A comparison of four typical green exercise environments and prediction of psychological health outcomes

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Keywords
green exercise; health; nature; wellbeing; parkrun; mental health

Abstract

Aims: 'Green exercise' (GE) is physical activity while simultaneously being exposed to nature. GE comprises three physical components: the individual, the exercise and the environment, and one processes component encompassing a range of psychological and physiological processes. Previous research has consistently shown affective benefits of GE compared to equivalent non-GE. Investigating the possibility of optimum GE environments may help maximise health benefits. The aim of this study was to compare affective outcomes of GE participation between four different typical GE environments (beach, grasslands, riverside, heritage), and further examine influences of several physical component–related variables and one processes component–related variable, on these outcomes.

Method: Participants ($N = 331$) completed questionnaires before and after a 5km run, at one of four parkrun event locations.

Results: Self-esteem ($\Delta = 1.61$, 95% confidence interval (CI) = (1.30, 1.93)), stress ($\Delta = -2.36$, 95% CI = (–3.01, –1.71)) and mood ($\Delta = -5.25$, 95% CI = (–7.45, –3.05)) all significantly improved from pre- to post-run ($p < .05$). Improvements in these measures were not significantly different between environments. Several component-related variables significantly predicted these improvements, accounting for 9% of self-esteem improvement, 1.6% of perceived stress improvement, and 9.5% of mood improvement.

Conclusion: GE offers accessible provision for improving acute psychological wellbeing. Although nature-based exercise environments can facilitate affective outcomes, the overall type of nature may be less critical. Other characteristics of the individual, exercise and environment can significantly influence attainment of psychological GE benefits. However, the results support a greater importance of the processes component in attaining previously reported affective outcomes.

INTRODUCTION

Parks were designated and designed in the 19th century, informed by a belief that they might provide health benefits.[1] Indeed, contact with nature can provide an upstream health and wellbeing promotion intervention.[2] In public health, 'upstream' initiatives target prevention of health issues in order to avoid later need for treatments.[3] Contact with nature can be described in terms of the extent of engagement with nature.[4,5] 'Green exercise' (GE), a direct form of engagement, describes physical activity with a simultaneous exposure to nature.[6,7] A typical example could be running in a park. Acute bouts of exercise facilitate affective improvements[8,9] such as mood[10,11] and self-esteem.[12] Research articles and systematic reviews report that compared to exercising either indoors[13,14] or in built outdoor environments,[15] exercise in nature-based environments can lead to greater psychological benefits[16,17] and improvements in physiological measures such as blood pressure and immune function.[16,18]

The ecological dynamics approach offers an explanation for how GE improves psychological wellbeing. Compared to synthetic environments, natural environments provide more challenging, complex, varied and intense affordances

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SAGE Publications
ISSN 1757-9139 DOI: 10.1177/1757913915589845

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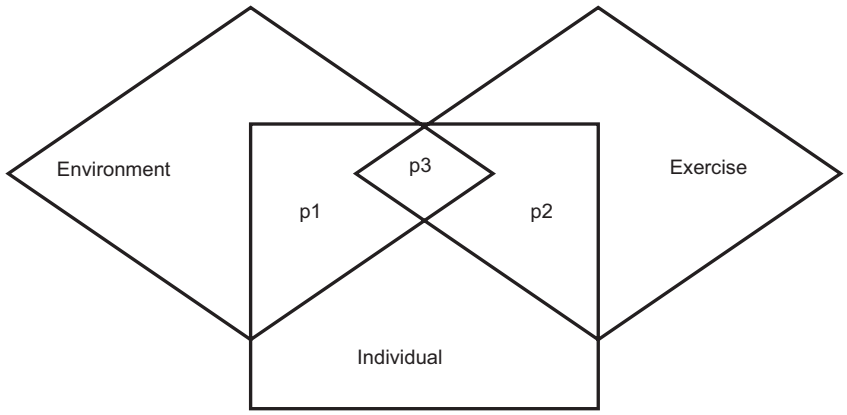
(invitations or possibilities),[19–21] whereby individuals can experience a broad range of emotions and other psychological feelings such as mindfulness, peace and calm.[20] This approach suggests that because laboratories afford different functional opportunities compared to natural environments, where possible, GE research should employ designs which prioritise the use of natural environments.[20] A number of studies have used opportunistic field sampling in order to examine GE participation via ecologically valid samples, reporting benefits to self-esteem and mood, across various GE activities such as horse riding and walking.[22–24] Barton and Pretty's meta-analysis of ten field sampling studies found that similar to exercise,[25,26] duration and intensity of exercise as well as age can influence GE outcomes.[24] However, other variables such as temperature and motivation for participation were not measured. Improvements in self-esteem (d = .46, 95% confidence interval (CI) = (0.34, 0.59)) and mood (d = .54, 95% CI = (0.38, 0.69)) resulting from acute bouts of GE are significant.[24] However, it is important to understand how to maximise these benefits in order to better direct the adoption of GE activities for psychological health in the wider public domain.

