Comparing the Effects of Affect- Regulated Green and Indoor Exercise on Psychological Distress and Enjoyment in University Undergraduate Students: A Pilot Study

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Comparing the Effects of Affect-Regulated Green and Indoor Exercise on Psychological Distress and Enjoyment in University Undergraduate Students: A Pilot Study

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The purpose of this pilot study was to compare the acute effects of affect-regulated green exercise and indoor exercise on psychological distress and enjoyment in university undergraduate students. Using a repeated measures experimental design, 18 undergraduate students at an urban university in England completed three conditions: green exercise; indoor exercise; and a non-exercise control condition. Stress and anxiety were measured using standardised measures before and after each condition, while enjoyment was assessed after each condition. Affective valance was also assessed during the exercise conditions. A significant decline in stress was found after each exercise condition, with pre- to post-condition anxiety changes shown only after the green exercise condition. When assessing effect sizes, larger reductions in stress and anxiety were shown after the green exercise condition compared to the indoor exercise condition. No significant effect was present for enjoyment for any of the conditions. A primary contribution of this pilot study was that participants reported greater anxiety reductions in the green exercise condition versus the indoor exercise condition, as well as decreased stress in both the green and indoor settings, of which, a larger effect was shown for green exercise. Affect-regulated exercise could be a promising approach for acute reductions in psychological distress in exercise bouts in university students.

Keywords: mental health; physical activity; anxiety; stress; enjoyment

In recent years, psychological distress and mental health issues in university students have emerged as growing public health concerns (e.g., Sharp & Theiler, 2018; Wynaden et al., 2013). Psychological distress refers to a discomforting emotional state people experience in response to specific demands (Ridner, 2004), while mental health is defined as a "state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community" (World Health Organization, 2018). Evidence indicates that university students report significantly more negative mental health symptoms compared to age-matched employed individuals (Winzer et al., 2014). For instance, up to 83.5% of Australian university students (*N* = 6,479) reported elevated psychological distress levels, with 19.2% of the sample reporting symptoms at a severe or extremely severe level (Stallman, 2010). Concerns about poor mental health in university students are also highlighted by the prevalence of suicidal thoughts in this population, which have been found to range from 11.1% to 22.3% in meta-analyses (Mortier et al., 2018; Rotenstein et al., 2016).

Several reasons can explain the prevalence of mental health problems in university students. The transition into university can be difficult for students as this period involves moving from dependent living to independence (Kim & McKenzie, 2014), financial pressures (Stallman, 2010), and a change in social environment (Mikami et al., 2019). In addition, university students are at greater risk of experiencing psychological distress, as the typical age range for university study (18-21 years)

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is a period during which mental health issues can reach their developmental peak (Ibrahim et al., 2013). Mental health problems can evoke a range of negative outcomes, such as decreased academic performance (Bruffaerts et al., 2018), higher dropout rates (Arria et al., 2013), and greater likelihood of self-harm and suicide attempts (McManus & Gunnell, 2020). Thus, given these adverse outcomes could have significant consequences for students, as well as society more generally, it would be valuable to identify strategies that help university students to maintain good mental health.

A substantial body of evidence suggests that physical activity (PA) can be an effective non-clinical intervention for reducing symptoms associated with poor mental health (see Wegner et al., 2014 for a review of meta-analyses). Physical activity refers to any movement that increases energy expenditure, with exercise being one sub-category of PA and is defined as structured, repetitive, and planned bodily movements undertaken for the primary goal of increasing physical fitness (Caspersen et al., 1985). Research across a broad spectrum of mental health symptoms and populations has generally found that PA can help to reduce psychological distress (e.g., Morres et al., 2019), as well as anxiety and depression symptoms (e.g., Wegner et al., 2014). Furthermore, there is also evidence to suggest that PA can have mood-enhancing benefits (Chan et al., 2019) and can improve positive affect and psychological wellbeing (Elkington et al., 2017). In university students, a range of cross-sectional studies have identified positive relationships between levels of PA and mental health, whereby students who engage in PA more frequently report better mental health and wellbeing (e.g., Budzynski-Seymour et al., 2020; Murphy et al., 2018). This evidence suggests that strategies to increase levels of PA could not only enable students to reap the considerable physical health benefits associated with engagement in PA (e.g., Reiner et al., 2013), but could also have a positive impact on their mental health.

