

Affective Outcomes During and After High-Intensity Exercise in Outdoor Green and Indoor Gym Settings

Abstract

Background: Outdoor exercise settings promote greater psychological well-being than synthetic equivalents, although the influence of the exercise context has not been investigated at high exercise intensities.

Methods: This study compared the psychological effects of high intensity exercise in outdoor green and indoor gym settings in 22 adult runners using a randomized repeated measures design. Affect and perceived exertion were assessed before, during, and after a 6000m run with the second half completed at maximum effort.

Results: Perceived exertion and activation increased in a progressive manner from baseline to 6000m, and decreased during the 10 min recovery post-run. Non-significant reductions in affective valence were observed between 3000m and 6000m, followed by a significant increase post-run. Outcomes did not differ at any time point between the settings.

Conclusion: This study suggested that regular runners experience positive affective responses during and after high-intensity exercise in both a natural outdoor environment and an indoor gym.

Keywords: psychological well-being, physical activity, natural environments, affect.

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Introduction

Psychological well-being has been identified as an important contributor to health, increasing longevity by up to 10 years (Diener & Chan, 2011). One of the strongest determinants of psychological well-being, as well as physical health outcomes, is exercise (Penedo & Dahn, 2005). Systematic review evidence suggests that physical activity interventions can lead to improvements in positive affect (Reed & Buck, 2009), stress-related illness (Geber & Pühse, 2009), and clinical mental disorders (Zschucke, Gaudlitz, & Ströhle, 2013). Vigorous intensity activity (e.g. running) is associated with the greatest cardiorespiratory health benefits (Swain & Franklin, 2006), but it is less clear if there is an optimal intensity for psychological well-being. According to the principles of the dual-mode theory, the highest-intensity exercise generates negative affective responses in most individuals, while exercise below the ventilatory threshold (so-called steady-state intensity) is associated with considerable inter-individual variation (Ekkekakis, Hall, & Petruzzello, 2005). One factor that may influence affective responses is the environmental context in which physical activity takes place.

Growing evidence supports natural environments or green spaces as an important contextual factor for improving psychological well-being (Pretty, 2004; Ryan et al, 2010). Exposure to nature has been shown to have emotionally restorative effects (Hartig, Mang, & Evans, 1991) through the countering of stress (Ulrich, 1979) and cognitive fatigue (Kaplan, 1995), attributable to humans' innate affiliation with the natural world (Mayer, McPherson Frantz, Bruehlman-Senecal, & Dolliver, 2009). Physical activity performed in natural environments (known as green exercise) has been shown to have synergistic benefits over

physical activity or nature alone (Pretty, Peacock, Sellens & Griffin, 2005; Barton & Pretty, 2010; Mitchell, 2013). Improvements in psychological well-being after green exercise participation have been demonstrated for patients with mental health problems (Barton, Griffin, & Pretty, 2012), as well as regular exercisers (Bodin & Hartig, 2003). A study comparing several groups of outdoor exercisers (e.g. road cycling, mountain biking, orienteering, kayaking, walking) found the psychological benefits were associated with the degree of “greenness” perceived (Mackay & Neill, 2010). Systematic reviews have concluded that in general, outdoor exercise settings are associated with greater well-being outcomes than synthetic alternatives, although the need for more rigorous comparisons is emphasized (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Thompson Coon et al., 2011).

Most previous green exercise research has assessed psychological well-being outcomes before and after exercise, and there is a lack of data measured during exercise bouts. This is an important omission given that affect can fluctuate in a non-linear fashion during and after exercise, possibly in response to changes in exercise intensity (Ekkekakis, Hall, & Petruzzello, 2008). A rise in exercise intensity is likely to lead to a switch in attentional focus, with the increasing physiological demands (e.g. heavier breathing; greater muscle pain) dictating an associative focus on somatic sensations, producing a progressive decline in affective valence (Welch, Hulley, Ferguson, & Beauchamp, 2007). However, significant improvements in affect are typically experienced after exercise cessation, known as the affective rebound (Ekkekakis, Parfitt, & Petruzzello, 2011). Accordingly, there is a need to better understand the role of natural environments in providing pleasant external stimuli that facilitate a more dissociative attentional focus and may result in lower perceptions of exertion, and more positive affective responses (Gladwell, Brown, Wood, Sandercock, & Barton, 2013; Welch et al., 2007).