A framework for categorising and considering variables in relation to GE can be derived from Bandura's triadic model of reciprocal determinism and the ecological dynamics approach.[20,27] Figure 1 shows that GE has three physical components (categories of variables): individual, exercise and environment, and a fourth, interactive processes component. The processes component comprises psychological and physiological processes within the individual, in relation to the environment or the exercise, or both. Some stimuli and accompanying processes are mutually environment- and exercise-related (p3 area of Figure 1). For example, when running in nature, the stimulus of visual optic flow, as perceived by the individual, is a product of exercise-related motion through the environment.[28,29] The ecological dynamics approach views each of the individual, environment and exercise (task) parts as a system comprising a complex arrangement of factors (e.g. within the individual system: cognitive, affective and physiological states, physical flexibility, limb length). These factors can act as constraints which influence inter-system interactions by impacting whether and how the individual will perceive and act upon the functional affordances of an environment. In this way, the component-related variables referred to within the current study might also be thought of in terms of being constraints.

Figure 1

The four components (categories of variables) of green exercise: the three physical components, and the processes component (p1–p3)



Exploration of phenomenological experiences of GE activities[30] and the underpinning cognitive processes of GE affects[31–33] has provided an initial insight into the processes component. Age and gender appear to influence psychological outcomes, addressing the individual component.[24] Regarding the exercise component, intensity and duration of GE can influence affective outcomes.[17,24] Examining the environment component, perceived colour of the visual exercise-environment affects mood and perceived exertion.[31] Climatic conditions influence mood and cognition,[34] but such temporary variables are often not well-accounted for. Furthermore, few research studies have compared exercise outcomes between different nature environments, despite suggestions that the presence of water features within nature-based environments can enhance the effects of GE.[24,35] To better understand GE outcomes, the four GE components should be studied simultaneously.

The modern function of parks often includes usage by organised running groups who participate in set distance runs. This provides an ecologically valid opportunity to control or record relevant variables while measuring outcomes of GE participation. The aims of this study were to investigate potential differences in affective outcomes of running between different typical GE environments, and to provide an initial consideration of the importance of other variables in relation to these outcomes. We hypothesised that environments with greater presence of visible water features would facilitate the greatest improvements in affective states via GE participation. Our secondary hypothesis was that a number of other measured individual factors, and those related to the environment, the exercise undertaken and the processes component, would significantly predict psychological improvements.

METHODS

Participants

A convenience sample of 331 participants was recruited for this study (180 males, 151 females; age = 40.8 ± 12 years). Participants were attendees at four UK parkrun event locations (Gorleston Cliffs, N = 67; Nowton Park, Bury St Edmunds, N = 83;

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Chelmsford Central Park, $N = 100$; Colchester Castle, $N = 81$). In order to produce variance in the environmental-component related measures of interest, data were collected on four separate dates at each event location, during September and November 2013. Adhering to Tabachnick and Fidell's[36] guideline that a case to independent variable (IV) ratio of 40 to 1 is reasonable for stepwise multiple regression (SMR) analysis, a minimum sample size of $N = 300$ was sought in order to allow for a maximum of six IVs to be entered into each SMR.

'parkrun' and event locations

'parkrun' is a weekly, timed, 5km run which takes place in public spaces, across multiple locations both within the UK and internationally. It is branded as 'not about racing, it's about running', in order to encourage individuals of wide-ranging fitness to participate.[37] During the first six months of 2014, a mean of 243 ± 16 events were held in the UK each Saturday. The average combined weekly attendance to UK parkrun events for this period was 42,966 ± 6,006 individuals.