Despite the well-known benefits of PA, research suggests that physical inactivity is prevalent across a high proportion of the university student population (e.g., Clemente et al., 2016). For example, an accelerometer study that examined PA over the course of a week in university students (n = 296) found that only 5.4% of participants accumulated the World Health Organisation's (WHO, 2020) recommendations of 150 minutes per week of moderate-intensity PA or 75 minutes per week of vigorous-intensity PA in bouts of 10 minutes or more (Arias-Palencia et al., 2015). Importantly, recent reviews have found the transition from secondary education to university can have an adverse effect on levels of PA (Gropper et al., 2020; Kwan et al., 2012). In turn, this highlights the importance of developing intervention approaches that encourage university students to become, and remain, physically active throughout their studies.

While the majority of early work on PA promotion was largely dominated by cognitivist approaches (e.g., social cognitive theory), there is growing recognition of the importance of approaching research on the promotion of exercise and PA from an affective perspective (Ekkekakis & Zenko, 2016). Evidence suggests that positive affect (i.e., pleasure) *during* exercise could be key to promoting future PA behaviour, with results of a meta-analysis indicating that positive affect during exercise was positively associated with long-term PA, but positive affect after exercise displayed no significant relationship with long-term PA (Rhodes & Kates, 2015). Furthermore, enjoyment during PA predicts long-term adherence to PA (Williams et al., 2006). However, research has found that inactive students report significantly lower enjoyment in PA than somewhat active and active students (McArthur & Raedeke, 2009). Collectively, this suggests that understanding how university students can experience positive affect in exercise could have benefits for promoting PA and its associated mental health benefits. Indeed, based on the growing evidence surrounding the importance of positive affect for long-term PA, it has been suggested that replacing traditional methods for prescribing PA (e.g., based on specific intensities) with guidelines that facilitate positive affective responses could offer a promising avenue to improve PA participation (Ekkekakis & Brand, 2019). For instance, recent research has found that affect-regulated exercise (e.g., exercising at an intensity that "feels good") had a more positive effect on subsequent PA than heart-rate guided prescription (Baldwin et al., 2016; Williams et al., 2016). Thus, shifting away from traditional exercise prescription methods and towards affect-regulated exercise prescription could have benefits for university students, although further research is required to substantiate and generate preliminary evidence in this cohort.

A final area that warrants further consideration in the prescription of exercise for reducing psychological distress in university students is the exercise environment. The term green exercise refers to PA or exercise that occurs in the presence of nature (Lahart et al., 2019). Green spaces, such as parks, open spaces, trails, beaches, and bodies of water (Araújo et al., 2019; Mackay & Neil, 2010), are a key facet of healthy universities (Holt et al., 2019).

Review evidence indicates that short-term exposure to nature can benefit students' cognitive performance (Mason et al., 2022) and much effort has been made to create green or urban-green spaces on university campuses (Speake et al., 2013). Although the evidence is far from conclusive, meta-analyses offer tentative evidence that green exercise can confer some additional psychological benefits over indoor exercise (Lahart et al., 2019; Li et al., 2022). For example, acute bouts of outdoor exercise (i.e., single sessions) have been found to produce greater reductions in stress (Olafsdottir et al., 2020) and anxiety (Lee et al., 2014; Song, 2019), as well greater enjoyment (Focht, 2009; Plante et al., 2007) compared to indoor or non-green environments. Green exercise could be a viable, accessible, and low-cost form of PA for students, yet limited attention has been directed towards understanding the effects of green exercise on mental health in university populations. Previous researchers that have examined the effects of green exercise on psychological well-being (i.e., affect and emotions) in university students have prescribed exercise intensity based on objective measures. For example, participants have been asked to walk and cycle at an intensity within a specific heart-rate range (i.e., 60-70% of their maximum heart rate, Plante et al., 2007), complete a specific distance or move at a specific speed (e.g., Plante et al., 2003; Rider & Bodner, 2016), or walk at a subjectively-perceived "comfortable" pace (Plante et al., 2006). In studies that instructed participants to use heart-rate ranges or subjective-intensity measures to regulate the intensity of outdoor and indoor exercise, participants have reported significantly greater enjoyment (Plante et al., 2007) and perceived energy (Plante et al., 2006) when exercising outdoors compared to indoors. To date, however, no studies have compared the effects of affect-regulated green exercise, whereby subjective measures of affect are used as a basis to prescribe exercise intensity, to affect-regulated indoor exercise on psychological distress in university students.