Perceived exertion is defined as the effort expended while performing exercise that is influenced by numerous physical sensations (Borg, 1998). A number of studies have investigated the effects of the external environment on perceived exertion during exercise, with mixed results. While LaCaille and colleagues (2004) found that outdoor running was perceived to be less strenuous than indoor treadmill running (LaCaille, Masters, & Heath, 2004), Ceci and Hassmén (1991) reported higher perceptions of exertion while running outside. Meanwhile, in two other trials, no differences in perceived exertion were reported between treadmill and outdoor running (McMurray, Berry, Vann, Hardy & Sheps, 1987), and between watching video footage of natural and built environments while running (Rogerson & Barton, 2015).

Similarly, subjective vitality is an affective outcome that appears to be influenced by the environmental context. Vitality is defined as “one’s conscious experience of possessing energy and aliveness” and is associated with positive behavioral and health outcomes (Ryan & Frederick, 1997, p. 530). Vitality ratings have been shown to be greater when walking outdoors compared with indoor walking (Plante, Cage, Clements, & Stover, 2006; Ryan et al., 2010), but the effect of higher intensity exercise is under researched.

The present study aimed to determine the effects of the environmental setting on affective outcomes while running 6000 m at varying exercise intensities. Outcomes were assessed before, during, and after, completion of two runs, involving both steady-state and high-intensity effort. One run was performed indoors on a treadmill in gym, while the other took place in an outdoor rural setting. Based on previous research, outcomes of affect and perceived exertion were expected to change during the runs. The present study hypothesized that the outdoor green setting would result in significantly greater positive affective responses and lower perceived exertion during steady-state intensity exercise and following a 10-minute recovery period when compared to the indoor gym setting, and that there would be no

significant difference between the settings in these outcome measures during high-intensity exercise. Finally, it was hypothesized that the outdoor green setting would yield the most marked increases in vitality ratings from pre- to post-exercise when compared with the indoor gym setting.

Materials and Methods

Participants

An *a priori* sample size calculation suggested that 20 participants in a repeated measures design would provide 80% power for detecting a difference ($p < .05$) between conditions of 1.0 unit on the Feeling Scale (Hardy & Rejeski, 1989) with a standard deviation of 1.5. A 1-point difference on this scale has consistently been shown to reflect a meaningful change in affective valence during exercise (Ekkekakis, Hall, Van Landuyt, & Petruzzello, 2000; Hall, Ekkekakis & Petruzzello, 2002; Rose & Parfitt, 2007) and to discriminate between affective states experienced while exercising in natural and urban settings (Kinnafick & Thøgersen-Ntoumani, 2014). Participants were recruited from seven local running clubs, with study information specifying that male and female participants must be at least 18 years of age, able to run the required distance, and provide informed consent. No incentives were offered for study participation. The institutional ethical committee approved all recruitment and data collection procedures.

Measures

Background characteristics. At the start of the study, participants self-reported age, sex, height, body mass, running status (competitive or recreational), prior running experience (in years or months), and typical weekly running distance. Preference for running outdoors or on a treadmill was not ascertained, but affiliation with the outdoor green setting was assessed using the short-form Nature Relatedness scale (Nisbet & Zelenski, 2013). Nature relatedness

reflects a “physical familiarity with the natural world, the level of comfort with and desire to be out in nature” (Nisbet, Zelenski, & Murphy, 2009, p. 313). The 6-item scale includes items such as “I take notice of wildlife wherever I am”. Participant’s responses were made on a 5-point scale ranging from 1 (disagree strongly) to 5 (agree strongly). The scale has demonstrated good internal consistency, and temporal stability has been confirmed (Nisbet & Zelenski, 2013).