Event locations were selected to enable comparisons between different typical GE environments (beach, grasslands, riverside, heritage). Two criterion measures were used: (1) average number of attendees per week (selection criteria was a minimum average of 80 attendees) and (2) environmental characteristics of the 5km run route, in particular, the quantity of water content.

The environmental characteristics of each location were as follows. The beach route was along a pathway which tracks both along the top of cliffs (with views of the beach and sea to one side, and a road and buildings to the other) and along the beach pathway below. The grasslands route was within a park, with the majority of the route comprising grassland which bordered areas of woodland and was interspersed with trees; there was no view of water on this route. The riverside route tracked along pathways within an urban park. The majority of the route closely followed a river and although had frequent views of buildings, was predominantly maintained grass areas interspersed with trees. The heritage route tracked along pathways within a heritage park. The route in part tracked along a river and although in parts had views of buildings (including a castle), was predominantly maintained grass areas interspersed with trees and maintained flower beds. A greater proportion of the riverside route was in visible proximity to a river than the heritage route.

Design and procedure

At one of four locations, participants completed questionnaires immediately pre- and post-run, creating a mixed between–within design. On arrival, attendees were approached at random by a researcher and asked whether they would be willing to complete the two questionnaires; this was 5–35 minutes before the run commenced. Participants completed their post-run questionnaire within 10 minutes of crossing the finish line. The authors estimate that approximately 35% of approached attendees declined to participate.

Questionnaires were composite, comprising standard international measures of self-esteem (Rosenberg Self-esteem Scale (RSE)[38]), perceived stress (Perceived Stress Scale (PSS)[39]), mood (Profile of Mood States (POMS)[40,41]) and nature relatedness (Nature Relatedness Scale – short-form version[42]). Questionnaires also included bespoke menu-based questions regarding participants' primary motivation for attendance (the available options for this were: improving your fitness; improving your performance time; the social aspects of attending; getting outdoors for a while; other), membership of a running club (the options for this were: yes; no), and run performance in relation to their expectation (measured in the post-run questionnaire, the options for this were: I did better than I had expected; I did worse than I had expected; I did equally as well as to how I had expected; I did not have an expectation today). Participants' enjoyment of the run was measured in the post-run questionnaire using a 100mm visual analogue scale as a continuum from 0 – 'not at all' to 100 – 'very much'.

Collection of data on four dates at each location produced variance measures of the climatic environmental factors (temperature, cloud cover, rain). On each data collection date, new participants were sought. Where participants completed questionnaires on more than one date, only data from their first date was included in the analysis.

Measures

RSE[38] is a widely used ten item measure of psychological wellbeing within physical activity research,[43] which has been tested for cross-cultural universality.[44] Responses to items are made via four point Likert scale ratings from 'strongly agree' to 'strongly disagree'. Higher scores (maximum score = 30, minimum score = 0) indicate greater self-esteem. With reported Cronbach's alpha coefficients ranging from .77 to .88,[45,46] validity of the RSE scale is widely acknowledged.[47]

PSS[39,48] consists of ten statement items which measure an individual's appraisal of potentially stressful life situations. Its continued use has been supported following examination of its relative item invariance. The PSS has been correlated with stress measures, self-reported health, health behaviour measures, smoking status and help-seeking behaviour.[48] To adhere to the short-term nature of the current study, a modified version of the PSS was employed. Items were adjusted from statements such as 'In the last month, how often have you felt nervous and "stressed"?' to 'I feel nervous and "stressed"', with an accompanying instruction telling participants to 'indicate how you feel right now, at the moment'. Responses on the original PSS are made via Likert-type scales from 0 - 'Never' to 4 - 'Very Often'. The modified PSS for this study replaced this scale with descriptors of 0 - 'Strongly Disagree' to 4 - 'Strongly Agree'. Higher scores indicate a greater level of stress (maximum score = 40, minimum score = 0).