The aim of this pilot study was to compare the acute effects of green exercise and indoor exercise on psychological outcomes when university undergraduate students were asked to exercise at an intensity that felt "good". More specifically, we sought to examine the acute effects of both exercise conditions to a non-exercise control condition on measures of psychological distress and enjoyment. By doing so, the findings of the study could expand understanding of exercise prescription for reducing psychological distress in university students, which could have important applied implications for students, university staff, and student well-being support provision. In the current study, we focused on two specific symptoms of psychological distress, stress and anxiety, both of which have been classified as constructs capturing aspects of psychological distress in past research (e.g., Awick et al., 2017). We hypothesised that there would be: (H_1) a significant reduction in psychological distress from pre-exercise to post-exercise in the green exercise and indoor exercise conditions, with no significant changes in the control group; (H_2) a greater effect of green exercise on psychological distress compared to the indoor exercise and control conditions; and (H_3) higher levels of enjoyment in the green exercise condition compared to the indoor exercise and control conditions.

Method

Participants and Recruitment

Ethical approval for the study was granted by the authors' school ethics committee. Eighteen university students (male n = 7, female n = 11; M age = 20.44 years, SD = 2.43) from one urban English university took part in the study. Participants were recruited on a voluntary basis through advertisements posted on online platforms and through snowball sampling. The inclusion criteria for the study stipulated that participants were (a) university undergraduate students, (b) aged 18-40 years, and (c) free from medical conditions, as confirmed by a screening form. Participants provided written informed consent and the International Physical Activity Questionnaire (IPAQ; Craig et al., 2003) was used to determine whether participants' PA levels, in terms of metabolic equivalents (METs), were low (≤ 599 MET-mins/week), moderate (600-1499 MET-mins/week), or high (≥ 1500 MET-mins/week). Based on the IPAQ criteria, most participants were highly (n = 10) or moderately (n = 7) active, with only one participant classified as having a low level of PA.

Procedures

A repeated measures experimental design was employed. Participants attended the laboratory three times over a 13.50-day period on average (range = 11-22 days). Participants were exposed to three conditions: green exercise condition; indoor exercise condition; and control condition. Each experimental trial lasted 20 minutes to coincide with previous research (e.g., Plante et al., 2006, 2007; Yamaguchi et al., 2006) and exercise guidelines of 150 minutes of moderate PA per week, or roughly 20 minutes per day (National Health Service, 2021). To avoid the potential for ordering, practice, or learning effects, participants were assigned

to the conditions in a randomised, counterbalanced (i.e., systematically varied) order. The randomisation was conducted using a Latin square with random allocation to one of six potential condition orders. All conditions took place during the academic term between November 2019 and February 2020.

Control Condition

For the control condition, participants completed two tasks that examined neuropsychological functioning. The first task was adapted from the memory-loaded search task (Smith & Miles, 1987) and required participants to draw a line through a specified target letter in each line as quickly as possible. A paper and pen version of the task was performed, with four grids of target letters. The second task was performed immediately after and used the iDichotic app (Bless et al., 2013) on an iPhone. This involved listening to a list of different sounds as a test of selective attention and auditory processing. These tasks were chosen for the control condition as previous research has employed similar tasks that do not involve PA to compare the effects of exercise to inactivity on psychological outcomes (e.g., Reed & Ones, 2006). For the green and indoor exercise conditions, participants performed a 5-minute warm-up within their exercising environment prior to completing their 20-minute exercise bout, with a 5-minute cool down period completed after the activity.