Affect. Affective valence and perceived activation were assessed to represent the two dimensions of the circumplex model of affect (Russell, 1980). Affective valence was measured with the Feeling Scale (Hardy & Rejeski, 1989), an 11-point bipolar scale ranging from -5 (very bad) to +5 (very good). Anchors were specified at 0 (neutral) and each odd integer. Perceived activation was assessed with the Felt Activation Scale of the Telic State Measure (Svebak & Murgatroyd, 1985), requiring ratings of arousal on a 6-point scale ranging from 1 (low arousal) to 6 (high arousal). Both scales are moderately to strongly correlated with other measures of affect (Ekkekakis et al., 2008), and have demonstrated satisfactory convergent and discriminatory validity (Backhouse et al., 2007).

Perceived exertion. Perceived effort was measured using the Rating of Perceived Exertion (RPE) scale (Borg, 1998), with responses made on a 15-point scale ranging from 6 (no exertion), through 13 (somewhat hard), to 20 (maximal exertion) with respect to physical exertion levels.

State vitality. The 7-item Subjective Vitality Scale (Ryan & Frederick, 1997) was used to measure state vitality. Items included “I feel energized” and “I feel alert and awake”. Responses were made on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree) with respect to how participants felt at that moment. The scale has been extensively validated, exhibiting both high reliability and covariation amongst psychological factors (Ryan & Frederick, 1997).

Protocol

The study employed a repeated measures experimental design, with participants completing a 6000m run on two occasions, at least 24 h apart under different conditions (outdoor green versus indoor gym). To address possible order effects, the exercise settings were presented in two randomized, counterbalanced orders: 1, 2 and 2, 1 (1 = outdoor green, 2 = indoor gym). An online random number generator determined allocation to each order (Urbaniak & Plous, 2008).

Ahead of the initial run participants read and signed an informed consent form, and background characteristics were documented. Before the start of each run participants acquainted themselves with all self-report measures. In both conditions, measures of affect and perceived exertion were recorded at four time-points: baseline, 3000m, 6000m, and 10 min post-exercise. Additionally, subjective vitality ratings were taken at baseline and then again 10 min post-exercise. Standardized instructions were issued to ensure that participants completed the first 3000m at steady-state pace, and the last 3000m at maximum intensity (i.e., as fast as possible). No verbal encouragement was provided by the researchers during the runs. Participants chose their own recovery strategy during the 10 min post-exercise period, and followed their own warm up and cool down routines before and after data collection. Completion times for the final 3000m were recorded in each condition. Times were not recorded during steady-state paced runs.

The indoor gym condition was conducted in a large fitness suite using a Life Fitness 95Ti treadmill (Life Fitness, UK) set at an elevation gradient of 1% in order to accurately reflect the energetic cost of running outdoors on a flat surface (Jones & Doust, 1996). Digital screens on the treadmill displaying feedback data (e.g. running speed) remained visible, allowing for alterations to the treadmill speed, which simulated self-pacing outdoors. Other users of the fitness suite were present during data collection sessions.

The outdoor green condition was conducted in a large woodland area, with walking/running trails lined with trees and bushes. The 3000m course followed a well-marked walking circular trail, and had additional high-visibility arrow signs positioned throughout the route for the purposes of the study. The circuit featured a short (1:5) climb and subsequent descent, but was otherwise flat. Participants were allowed to carry a non-intrusive map of the course while running, and watches that provided equivalent feedback data to the treadmill condition were permitted, but listening to music was forbidden. Dog walkers and other runners occupied the woodlands during data collection. Field notes were taken regarding the climatic and contextual conditions.

Statistical analysis

Data were statistically analyzed using SPSS version 21 (IBM, US). Participant characteristics were summarized using descriptive statistics. Body mass index was calculated from weight and height data (kg/m^2). Participants scoring above 3 on the Nature Relatedness scale (the average score reported in validation studies with community, student, and employee samples) (Nisbet & Zelenski, 2013) were identified as having high nature-relatedness. Measures of affect, RPE and subjective vitality required a non-parametric approach to analysis because the scales provided data at an ordinal level and were not all normally distributed. Affective responses and perceived exertion were analyzed using a Friedman Two Way Analysis of Variance by Ranks. Subsequent pairwise differences were investigated using Wilcoxon matched pairs *post-hoc* tests. Analysis of subjective vitality ratings also required a Wilcoxon matched-pairs test. Measures of affect and perceived exertion recorded at 3000m were analyzed for five moderators (sex, running status, weight status, age, and nature relatedness) using a mixed 2 x 2 Analysis of Variance since a non-parametric alternative does not exist. An alpha level of .05 indicated statistical significance, but *post-hoc* tests required a Bonferroni corrected alpha level of .0125.