The shortened version of the POMS[40,41] requires individuals to describe how they feel 'right now' via responses to 30 single-word mood descriptor items, along at five point Likert-type scale. Five mood descriptor items represent one

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subscale mood factor, and there are six subscale mood factors in total (anger, confusion, depression, fatigue, tension and vigour). Each mood descriptor's score ranges from 0 – 'Not at all' to 4 – 'Extremely', and for each subscale, raw scores are converted to T scores.[41] An overall mood score (Total Mood Disturbance (TMD)) is calculated by summing all the negative mood factors (tension, depression, anger, fatigue, confusion) and subtracting the positive vigour score. Higher TMD scores indicate poorer overall mood (maximum = 282, minimum = 112). POMS has been shown to have acceptable internal consistency with Cronbach's alpha values of .67–.93 and .84–.95 reported.[41,49] Validity and reliability tests show that a shortened version of the POMS is suitable for use in exercise contexts.[50]

The Nature Relatedness–6 (NR-6) is a short form of the Nature Relatedness Scale[42] which includes six items from the full questionnaire. Items are statements which the participant rates on a five point Likert-type scale from 1 – 'disagree strongly' to 5 – 'agree strongly'. In line with Nisbet *et al.*,[42] items were averaged to create a nature relatedness score. A higher score indicates a greater level of nature relatedness (maximum = 5, minimum = 0).

Other factors relating to the climate, individual and the exercise performed were also measured via questionnaire and collected from the parkrun website (Table 1). Participants' performance time (time taken to complete the run) and an age-adjusted performance level were obtained from the parkrun organisation's database. Age-adjusted performance was calculated by the parkrun organisation as an expression of participants' run completion time in relation to the 5km world record for their sex and age. Temperature and cloud cover percentage at 9 a.m., and rainfall during the run were also recorded (Table 1).

Data treatment

For SMR analyses, the variable of 'primary motivation' was dichotomised into two categories: improving fitness (the most frequent response) and other reasons (created by collapsing all other options: improving your performance time; the social aspects of attending; getting outdoors for a while; other). The variable of 'expectation' was also dichotomised into two categories: I did better than I had expected (most frequent response) and other (created by collapsing all other options: I did worse than I had expected; I did equally as well as to how I had expected; I did not have an expectation today).

Statistical analysis

IBM SPSS version 19.0[51] software was used for all statistical analysis. An alpha level of .05 (two-sided) was employed to indicate statistical significance. For the primary hypothesis, mixed 4 (between (event location: beach, grasslands, riverside, heritage)) × 2 (within (time: pre-exercise, post-exercise)) analyses of variance (ANOVAs) compared change in the measures of RSE, PSS and TMD, according to location. Locations were ordinally ranked in terms of the proportion of the 5km route from which water was visible. A one-way within-subjects multivariate analysis of variance (MANOVA) analysed changes in subscale mood factors from pre- to post-run.

For the secondary hypothesis, SMRs examined the extent that individual-, environment- and exercise-component-related IVs (Table 1) were associated with the selected outcomes (RSE, PSS, TMD). Predictors were selected based on their strength of association with the pre- to post-exercise change in that measure. For each outcome, only statistically significant predictors were entered into an SMR. For the continuous-data variables, strengths of associations were indicated by beta values, calculated via simple linear regressions with the delta value for each selected measure (Table 2, online as supplementary material). For the dichotomised, categorical-data variables, strength of association was indicated by Cohen's *d*, obtained via independent sample *t*-tests on the delta values of each measure (Table 3, online as supplementary material).

RESULTS

Analysis of means

Although visual checks of frequency distributions suggested that data for the main measures (RSE, PSS, TMD) were normally distributed, assessment by Shapiro–Wilk tests for normality indicated that data was not normally distributed. However, non-normal distributions of data are unlikely to cause statistical problems for sample sizes greater than 40,[52] and normality of data distribution can be ignored for sample sizes of hundreds.[53] Indeed, parametric methods can be used even when data are not normally distributed.[54,55] Parametric methods were therefore used.

Mixed ANOVAs showed significant ($p < .001$) improvements from pre- to post-exercise for RSE (7.7% improvement; $F(1, 324) = 100.58$, $\eta_p^2 = .24$), PSS (18.4% improvement; $F(1, 315) = 50.78$, $\eta_p^2 = .139$) and TMD (14.2% improvement; $F(1, 278) = 22.15$, $\eta_p^2 = .07$) (Figure 2). There were no significant main effects for location ($p > .05$), or time by location interaction effects ($p > .05$) for any of the main measures.

