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Acute Effects of Competitive Exercise on Risk-Taking in a Sample of Adolescent Male Athletes

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Abstract

Exercise acutely reduces cravings for tobacco and alcohol, but the mechanism accounting for this relationship is not fully understood. To explore exercise's effects on general risk-taking, we compared the performances of 20 adolescent male athletes on the balloon analog risk task (BART) immediately after periods of exercise (playing tennis) and rest. Statistically significant risk-taking effects were observed post-exercise. The established attenuating effect of exercise on desire for substance use did not extend to impulses for other risk behaviors in this study. In future studies, the moderating effects of participant characteristics and type of risk behavior should be considered.

Exercise acutely affects neurotransmitter systems associated with pleasure and mood regulation. Like substances of abuse such as alcohol, nicotine, and cocaine, exercise acutely increases dopamine function in critical sub-cortical brain regions (Dishman & O'Connor, 2009; Read & Brown, 2003). A model of exercise's effects proposes that endorphins released during exercise act to increase production of dopamine (Dishman & O'Connor). Temporary post-exercise dopamine increases might acutely increase reward-seeking behavior, even if that behavior entails risk. Dopamine activates the brain regions associated with novelty-seeking, and with evaluation and response to reward. Preclinical studies have shown that increased dopamine activity in the limbic, prefrontal, and ventral striatal regions has been associated with increased risk-taking (Doremus-Fitzwater, Varlinskaya, & Spear, 2010; Spear, 2000; Wahlstrom, Collins, White, & Luciana, 2010).

Nevertheless, evidence has accrued in recent years to establish that exercise acutely reduces cravings for some substances of abuse among current users, suggesting a tempering effect on reward-seeking inclination. Engaging in exercise acutely reduced tobacco withdrawal

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symptoms (Ussher, West, Doshi, & Sampuran, 2006), and cravings for cigarettes and alcohol in study participants who used those substances (Taylor, Ussher, & Faulkner, 2007; Ussher, Sampuran, Doshi, West, & Drummond, 2004; Ussher et al., 2006; Van Rensburg & Taylor, 2008; Van Rensburg, Taylor, Hodgson, & Benattayallah, 2009). The attenuating effect of exercise on the desire to engage in some health risk behaviors has raised interest in its utility as an intervention for substance use (Taylor et al., 2007).

A variety of mechanisms have been proposed to account for exercise's documented effect on cravings for substance use, including decreased stress, increased stimulation, improved affect, distraction (Taylor et al., 2007), increased glucose level, effect on serotonergic systems (Ussher et al., 2004), change in cortisol concentration (Scerbo, Faulkner, Taylor, & Thomas, 2010), and change in the salience of substance use cues (Van Rensburg et al., 2009). The range of mechanisms involved suggests the process by which exercise affects risk-taking behaviors is multifaceted. As such, it is unclear whether exercise acutely affects the inclination toward all risk behavior in the same way or whether its effect is more specific.

To better understand the relationship between exercise and risk-taking and assess whether documented reductions in substance use after exercise might be accounted for by a decrease in overall risk inclination, we examined exercise effects in healthy participants. The study involved a convenience sample of adolescent male athletes. Adolescents are prone to risk-taking by virtue of their developmental stage (Steinberg, 2008) and studies have suggested athletes engage in behaviors that place them at increased health risk relative to non-athletes, including fast driving, failure to wear bike or motorcycle helmets (Baumert, Henderson, & Thompson, 1998), fighting, unsafe sexual behavior (Nattiv, Puffer, & Green, 1997), use of smokeless tobacco, and disordered eating (Pritchard, Milligan, Elgin, Rush, & Shea, 2007).

METHOD

Sample

Twenty male high school student athletes, aged 13–17, were selected by convenience sampling. All participants provided parental consent and personal assent for participation.

Study Conditions

Participants were exposed to two study conditions, rest and exercise. To control for sequence effects, the order of condition was varied by participant, with the first 10 enrolled students assigned to rest first and the second 10 to exercise first. In the rest condition, participants sat quietly for 20 min with one of the study authors (EH). In the exercise condition, participants engaged in a 60-min tennis match with the same author.

Instrumentation

Exercise Intensity—To account for differences in perceived exercise intensity, participants rated the intensity of the structured exercise on a scale of 1 (*light*) to 5 (*extremely intensive*).