Experimental Conditions

In the green exercise condition, the participants were required to walk or run around a 200-meter rectangle on a synthetic surface surrounded by trees on a university campus. An urban green space on the university campus was selected to enhance the ecological validity of the findings on the basis that most students live close to and spend large periods of time in this setting. Only the participant and researcher were present on the synthetic surface during testing. The temperature of the green exercise condition averaged 7.7 degrees Celsius (range = 6-9 degrees Celsius) and testing was conducted during daylight hours (09:00 to 15:00). In the indoor exercise condition, participants walked or ran for 20 minutes on a treadmill in a laboratory. Instructions for adjusting the speed of the automatic treadmill were provided before the warm-up to allow participants to increase or decrease the pace as desired. Participants were instructed before the exercise trials began to walk or run at a pace that felt between "*good*" and "*very good*" on the Feeling Scale (FS; Hardy & Rejeski, 1989; see measures), which corresponded to a FS value of 3-5. Although previous research has instructed participants to exercise at an intensity that feels "good" (e.g., Hutchinson et al., 2018), the instructions in the current study were adapted on the basis that understanding the effects of exercise experiences that are at least "good" could have important applied implications.

Measures

Affective Valence

Affective valence (pleasure-displeasure) was assessed using the FS (Hardy & Rejeski, 1989) during the exercise conditions. The FS is an 11-point bipolar scale, with anchors that range from -5 (*very bad*) to +5 (*very good*). As the FS was used to regulate the pace and intensity of exercise in the current study, participant ratings on this measure served as a manipulation check. The FS has been widely used as a measure of affect in exercise (e.g., Hawkins et al., 2020; Hutchinson et al., 2018) and has demonstrated good convergent validity ($.41 \geq r \geq .88$) with other measures of affect (Van Landuyt et al., 2000). Measures of affective valence were obtained before, during (at minutes 5, 10, and 15), and at the end (at minute 20) of each exercise condition. An aggregate score was obtained for each trial by computing the average of all time points.

Stress

Perceived stress was measured using a modified Perceived Stress Scale-10 (PSS-10; Cohen et al., 1994). The PSS-10 is a unidimensional scale consisting of 10 items that range on a continuum from 0 (*never*) to 4 (*very often*). Scores on the PSS-10 range from 0 to 40, with higher scores indicating greater perceived stress. The PSS-10 has demonstrated excellent internal consistency ($\alpha = .84$ - $.86$) and test-retest reliability scores ($r = .85$; Roberti et al., 2006). To anchor each participant's responses in the present moment, participants were asked to complete each item based on how they felt "right now at this moment." Items were modified from the original scale to ensure that the measure captured how participants felt in a specific moment (i.e., present tense). Example item modifications to present tense include: "in the last month, how often have you been able to control irritations" to "I feel able to control irritations in my life"; and "In the last month, how often have you been angered because of things that were outside of your control?" to "I feel angered by things that are outside of my control." The PSS-10 was completed before and after all conditions by each participant. The internal consistency coefficient of the PSS-10 in the current study was excellent ($\alpha = .92$).

Anxiety

The state subscale of the State-Trait Anxiety Inventory (STAI Y-1) was employed to assess state anxiety (Spielberger et al., 1983), which has displayed excellent internal consistency (α = .89 - .94; Guillén-Riquelme & Buela-Casal, 2011) and test-retest reliability scores (*r* = .88; Grös et al., 2007). Participants completed the STAI Y-1 before and after all conditions. The STAI Y-1 contains 20 items that are rated on a Likert scale, which ranges from 1 (*not at all*) to 4 (*very much so*). Scores on the STAI Y-1 range from 20 to 80, with higher scores indicating higher anxiety. Sample items included: "I am relaxed" and "I feel nervous." The STAI Y-1 demonstrated very good internal consistency in the current study (α = .81).