A one-way within-subjects MANOVA showed a significant ($p < .001$) main effect for time on POMS subscale scores ($F(6, 276) = 51.13$, $\eta_p^2 = .526$). Univariate analyses showed that tension, depression, anger and confusion all significantly ($p < .001$) decreased from pre- to post-run. Vigour and fatigue significantly ($p < .001$) increased (Figure 3).

Prediction of outcomes

SMR showed that RSE improvement was predicted by enjoyment rating and performance in relation to expectation. Enjoyment rating was the primary predictor of ΔRSE, whereby each percent of greater enjoyment of the run explained 0.26% (B = 0.03, 95% CI = (0.02, 0.05)) of the improvement in self-esteem. Reporting 'better than expected' performance in relation to expectation was associated with greater RSE improvement (B = 0.86, 95% CI = (0.22, 1.50)) than was reporting one of the other collapsed options for this measure. This model accounted for 9% of the variance of RSE improvement. That is, participants who reported greatest enjoyment of the run and reported feeling that they performed 'better than expected' obtained 9% more benefit from their participation in terms of RSE than those who reported least enjoyment and reported feeling that they either performed worse than expected,

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Table 1

Descriptive statistics for environment-, exercise- and individual-related variables.

Individual-related variables	Mean ± SD	Frequency	
Age (years)	40.8 ± 12.00		
Sex		Male – 54.4% (*n* = 180)	Female – 45.6% (*n* = 151)
Motivation for attendance		Improving fitness – 67% (*n* = 208)	Other – 33.3% (*n* = 104)
Club-runner		Club-runners – 33.8% (*n* = 112)	Non-club-runners – 66.2% (*n* = 219)
Performance expectation		Did better than expected – 40.2% (*n* = 132)	Other – 59.8% (*n* = 196)
Nature relatedness	3.71 ± 0.78		
Exercise-related variables			
Performance time (s)	1,642.15 ± 341.84		
Age-adjusted performance (%)	56.11 ± 9.60		
Environment-related variables			
Temperature (°C)	12.21 ± 4.00		
Cloud cover (%)	58.16 ± 30.11		
Rain during run (yes or no)		Rain – 2 events	No rain – 14 events
Processes-related variable			
Enjoyment rating (mm)	80.5 ± 19.3		

SD: standard deviation.
Age-adjusted performance: calculated by parkrun as a comparison of participants' run completion time against the 5km world record for the participant's sex and age (greater score % = better relative performance). Primary motivation for attendance: options for this were 'improving your fitness'; 'improving your performance time'; 'the social aspects of attending'; 'getting outdoors for a while'; 'other'. Enjoyment rating: visual analogue scale continuum from 0 mm – not at all, to 100 mm – very much. Performance expectation: how well participants felt that they performed in the run in relation to how they had expected to do – options for this were: 'I did better than I had expected'; 'I did worse than I had expected'; 'I did equally as well as to how I had expected'; 'I did not have an expectation today'. Nature relatedness: ranging from 0 to 5, higher scores indicate greater level of nature relatedness.

performed equally as well as expected, or did not have an expectation.

Only age-adjusted performance level predicted ΔPSS. Each percent lower of age-adjusted performance level was associated with 0.08% (95% CI = (0.01, 0.15)) of the reported improvement in PSS. This model accounted for 1.6% of variance in PSS improvement.

Nature relatedness, sex and enjoyment independently predicted improvement in TMD. Each percent of greater nature relatedness was associated with 3.68% (B = –3.68, 95% CI = (–6.40, –1.0)) of the reported improvement in TMD (as indicated by greater negative Δ value). Greater enjoyment of the run was associated with greater improvement in TMD (B = –0.15, 95% CI = (–0.24, –0.06)), and females reported greater improvement in TMD than males (B = –6.82, 95% CI = (–11.12, –2.51)). This model accounted for 9.5% of the variance of TMD improvement. That is, females who reported greatest levels of nature relatedness and greatest enjoyment obtained 9.5% more improvement in mood than did males who reported lowest nature relatedness and enjoyment.

All tolerance values were greater than 0.9, indicating that there were no cases of significant multicollinearity for any of the multiple regression models.[36] Summary of regression models can be seen in Table 4.