Risk-taking—The balloon analogue risk task (BART), a validated behavioral assessment of risk-taking (Lejuez, Aklin, Zvolensky, & Pedulla, 2003; Lejuez et al., 2002), was administered to participants immediately following each study condition. BART validation studies have established adequate score reliability across trials ($r = .86$; Lejuez et al. 2003), and convergent and discriminant validity ($r = .28, p < .01$ with Barratt Impulsiveness Scale; $r = .24, p < .05$, with impulsiveness subscale, Eysenck impulsiveness scale; $r = .35, p < .01$ with the sensation seeking scale, $r = .29, p = .01$ with psychopathy scale SRP-II; $r = .33, p < .01$ with behavioral constraint scale, Multidimensional Personality Questionnaire; and $r = .07, p > .05$ with empathy subscale, Eysenck impulsiveness scale; Hunt, Hopko, Bare, Lejuez, & Robinson, 2005; Lejuez et al., 2002). Importantly, BART scores have also correlated positively with real-world risk-taking behaviors (e.g., $r = .44, p < .01$ with gambling; $r = .36, p < .01$ with cigarette smoking, $r = .28, p < .01$ with polydrug use; $r = .48, p < .01$ with number of risk behaviors; CDC youth risk behavior surveillance system; Lejuez et al., 2002; 2003). The task involves accrual of points for inflating simulated balloons by clicking a pump on the computer screen, and point loss for overinflating and popping balloons. To encourage valid responses, participants were told that they would receive two cents for each point earned. Participants completed 10 trials of the task per study condition. The mean number of successful pumps (the average number of pumps per balloon, excluding balloons that exploded) was recorded for each administration (Lejuez et al., 2002).

Data Analysis

Descriptive statistics were used to characterize the sample by age and exercise habits. Repeated measures ANOVA was used for the primary outcome analysis to estimate the main effects of condition (exercise vs. rest) on BART scores. We also estimated the main effect of order, and condition-by-order interaction effect using 2×2 ANOVA.

RESULTS

Sample Characteristics

The mean age of the sample was 15.35 years (range 13–17 years). Study participants exercised 5 days per week ($SD = 1.45$). Participants perceived the exercise as “intensive,” with a mean score of 3.8 out of 5 ($SD = 1.06$) on the subjective intensity scale.

Acute Effect of Exercise on Risk-taking

Mean scores on the BART were significantly higher post-exercise than following rest ($M = 39.82$ and $M = 36.43$, respectively; $p = .048$, $ES = .31$). BART means were slightly higher than means published in other studies of adolescents ($M = 30.93$; Gordon, 2007; $M = 33.00$; Lejuez et al., 2003). There was no significant order-by-condition effect on scores; performance was equally affected by exercise regardless of condition sequence.

Effect of Condition Order on Risk-taking

A significant main effect of order was observed. Averaging across exercise and rest conditions, participants who rested first and then exercised (the first 10 participants) had significantly higher overall mean BART scores than the second 10 who exercised, then

rested ($p .018$). Mean scores across trials for the rest-first and exercise-first groups were $M = 44.04$ ($SD = 12.0$) and $M = 32.21$ ($SD = 8.1$), respectively. The groups did not differ significantly on any other measured characteristic.

DISCUSSION

This study revealed that participation in a single bout of intensive, competitive exercise resulted in increased risk-taking in a sample of adolescent athletes. The current study's findings are inconsistent with those highlighting exercise's attenuating effects on substance-related risk behavior, and suggests exercise may differentially impact different types of risk-taking behaviors. Alternately, the difference may be explained by the different populations tested, and exercise may increase risk-taking in healthy adolescent athletes but not in people who are substance-using or adults.

Temporary dopaminergic effects of exercise could account for the observed increase in risk-taking in the current study, and it is possible that adolescents are more likely than adults to respond to dopaminergic stimulation with increased risk-taking. Studies have revealed that long-term, aerobic exercise enhances the availability and processing of neurotransmitters (Ma, 2008; MacRae, Spirduso, Cartee, Farrar, & Wilcox, 1987). Thus, athletes may be more tolerant of post-exercise increases in dopamine, and may seek additional stimulation through risk-taking.

Another plausible explanation for the observed post-exercise increase in risk-taking is fatigue. It is possible that participants were more tired after exercise and increases in balloon pumps reflected performance errors, rather than increased willingness to take risks.

A significant order effect demonstrated that individuals assigned to rest first had higher overall BART scores. Given non-random assignment of participants to condition order, there may have been unmeasured covariates that could account for the observed differences in risk behavior between these groups. For example, it is possible that the 10 first-enrolled participants (the rest-first group) agreed more readily to study participation because of greater sensitivity to peer influence (the request to participate by EH, a co-author and participant peer), a variable associated with increased risk-taking (Gardner & Steinberg, 2005). Greater sensitivity to peer influence (EH's presence) during the risk task could account for higher mean risk scores.

LIMITATIONS

Because the exercise activity involved a competitive tennis match, we cannot disentangle the effects of exercise from those of competition. Given the small sample size and the sampling strategy, we do not know to what extent these results may generalize to other populations. Nevertheless, the current findings suggest that additional study of the relationship between exercise and risk-taking propensity is warranted.

CONCLUSION

Engaging in a bout of exercise affects the probability of engaging in some risk behaviors. The current study demonstrated that exercise acutely increased risk-taking on a computerized risk task in adolescent athletes. The fact that risk-taking increased rather than decreased immediately following exercise suggests that documented post-exercise reductions in cravings for tobacco and alcohol are not explained by a more general reduction in willingness to take risks. Further study of the relationship between exercise and risk-taking should consider potential moderators including participant characteristics such as age, personality, or health, as well as type of risk.

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