Enjoyment

The Physical Activity Enjoyment Scale (PACES; Kendzierski & DeCarlo, 1991) was administered after each condition to assess enjoyment. The PACES is an 18-item bipolar scale that asks participants to rate their experience in a task on a 7-point scale, ranging from 1 (*I hated it*) to 7 (*I enjoyed it*). Scores on the PACES range from 18 to 126, with higher scores indicating greater enjoyment. Within exercise, the PACES has been widely used to assess enjoyment (e.g., Hawkins et al., 2020) and has previously exhibited very good internal consistency (α = .79 - .90; Crocker et al., 1997). The internal consistency coefficient of the PACES in the current study was acceptable (α = .73).

Distance

Distance was measured in both exercise conditions. In the green exercise condition, the number of 200-meter laps completed by participants were tallied. In addition, participants carried a bean bag and after dropping this at the end of the 20 minutes, the additional distance was recorded using a measuring wheel. The distance walked for the indoor exercise condition was recorded on the treadmill and noted by the researcher.

Statistical Analyses

Data were analysed using SPSS 27. Descriptive statistics, including means and standard deviations, were calculated for each variable (see Table 1). Non-parametric tests were used for all statistical analyses to account for the small sample size in the present study. A manipulation check using a Wilcoxon signed-rank test was conducted to compare affect in the green exercise and indoor exercise conditions. Preliminary analysis using two separate Friedman tests were performed on the anxiety and stress variables to test for any baseline differences between the three conditions. Follow-up post hoc tests using Wilcoxon signed-rank tests were conducted to identify specific differences between conditions (e.g., green vs indoor, green vs control, indoor vs control). Two separate Friedman tests were conducted to test anxiety and stress changes (pre−post) between the three experimental conditions. Follow-up Wilcoxon signed-rank tests were used to identify which conditions displayed significantly different change scores. Wilcoxon signed-rank tests were also conducted to identify pre-to-post differences in anxiety and stress within each condition (e.g., green pre-to-post, indoor pre-to-post, and control pre-to-post). A Friedman test compared differences in enjoyment between the three conditions. Distance walked was compared between the green and indoor conditions via a Wilcoxon signed-rank test. Effect sizes (*r*) were calculated from the post-hoc Wilcoxon results and interpreted as small ($r < .30$), moderate ($.30 \leq r \leq .50$), and large ($r \geq .50$).

Table 1. Mean and Standard Deviation Scores for all Psychological Variables in the Study

Condition	Time	Stress		Anxiety		Enjoyment		Distance		Affect	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Green	Pre	15.11	5.04	35.83	7.53	-	-	-	-	3.64	.39
	Post	9.89	6.50	29.72	6.38	98.39	15.71	2482.47	835.36		
Indoor	Pre	13.50	6.11	32.72	5.38	-	-	-	-	3.57	.51
	Post	10.00	6.07	31.06	5.20	95.22	17.29	1892.74	800.13		
Control	Pre	12.67	5.55	35.17	8.16	-	-	-	-	-	-
	Post	12.33	5.56	33.22	6.77	81.33	18.59	-	-		

Note. M = mean; *SD* = standard deviation.