DISCUSSION

parkrun participation increases sense of community and improves perceived fitness and mental wellbeing.[56] The current study aimed to determine potential sources of variation in these changes. To the authors' knowledge, this is the first study to rigorously examine the

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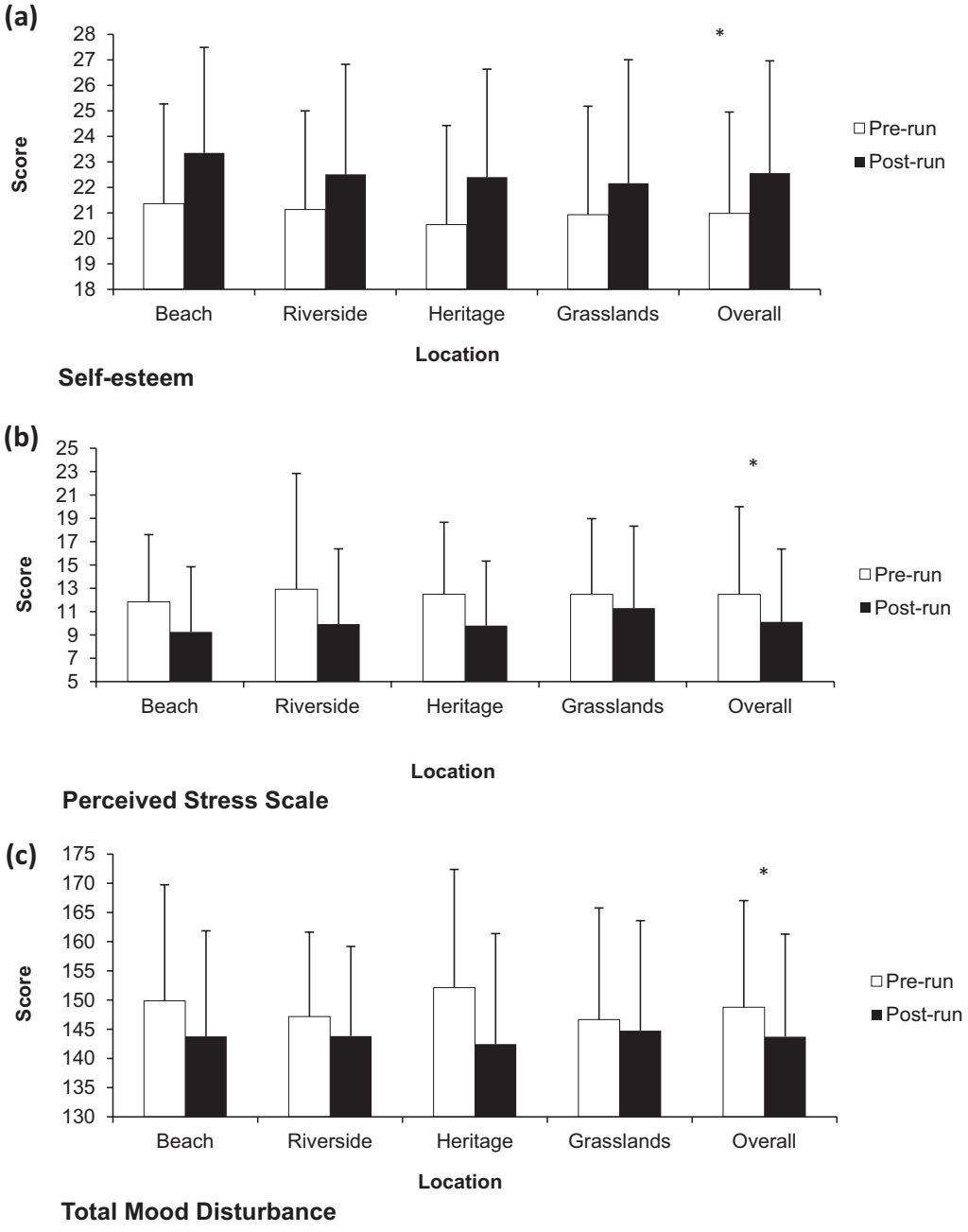
Figure 2

Pre- and post-run scores for (a) RSE (higher score indicates greater self-esteem), (b) PSS (higher score indicates greater stress) and (c) POMS total mood disturbance (lower score indicates better mood)



RSE: Rosenberg Self-esteem Scale; PSS: Perceived Stress Scale; POMS: Profile of Mood States.
*Indicates significant pre- to post-run improvement at an alpha level of .05.

importance of a range of factors relating to the individual, exercise, environmental and processes components, to GE health outcomes. The aims of the study were twofold – (1) to investigate whether psychological GE effects might differ according to the type of green setting (e.g. quantity of water) and (2) to investigate which individual-, environment-, exercise- and processes-related factors might predict GE health outcomes.