Results

Participant Characteristics

A total of 25 participants were recruited to take part in the study. Over the data collection period, three individuals withdrew due to unforeseen circumstances (e.g. family bereavement). Consequently, 22 (14 male, 8 female) runners with a mean age of 33 (\pm 8.3) years successfully completed both conditions. Participant characteristics are summarized in Table 1. An equal number of participants ($n = 11$) were assigned to each order.

Climatic Conditions and Performance Times

The weather conditions in the outdoor green setting were typically cloudy with sunny intervals, although two sessions had to be postponed due to extreme conditions. Comparable mean temperatures were recorded in the outdoor green and indoor gym settings (17.5 °C and 19 °C respectively). Participants reported no trouble in following the outdoor route, and no participants needed to refer to maps during the run. Other members of the public were present in both the gym and woodland setting, but no interaction took place between them and participants.

There was a twelve second difference in completion times of the maximum paced 3000m run between the outdoor green (14 min 54 s \pm 2 min 53 s) and indoor gym setting (14 min 42 s \pm 2 min 55 s). A paired t-test revealed no significant difference ($t_{(22)} = -0.475$, $p = .640$) between conditions, and the intra-class correlation coefficient was 0.91 (95% confidence interval: 0.79, 0.96).

Affective Responses and Ratings of Perceived Exertion

Differences in valence, activation, and perceived exertion between the outdoor green and indoor gym condition across the 6000m run and recovery period are presented in Figures 1 to 3. Analysis revealed that mean ranks differed between each time point (pre-run, 3000m, 6000m, and 10-min post-run) for valence ($X^2 = 30.4$, $p < .001$), activation ($X^2 = 89.0$, $p <$

.001) and perceived exertion ($X^2 = 136.4, p < .001$), Initial *post-hoc* tests indicated that perceived exertion and affect changed over the run time (pre-run vs. 3000m vs. 6000m vs. 10 min post-run). Mean ranks for both perceived exertion ($Z \geq -4.045, p < .001$) and activation ($Z \geq -3.376, p < .001$) increased significantly in a progressive manner from baseline (pre-run) through to the culmination of the 6000m run. Subsequently, responses significantly decreased ($p < .001$) when assessed 10 min post-exercise. This was observed in both settings.

By contrast, only slight differences were observed in valence mean ranks ($Z \geq -0.103, p \geq .034$) from baseline to 3000m to 6000m in both conditions. Significant differences became apparent from 6000m to 10 min post-run as valence increased ($Z \geq -3.042, p < .001$), reflecting a 1.9 (95% CI: 0.9, 2.9) unit change in the outdoor condition, and a 1.6 (95% CI: 0.7, 2.5) unit change in the indoor condition. Further *post-hoc* tests revealed that valence ($Z \geq -0.161, p \geq .030$), activation ($Z \geq -0.462, p \geq .408$), and perceived exertion ($Z \geq -0.431, p \geq .045$), did not differ at any time point between the settings.

Exploratory analysis revealed no significant sub-group by exercise setting interaction for any of the moderators (sex, running status, weight status, age, and nature relatedness) in measures of valence ($F_{(1, 20)} \geq .088, p \geq .523$), activation ($F_{(1, 20)} \geq .031, p \geq .210$), or perceived exertion ($F_{(1, 20)} \geq .043, p \geq .104$).

Subjective Vitality

The vitality median for the outdoor green ($Z = -2.751, p = .005$) and indoor gym ($Z = -2.501, p = .011$) settings significantly increased from baseline values to 10 min post-exercise, but did not differ between conditions.