Results

Preliminary Analyses

When comparing the average affect scores between exercise conditions, a Wilcoxon signed-rank test showed no significant difference (Z = -0.76, p = .45, r = -.13) between green (M = 3.64, SD = 0.39) and indoor (M = 3.57, SD = 0.51) conditions. Two separate Friedman tests showed significant differences in pre-condition scores for anxiety (χ^2[2] = 6.43, p = .04), and stress (χ^2[2] = 6.54, p = .04), between the three conditions. For anxiety, follow-up Wilcoxon signed-rank tests showed no significant differences in pre-condition anxiety between the green and indoor conditions (Z = -1.95, p = .05, r = -0.33), green and control conditions (Z = -1.12, p = .26, r = -0.19), or indoor and control conditions (Z = -1.33, p = .18, r = -0.22). Wilcoxon signed-rank tests were also used to investigate significant differences in pre-exercise stress between conditions. The only significant baseline difference for stress was between the green and control conditions (Z = -2.54, p = .01, r = -.42), with reported stress in the green condition significantly higher than in the control condition. Non-significant differences in baseline stress scores were shown between the green and indoor conditions (Z = -1.63, p = .10, r = -.27), and indoor and control conditions (Z = -0.18, p = 0.86, r = -.03).

Main Analyses

Stress

For change in stress scores (pre–post), a Friedman test revealed no significant effect (χ^2[2] = 5.48, p = .07), indicating no significant differences in changes from pre-to-post conditions between the three conditions. However, Wilcoxon signed-rank tests revealed significant pre-to-post condition changes in stress in the green condition (Z = -3.30, p = <.01, r = -.55) and indoor conditions (Z = -2.64, p = .018, r = -.44), but not in the control condition (Z = -0.17, p = .86, r = -.03). Results suggest significantly lower stress scores were reported from pre-to-post condition for the green and indoor groups. Non-significant differences were reported for the control condition.

Anxiety

A Friedman test revealed a significant effect between conditions on changes in pre- to post-condition anxiety scores (χ^2[2] = 7.39, p = .03). Follow-up Wilcoxon signed-rank tests showed moderate, significant differences in anxiety changes in the green condition compared to the indoor condition (Z = -2.43, p = .01, r = -.41) and in the green condition compared to the control condition (Z = -2.12, p = .03, r = -.35), but no significant difference between the indoor condition and the control condition (Z = -0.63, p = .53, r = -.11). Results suggested that reported anxiety scores changed significantly more in the green condition compared to the other two conditions. Moreover, Wilcoxon signed-rank tests showed large, significant changes from pre-to-post conditions for the green condition (Z = -3.62, p = < .01, r = -.60), but not the indoor (Z = -1.24, p = .21, r = -.21) or control conditions (Z = -1.59, p = .11, r = -.27). In turn, this suggests anxiety was significantly lower from pre-to-post condition in the green condition, but not the indoor or control conditions.

Enjoyment

A Friedman test was conducted to compare enjoyment between the exercise conditions. The results indicated no significant difference between the green and indoor conditions (χ^2[2] = 4.97, p = .08).

Distance

Results from a Wilcoxon signed-rank test showed significant differences between conditions for distance covered (Z = -3.20, p = <.01, r = -.75). Participants ran or walked significantly further in the green condition (M = 2482.47m, SD = 835.36) compared to the indoor condition (M = 1891.74m, SD = 800.13).

Discussion

This pilot study aimed to compare the effects of green exercise and indoor exercise on psychological distress and enjoyment when university undergraduate students were asked to exercise at an intensity that felt at least “good.” As such, the study sought to explore whether exercising in accordance with an affect-regulated instruction in green and indoor environments would produce different psychological effects. Although the study hypotheses were only partially supported, undertaking green exercise decreased both stress and anxiety from pre-to-post condition, with anxiety changes being significantly greater in the green condition compared to the indoor and control conditions. Further, the manipulation check indicated that participants reported their experiences felt at least “good” during the exercise conditions, which offers further support for the utility of an affect-regulated exercise prescription (Baldwin et al., 2016; Ekkekakis & Brand, 2019; Williams et al., 2016). Together, the findings provide preliminary evidence of the efficacy of affect-regulated exercise for reducing psychological distress in university undergraduate students, which could

prove particularly beneficial for university students, a population that has reported elevated psychological distress levels (Stallman, 2010; Winzer et al., 2014). However, further large-scale studies are required to generate more robust practical recommendations for universities, practitioners, and students.