Consistent with previous research, a single bout of GE improved self-esteem by 7.7%, stress by 18.4% and mood by 14.2%.[23,24] The finding that GE improved TMD, tension, depression, anger, vigour and confusion is consistent with previous research.[23] Although these measures cannot indicate either the real term benefit to participants or the

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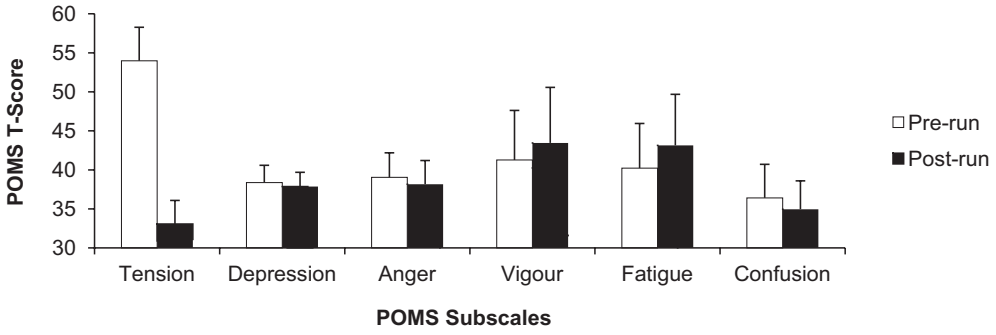
Figure 3

Pre- and post-run differences in scores for POMS subscales (higher score indicates greater level of subscale mood state)



POMS: Profile of Mood States.

potential clinical significance, the findings demonstrate significant improvements in acute psychological wellbeing nonetheless, which in the short term may be used by health promotion initiatives.[57] Acute affective exercise outcomes influence longer term motivation for and adherence to exercise behaviours.[58–60] Here, GE participation might function as a tool for maintenance of exercise behaviours.[17] The worsening of POMS fatigue contradicts previous work. Timed 5km runs are likely to be more strenuous than the exercise of previous GE studies.[7,13,24,31] Greater exercise intensity may increase likelihood of participants interpreting items of the fatigue subscale ('fatigued, worn out, exhausted, sluggish, weary') as referring to physiological senses of these words, rather than the intended psychological sense.

Although exercise may have been more strenuous than that examined in previous GE studies, it seems likely that the intensity of exercise tended to be below ventilatory or lactate thresholds. Whereas intensities below these thresholds are associated with positive affective responses, for most recreational exercisers, intensities above these are associated with affective displeasure.[26] However, self-pacing of exercise facilitates greater tolerance of high intensities than does imposed pacing.[26] For some individuals, this may have buffered their overall affect from detrimental influences of high intensities.

Global self-esteem is typically considered to be a stable construct. However, acute effects of exercising in different environments on self-esteem have been reported.[17,24] As suggested by Fox's hierarchical model of physical self-perceptions in the physical domain,[61] the acute impact reported for global self-esteem was likely to have been contributed to by underpinning perceptual domains of sports competence and physical self-worth.[61] A limitation of the current study was that it did not additionally use the physical self-perception profile or a similar inventory to enable these domain and sub-domains to be fully considered.[62]

Our hypothesis that event locations with greatest presence of water features would facilitate greatest psychological improvements was not supported. Event location was not shown to influence the extent of the psychological improvements, despite differences in environmental characteristics. This is in contrast to previous evidence that the presence of water might enhance psychological affects of GE.[24,35] Although the beach route incorporated most water – with the sea visible along the entire route, buildings were also visible along much of the route, which may have been detrimental to affect.[7] The possibility that timed parkrun 5km exercise may have been more strenuous than previous GE studies is also important.[7,13,24,31] Environmental characteristics might be less influential at greater exercise intensities, as attention is focused more internally.[63,64]

The finding that outcomes were not different between typical GE environments can be interpreted in different ways. Considered in relation to previous research reporting GE to elicit comparatively greater psychological benefits than exercising either indoors[13,14] or in built outdoor environments,[15–17] this finding suggests that additional affective benefits may be universally obtainable across a range of GE environments. However, the current study did not include a non-nature-based comparison exercise-environment. Here, as acute affective benefits of single exercise bouts have been consistently reported,[8–11,65,66] it is not possible for the current study to decipher between the respective contributions of the 'greenness' of the exercise environments and the exercise per se. That is, similar affective benefits might have been gained by 'non-green' exercise.