Discussion

This study compared the affective outcomes of running 6000m in outdoor green and indoor gym settings. Consistent with previous research, perceived exertion, affect and vitality all increased post-exercise, with affect scores showing the typical rebound after a short

recovery. However, no significant differences between the outdoor and indoor conditions were observed at any point mid- or post-run. Exploratory moderator analyses also revealed no influence of the environmental conditions for specific sub-groups, including those with high nature-relatedness scores. Overall the results suggest that natural and synthetic environments both have a positive influence on psychological well-being for regular runners regardless of the exercise intensity.

The lack of significant differences between the outdoor green and indoor gym settings contradicts the general conclusions of systematic reviews on this subject (Bowler et al., 2010; Thompson Coon et al., 2011). However, it is notable that the majority of trials indicating superior effects of outdoor exercise have involved walking (Focht, 2009; Kinnafick & Thøgersen-Ntoumani, 2014; Ryan et al, 2010; Teas, Hurley, Ghumare, & Ogoussan, 2007), while previous trials of running have also found the well-being improvements to be similar in natural and synthetic settings (Kerr et al, 2006; McMurray et al, 1987). It may be that the influence of the environment is strongest with lower-intensity exercise that allows more attention to be paid to surroundings. Assessing attentional focus alongside affective outcomes would help further understand the relationship between exercise intensity and setting.

Another consideration in interpreting the similar findings across conditions in the present study is that the two ecologically valid exercise locations may have been equally aesthetically pleasing to participants. The indoor setting was a modern, well-decorated, air-conditioned fitness center, and therefore may not be comparable to the synthetic settings used in previous research (e.g. laboratories). Given that viewing pleasant scenes whilst exercising positively influences well-being indicators (Kinnafick & Thøgersen-Ntoumani, 2014; Pretty et al., 2005), it is possible that the perceived pleasantness of the visual cues, is more important than the specific nature of the surroundings. This may be particularly pertinent in the present study since the participants were regular runners and likely to be comfortable with

a fitness center environment. Obtaining participant ratings for preferred exercise environment and the aesthetic qualities of the location would help understand the degree of importance of specific components of the setting for changing affective states. The cognitive mechanisms that explain mental health benefits derived from green exercise are not yet well understood (Akers et al., 2012), hence it is possible that the outdoor natural setting in this study did not adequately reflect the underlying effective elements of green exercise.

The status of participants as regular runners may also be important in terms of possible motivational confounders of the impact of the external environment. Since participants were running club members who frequently chose to run at maximal intensity (e.g., in races and training), the study required them to perform at a familiar level. The importance of intrinsic motives such as enjoyment, mastery and physical fitness has been identified for regular exercisers (Aaltonen, Rottensteiner, Kaprio, & Kujala, 2014), and it is plausible that intrinsically motivated behavior overpowers subtle external cues (Bodin & Hartig, 2003). It is notable that even at maximum effort when affect scores declined, they nonetheless remained in the positive range. This suggests that the affective responses of highly motivated exercisers may be different to other populations, and it would be important for future research to focus on less active individuals.

Physical activity guidelines for adults recommend a minimum of 150 minutes per week of moderate intensity activity in order to maintain a healthy lifestyle, or alternatively 75 minutes of vigorous intensity activity, but the majority of adults fail to meet these thresholds (World Health Organization, 2010). The importance of experiencing positive affective responses to exercise for continued motivation and future adherence has been established among sedentary adults (Williams et al., 2008). In contrast to the regular exercisers in the current study, inactive individuals attribute greater importance to extrinsic factors for exercise participation (Aaltonen et al., 2014). There is considerable scope therefore for further

research exploring the role of different environmental contexts for the psychological benefits and associated impact on adherence. Factors such as climate and cost may be significant determinants of participation that can vary between indoor and outdoor exercise opportunities. It is also important to study different exercise modes, and assess physical activity motivation, and attentional focus. There is particular need to understand participation in vigorous intensity physical activity which is associated with some of the greatest health benefits. The results of the present study suggest that both exercise contexts facilitated improved well-being after high-intensity exercise, and future studies using inactive samples could further understanding of the relationship between exercise intensity, affective responses, environmental context, and sustained participation.