The first hypothesis, which specified that there would be a significant reduction in psychological distress from pre-exercise to post-exercise in the green exercise and indoor exercise conditions was partially supported. Undertaking green exercise significantly reduced levels of stress and anxiety, with indoor exercise resulting in a significant reduction in stress, but not anxiety. No pre- to post-condition changes were observed for the control condition. Overall, the findings indicate that engaging in short bouts of green or indoor exercise were more beneficial for reducing stress than sedentary behaviour and green exercise had a particularly positive acute effect on anxiety. The current results show a similar trend to previous research with significant improvements in stress after both indoor and outdoor walks (Olafsdottir et al., 2020) and significantly lower anxiety after walking outdoors (Lee et al., 2014; Song, 2019). In turn, the current findings support past evidence on the positive effects of exercise for reducing psychological distress (Chan et al., 2019; Elkington et al., 2017).

Our second hypothesis that there would be a greater effect of green exercise on psychological distress compared to the indoor exercise and control conditions (H_2) was partially supported. Significantly larger reductions in anxiety scores were produced after the green exercise condition compared to the indoor and control conditions, with no differences between indoor and control conditions. Therefore, these findings concur with previous research (Lawton et al., 2017) suggesting that exercising in a green location conferred additional benefits for reducing anxiety symptoms in comparison to indoor exercise. In contrast, the green and indoor exercise conditions both produced significant reductions in stress, but no significant differences were revealed between conditions. Although the absence of a significant difference between the green and indoor conditions for stress reductions was not in line with our hypotheses, past studies have also reported no significant interaction effects for stress based on environment (e.g., Klaperski et al., 2019). Interestingly, Klaperski et al. (2019) reported that outdoor environments perceived as more calming had greater stress-reducing effects than those perceived as less calming. Although somewhat speculative, it is plausible to suggest that in comparison to other potential green exercise environments, the environment used in the current study (i.e., walking on a synthetic surface on a university campus) might not have been as calming as the environments used in other green exercise studies (e.g., woodlands in Olafsdottir et al., 2020), and thus might have been less stress reducing than other green environments in comparison to an indoor environment. The nuanced differences in anxiety and stress responses also somewhat align with previous research by Kajosaari and Pasanen (2021), which found that different outdoor exercise environments elicited different psychological responses; for example, stress reductions were more likely to be experienced during exercise in larger natural areas and near blue spaces, whereas enjoyment was related to exercising in all natural environments regardless of size. Overall, the study offers evidence that green exercise could have greater potential to ameliorate anxiety in university students versus indoor exercise, as well as exercise in general being beneficial for reducing stress compared to sedentary activities.

The third hypothesis, that enjoyment would be significantly higher in the green exercise condition compared to the indoor and control conditions (H_3), was not supported. The lack of a significant effect for enjoyment is in contrast to previous research highlighting significantly greater enjoyment in outdoor walks compared to indoor walks in 10-minute (Focht et al., 2009) and 20-minute durations (Plante et al., 2007). Despite no significant effect being present for enjoyment scores, it should be noted that the mean scores for both the green exercise and indoor exercise conditions appear considerably larger than enjoyment in the control condition. The inclusion of an affect-regulated exercise instruction may have contributed to the similar enjoyment scores in the exercising conditions, as the affect scores also showed no significant differences between conditions. Future research regarding affect-regulated exercise prescriptions and comparisons between green and indoor exercise in larger samples should further examine enjoyment, as enjoyment during exercise is associated with a higher likelihood of engaging in long-term PA (Williams et al., 2006) and may be integral to reducing physical inactivity (Brand & Ekkekakis, 2018). Additionally, further empirical work examining affect-regulated exercise and the mediating effect of enjoyment could be useful.