A main strength of this study was its ecological validity. The results represent improvements in psychological wellbeing as observed from a real-world agency of individuals rather than of a designed and instructed intervention. Further strengths of this study were the control of exercise type and the rigorous accounting for component-related variables – a first within GE research using field sampling.[22–24] Our secondary hypothesis, that a number of such variables would predict psychological outcomes, was supported. Run enjoyment and performance in relation to expectation accounted for 9% of the variance in RSE

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improvement. Furthermore, age-adjusted performance level accounted for 1.6% of the variance in improved stress. Individuals' nature relatedness, sex and enjoyment accounted for 9.5% of the variance in improved overall mood. The positive correlation of enjoyment with affective state outcomes from GE participation is consistent with the findings of Focht.[13] Enjoyment significantly predicting mood was anticipated, as enjoyment has been categorised as a tertiary emotion[67,68] and describes self-appraisals of emotional responses to an event.

As the individual system comprises personal characteristics which influence relationships with the environment, identification of the most relevant characteristics to beneficial outcomes of GE is important.[20] There was positive association between the individual component–related variable of nature relatedness and improvement in mood. As psychological wellbeing has been associated with individuals' relationships with nature,[69–71] it might also be expected that individuals who have the greatest level of nature relatedness would respond most positively to GE.[72] To the authors' knowledge, this is the first study to measure nature relatedness within GE research. That it accounted for a proportion of the improvement in mood suggests that this variable warrants inclusion in future examinations of GE.

Explanation of the negative association between age-adjusted performance level and perceived stress improvement is unclear. To speculate, a higher age-adjusted performance level might be indicative of greater focus on exercise cues and therefore less psychological engagement with the environment, which may limit affective benefits from environment-related semantic and episodic memory recall.

Less than 10% of the variance in the health measure improvements was predicted by the IVs, alluding to importance of processes component–related factors such as individuals' phenomenological experiences of both exercise and environment. The lived experience of exercise can be complex and difficult to measure.[73] Methods more complex than the quantitative approach of this study may offer greater scope for understanding and assigning meaning to occurrences within the 'black box' of the processes component, which underpin the reported outcomes. Phenomenological methodologies of interviews, written reports and auto-ethnography may be of use here.

The demonstrated inclusiveness of affective improvements is consistent with psycho-evolutionary perspectives, which suggest that via the evolutionary history of human experiences within nature environments, today's individuals are pre-disposed to positive psychological responses to nature environments, given an absence of perceived threat.[69,74–76]

GE improves self-esteem and mood and reduces feelings of stress, irrespective of the type of green setting. The findings advance previous understanding of the importance to GE outcomes, of specific individual-, environment- and exercise-related variables (constraints). Although a range of component-related variables can influence the attainment of GE benefits, much of the variance in the data was not explained by these. This suggests that large proportions of the psychological benefits of GE are universally obtainable, independent of demographic, performance level, climatic and other environmental characteristics. Considered with previous research, the implication of this finding is a reinforcement of confidence in the notion of prescribing GE participation, potentially above non-green equivalent exercise, for psychological health and wellbeing improvements. Such prescription can benefit a range of individuals without requiring specificity of green space type. Additionally, the findings allude that further examination of the processes component of GE is warranted.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Sophie Carter, Dr Carly Wood and Claire Colley for their valued roles in organisation and data collection; Glenn Doel for initial concept development regarding data collection; parkrun for their permission and support regarding the collection of data at their UK events; and all participants for their willingness to take part in the study.

CONFLICTS OF INTEREST

Daniel Brown, Gavin Sandercock, John-James Wooler, and Jo Barton declare that they have no conflicts of interest. Mike Rogerson has no conflicts of interest other than holding a seat on parkrun's research board. He was appointed to this position only following the completion of this research.

ETHICAL APPROVAL

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration. Informed consent was obtained from all patients for being included in the study.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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