This is the first study to compare psychological outcomes before, during, and after high-intensity exercise in different exercise settings, combining a rigorous randomized design, with the use of ecologically valid exercise locations. Nonetheless, there are inevitable limitations associated with this type of fieldwork. For example, the potential for social facilitation factors influencing participant outcomes must be considered, since these could not be controlled at the gym or running trail. Furthermore, there are inherent difficulties in matching the energy expenditure demands of running on uneven rural terrain versus on a treadmill (Chakravarthy, Devi, & Adinarayana, 2013), and no physiological measures of effort or energy expenditure were recorded. Although not significantly different, the mean completion time of the maximally paced run was twelve seconds slower in the outdoor condition. Hence, it is possible that the rural course was actually more physically demanding for participants, with the similarity in RPE reflecting a lowered perception of effort from the green environment.

Other key differences between treadmill and outdoor running involve alterations to gait and other biomechanical factors (Hanley & Mohan, 2014), along with pace being

controlled mechanically versus spontaneously (Plotnik, Azrad, Bondi, Bahat, Gimmon, Zeilig, et al, 2015). Additionally, there are major differences between these conditions in optic flow (sense of movement related to visual sensations). Perceptions of effort have been shown to be influenced by sensory cues (Abbiss, Peiffer, Meeusen, Skorski, 2015), and experimental manipulation of optic flow during treadmill running affects RPE, although not actual running pace (Parry & Micklewright, 2014). It is conceivable therefore, that in the current study, RPE was reduced in the gym setting due to the static environment, thereby negating the potential effects on this variable through exposure to the natural outdoor surroundings.

In conclusion, this study suggested that regular runners experience positive affective responses during and after high-intensity exercise in both a natural outdoor environment and an indoor fitness center. However, there is a need for similar research with inactive populations to understand if features of the environment can influence affective responses to vigorous physical activity given the health-related benefits associated with high intensity exercise.

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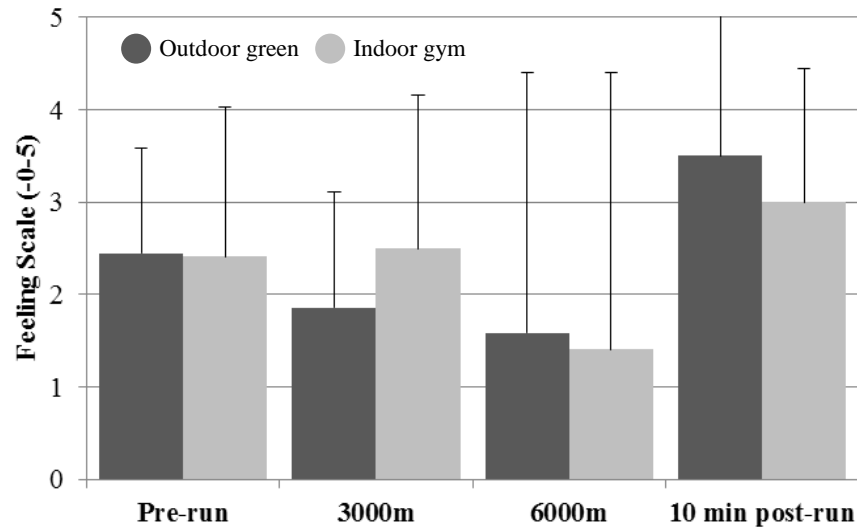


Figure 1. Change in affective valence (assessed by the Feeling Scale), before, during, and after a 6000m run (at a steady-state intensity for the first 3000m and maximum intensity for the final 3000m) in outdoor green and indoor gym environment (n = 22).

