A second possible limitation was that, compared with the younger participants, the older participants were more aerobically fit, active, and healthy than average for their age. However, there is no consistent or compelling evidence that fitness is associated with greater anxiolytic response to exercise (Dishman, Farquhar, & Cureton, 1994; O'Connor et al., 1995; Petruzzello et al., 1991). Moreover, it is noteworthy that in a sample of sedentary participants, Hatfield et al. (1987) also found greater anxiolytic effects of exercise in older versus younger individuals. Finally, post hoc analysis for the present study found no association of fitness with anxiolytic response. Nonetheless, there could have been more of a self-selection bias toward favorable responses to exercise in the rare sample of older participants that was assessed.

A third limitation might be the unique laboratory environment of the present study. However, we and others have found that the protocol is well-tolerated by participants (about 2% drop-out). Moreover, an advantage of this lab-based protocol is that it allowed better standardization of the daily environment than is typical in experimental studies of exercise and anxiety. Furthermore, since the participants were in the laboratory for 30 hr prior to the first exercise bout, the anxiolytic effects might be less confounded by the "time-out" effects associated with removal from usual daily stressors than in other studies.

A fourth limitation was the low-baseline anxiety levels of the participants. Greater anxiolytic effects of exercise have been found in high-anxious individuals (O'Connor, Raglin, & Martinsen, 2000; Youngstedt, O'Connor, Crabbe, & Dishman, 1998). The reasons for the high number of exclusion for low-baseline STAI are unclear. Recommended, standardized instructions for completing the STAI were provided to the participants (Spielberger et al., 1983). Similarly, low values were not found for other psychometric scales assessed in the parent study (e.g., Center for Epidemiologic Studies Depression Scale [CESD], Radloff, 1977). The higher number of exclusions of the older participants is consistent with generally lower levels of anxiety in older adults (Spielberger et al., 1983).

In summary, notwithstanding the limitations, there is little compelling evidence to suggest that the results can be entirely explained by the unique aspects of the study. Even a finding of similar anxiolytic benefits of exercise across age could have important implications for exercise adherence in older adults. The available evidence indicates greater anxiolytic effects of acute exercise in older versus younger adults, both in sedentary and aerobically fit individuals.

Older adults can be advised that available evidence suggests exercise is an effective means of reducing their anxiety. Indeed, analogous to other positive outcomes of exercise, such as improved cognitive function, evidence suggests that older adults might experience greater psychological benefits of exercise than younger adults. Future research should further confirm these findings in individuals with lower levels of fitness and mental and physical health as well as under more normal environmental conditions. Future studies should also explore mechanisms mediating age-related differences in anxiolytic effects of exercise.

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Figure 1. Mean ($\pm$ Standard Deviation) State Anxiety (STAI-Y1) Assessed 5 min Before and 20 min After Exercise (1 hr at 65%-75% HRR) Averaged Over 3 Consecutive Days for Young ($n = 45$) and Older ($n = 32$) Participants
Note: Data are combined across gender.

Table 1Demographic Data ($M \pm SD$) of Participants Included in the Study

	Older Adults			Young Adults		
	Women (<i>n</i> = 13)	Men (<i>n</i> = 19)	Total (<i>N</i> = 32)	Women (<i>n</i> = 27)	Men (<i>n</i> = 18)	Total (<i>N</i> = 45)
Height (cm)	163.1 $\pm$ 5.2	181.4 $\pm$ 27.0	173.7 $\pm$ 4.1	165.5 $\pm$ 5.4	179.2 $\pm$ 8.6	170.8 $\pm$ 1.4
Weight (kg)	63.6 $\pm$ 8.3	74.0 $\pm$ 7.3	69.6 $\pm$ 1.7	65.0 $\pm$ 8.7	80.6 $\pm$ 9.6	71.1 $\pm$ 1.8
Age (years)	65.3 $\pm$ 4.4	67.5 $\pm$ 4.4	66.6 $\pm$ 0.8	24.2 $\pm$ 3.9	22.2 $\pm$ 3.4	23.4 $\pm$ 0.6
VO2 peak (ml/kg/min)	37.8 $\pm$ 1.8	39.4 $\pm$ 2.1	38.7 $\pm$ 1.4	34.1 $\pm$ 1.9	45.7 $\pm$ 2.7	38.6 $\pm$ 1.7
Trait anxiety	31.8 $\pm$ 2.0	33.2 $\pm$ 1.2	32.6 $\pm$ 1.5	32.3 $\pm$ 1.3	31.8 $\pm$ 1.4	32.1 $\pm$ 1.4
CES-D	4.3 $\pm$ 0.5	5.7 $\pm$ 1.3	4.5 $\pm$ 0.9	8.0 $\pm$ 1.0	6.3 $\pm$ 1.3	7.3 $\pm$ 0.8

Note: CES-D = Center for Epidemiologic Studies-Depression Scale (Radloff, 1977).