Finally, the distance walked after 20 minutes was significantly higher in the green environment compared to the indoor environment, despite participants being instructed to walk at the same intensity (+3 to +5 on the FS) and there being no significant difference in affective valence between conditions. This finding is similar to

past research (Krinski et al., 2017), which found that participants walked significantly further in the outdoor track-walking condition versus an indoor treadmill walking condition. A potential explanation for this finding is that participants were more familiar with walking outdoors compared to treadmill walking (Gladwell et al., 2013), which might have increased the pace at which they walked. In addition, as treadmill exercise requires greater voluntary control to alter walking speed compared to outdoor walking (i.e., adjusting the pace), participants might have chosen to stay at a constant velocity on the treadmill rather than changing their velocity, as might occur when walking outdoors (Lindsay et al., 2014). Future studies could assess the degree of variability in walking speed during indoor and outdoor walking tasks in addition to total distance.

Limitations and Future Directions

Whilst the current study provides novel understanding of affect-regulated green and indoor exercise, several limitations should be noted. First, as the current research was a pilot study, the sample was relatively small, meaning that caution should be taken when considering the wider impact of the results. Accordingly, there is a need for further studies using larger sample sizes with a wider range of physical activity levels to produce stronger evidence for affect-regulated green exercise in order to impact the way universities and practitioners facilitate or prescribe exercise to students. With additional supporting research, universities could increase efforts to promote and facilitate green exercise on university campuses as this form of exercise could confer additional benefits for reducing psychological distress, an issue that has been highlighted for students in recent years, whilst providing a cost-effective form of exercise for many students. Additionally, the small sample size might have had some effects on statistical power. As such, effect sizes generated in the current study could be used in power tests to determine an appropriate sample size in future, larger-scale studies. Future, more adequately powered, studies could also consider using more sophisticated analytic techniques to examine the mechanisms underlying the effects of exercise environment on psychological outcomes (e.g., mediation analysis).

Second, the sample consisted of university students at one institution, the majority of whom were moderately or highly active, which may have limited the findings' generalisability. Therefore, future studies could use purposive sampling to recruit active and insufficiently active participants to determine if the study findings can be replicated in more diverse populations. Third, the current study only examined the psychological effects of green and indoor exercise on participants on one occasion, hence, the long-term effects of the interventions remain unknown. Consequently, future studies should examine the effects of affect-regulated exercise on psychological outcomes over a longer period and examine the effects of such interventions on longer-term PA adherence. Fourth, the green exercise condition was performed on a synthetic surface on a university campus, whereas the indoor condition was undertaken on a laboratory treadmill. Large-scale versions of the current study may benefit from using more ecologically valid outdoor and indoor exercise spaces. For example, potential green spaces could include parks, countryside, or any open green spaces (Mackay & Neill, 2010) and indoor settings could include gym and/or leisure centre environments (Olafsdottir et al., 2020). In addition, as the study was conducted during the winter, it may be beneficial to compare the effects when exercise is undertaken in the summer, to determine the interplay between environmental factors (e.g., temperature, light exposure, ambience) and psychological responses during outdoor exercise. Finally, the current study only compared the affect-regulated exercise prescription to a control condition. Future studies are required to compare the effects of affect-regulated exercise to more traditional forms of exercise prescription (e.g., percentage of heart rate maximum) to determine the effectiveness of affect-based exercise regulation. In future, affect-regulated exercise may offer a pragmatic alternative to traditional exercise prescription, but expansions on the current pilot study are needed before stakeholder recommendations can be made.

Conclusion

The current study examined the effects of affect-regulated green exercise and indoor exercise on mental health and affective outcomes in university undergraduate students. As such, current findings respond to calls for research that examines participatory experiences in exercise and PA from an affective perspective (Ekkekakis & Zenko, 2016). Overall, the findings support the efficacy of affect-regulated exercise prescription for reducing stress and anxiety as acute symptoms of psychological distress. Further, exercising at an intensity that feels at least "good" in green exercise conditions could confer additional psychological benefits compared to indoor exercise for reducing anxiety. In sum, the current pilot study provides preliminary evidence of the efficacy of affect-regulated exercise in both green and indoor

environments for improving psychological outcomes in university students, but further research that recruits a larger sample is required to examine these effects in more detail and generate more robust conclusions.

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