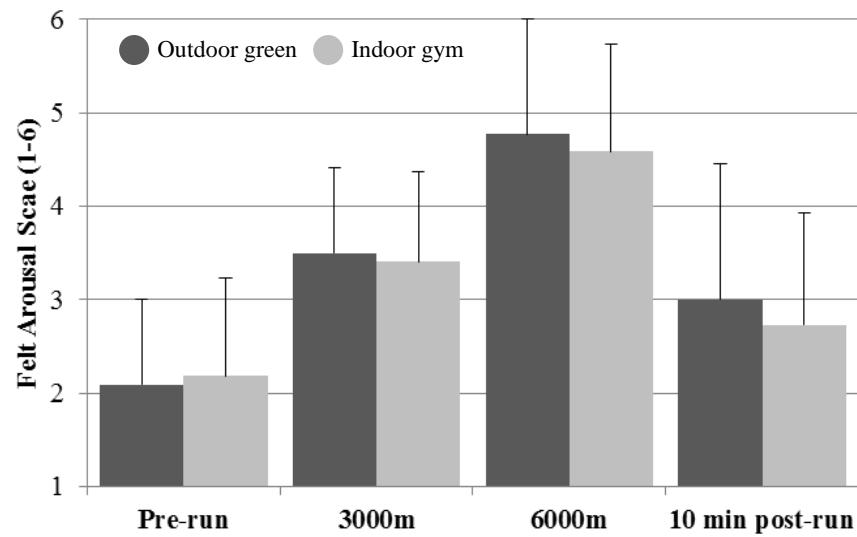


Figure 2. Change in activation (assessed by the Felt Arousal Scale) before, during, and after a 6000m run (at a steady-state intensity for the first 3000m and maximum intensity for the final 3000m) in outdoor green and indoor gym environment (n = 22).

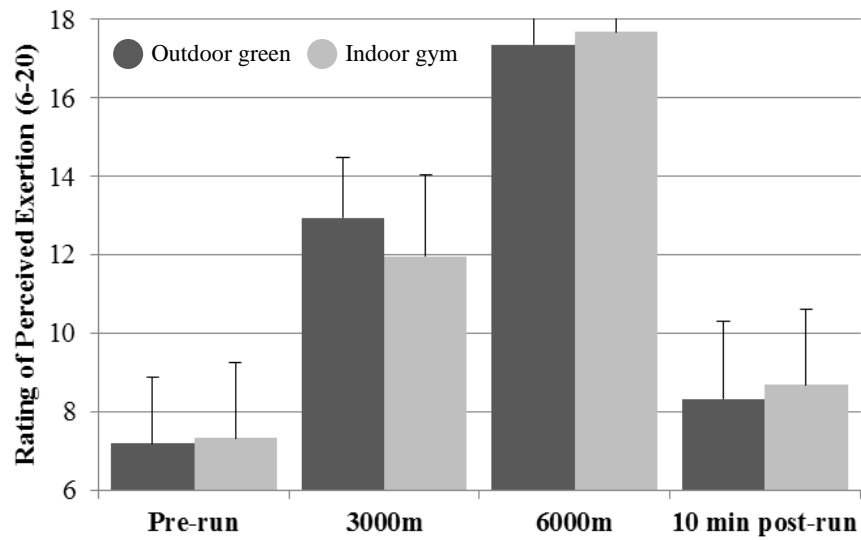


Figure 3. Change in ratings of perceived exertion before, during, and after a 6000m run (at a steady-state intensity for the first 3000m and maximum intensity for the final 3000m) in outdoor green and indoor gym environment (n = 22).

Table 1. Participant characteristics

Characteristic	Total (<i>n</i> = 22)	Males (<i>n</i> = 14)	Females (<i>n</i> = 8)
Age			
18-34 years	14	9	5
35-51 years	8	5	3
Weight Status			
Normal weight (BMI \leq 24.9)	16	9	7
Overweight (BMI \geq 25.0)	6	5	1
Running status			
Competitive	15	12	3
Recreational	7	2	5
Prior running experience			
\leq 12 months	7	2	5
13-48 months	11	9	2
$>$ 48 months	4	3	1
Weekly running distance			
\leq 20 km	6	3	3
21-50 km	14	9	5
$>$ 50 km	2	2	0
Relatedness to nature			
High (NR-6 score $>$ 3)	19	12	7
Low (NR-6 score \leq 3)	3	2	1

Key

BMI: body mass index (kg/m^2); NR-6: short-form Nature Relatedness scale