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The mental and physical health outcomes of green exercise

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Abstract
Both physical activity and exposure to nature are known separately to have positive effects on physical and mental health. We have investigated whether there is a synergistic benefit in adopting physical activities whilst being directly exposed to nature ('green exercise'). Five groups of 20 subjects were exposed to a sequence of 30 scenes projected on a wall whilst exercising on a treadmill. Four categories of scenes were tested: rural pleasant, rural unpleasant, urban pleasant and urban unpleasant. The control was running without exposure to images. Blood pressure and two psychological measures (self-esteem and mood) were measured before and after the intervention. There was a clear effect of both exercise and different scenes on blood pressure, self-esteem and mood. Exercise alone significantly reduced blood pressure, increased self-esteem, and had a positive significant effect on 4 of 6 mood measures. Both rural and urban pleasant scenes produced a significantly greater positive effect on self-esteem than the exercise-only control. This shows the synergistic effect of green exercise in both rural and urban environments. By contrast, both rural and urban unpleasant scenes reduced the positive effects of exercise on self-esteem. The rural unpleasant scenes had the most dramatic effect, depressing the beneficial effects of exercise on three different measures of mood. It appears that threats to the countryside depicted in rural unpleasant scenes have a greater negative effect on mood than already urban unpleasant scenes. We conclude that green exercise has important public and environmental health consequences.

Keywords: *Green exercise, physical activity, mental health, self-esteem, mood, environmental health*

Nature, health and lifestyle

In the face of widespread and growing threats to the natural environment, two major arguments about the need for conservation have come to dominate: the environment should be conserved for ethical (e.g., Leopold 1949; Eckersley 1999) or economic (e.g., Costanza et al. 1997; Sandifer et al. 2004) reasons. Relatively little attention, though, has been paid to the potential emotional benefits. Nature and living things, it seems, tend to make most people feel good (Kellert & Wilson 1993; Maller et al. 2002). The idea that the quality of nature in peoples' home neighbourhood affects their mental health is not a new one, but it has not greatly affected either the planning of our urban and rural environments or public health priorities (Lindheim and Syme 1983; Frumkin et al. 2004).

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During the 20th and 21st centuries, an increasing number of people have found themselves living in wholly urban settings. Indeed, within the next decade, the number of people living in urban areas will exceed those living in rural environments for the first time in human history, with more than 3 billion people dwelling in urban settlements. Some of this will be by choice, as urban areas have more services and jobs concentrated together, with better access to schools, hospitals and leisure facilities. But urban settings by definition have less nature than rural ones. And less green nature means reduced mental well-being, or at least less opportunity to recover from mental stress (Pretty et al. 2004). As natural green environments have increasingly come under pressure from economic development, so it seems our own wellbeing has suffered as a consequence.

Today, stress and mental ill-health are becoming more common, and the public health costs associated with these conditions are growing. The World Health Organisation (WHO 2001) estimates that depression and depression-related illness will become the greatest source of ill-health by 2020. This is because many other behaviours, such as smoking, over-eating and high alcohol consumption, are coping mechanisms for depression, and have their own serious consequences. Stress, a major problem for people living in modern societies, is a strong predictor of mortality (Rainford et al. 2000), with industrialised countries increasingly having to raise expenditure for the provision of care, lost outputs and costs to individuals. Depression is known to be a risk factor for a range of chronic physical illnesses, including asthma, arthritis, diabetes, strokes and heart disease (Hippisley-Fox et al. 1998; Turner & Kelly 2000; Ostir et al. 2001). On the other hand, emotional well-being is known to be a strong predictor of physical good health (Goodwin 2000).

Many of these urgent physical health challenges, including obesity and coronary heart disease, are also connected to sedentary and indoor lifestyles (CDC 1996; DCMS 2002; DoH 2004). Physically active people have lower risk of dying from coronary heart disease, type II diabetes, hypertension and colon cancer. Activity also enhances mental health, fosters healthy muscles and bones, and helps maintain health and independence in older adults (Paffenbarger et al. 1994; Scully et al. 1999; Pretty et al. 2004). The recent UK Chief Medical Officer's report (DoH 2004) indicated that: 'physical activity helps people feel better, as reflected in improved mood and decreased state and trait anxiety. It helps people feel better about themselves through improved physical self-perceptions, improved self-esteem, decreased physiological reactions to stress, [and] improved sleep'.

In Europe and North America, there has been a dramatic fall in physical activity over the past 50 years with on average 2 MJ (500 kcal) less energy output per day in adults aged 20–60 years (DCMS 2002). Jobs have become less physical, people are more likely to take the lift than walk the stairs, and adults and children are more likely to travel to work or school by car than to walk or bicycle. In almost all activities (except swimming and yoga), female participation is lower than male (CDC 1996). A major problem is that although 80% of people correctly believe that regular exercise is good for their health, most wrongly believe that they take enough exercise to avoid ill-health (Allied Dunbar 1992). As a result of these changes, combined with transitions towards calorie-rich diets (Popkin 1998; Pretty 2002; Lang and Heasman 2004), obesity and hypertension have emerged as serious threats to health in most industrialised countries. A total of 20–25% of adults in the UK and US are now classed as clinically obese (BMI $> 30 \text{kg m}^{-2}$).

As physical activity can positively affect both physical and psychological well-being (Scully et al. 1999), we hypothesise that there may be a synergistic benefit in adopting physical activities whilst at the same time being directly exposed to nature (Hayashi et al. 1999). We have called this 'green exercise' (Pretty et al. 2003). It is increasingly well established that the natural and built features of the environment affect behaviour, interpersonal relationships and

actual mental states (Tuan 1977; Freeman 1984; Kellert and Wilson 1993; Tall 1996; Frumkin 2001). The environment can, therefore, be therapeutic or pathogenic (Burgess 1988; Gesler 1992; Lewis and Booth 1994). Why, then, does nature still seem to have a positive effect on people, despite the increasing urbanization of modern societies?

The evidence indicates that nature can make positive contributions to our health, help us recover from pre-existing stresses or problems, have an 'immunising' effect by protecting us from future stresses, and help us to concentrate and think more clearly. We have discerned three levels of engagement with nature (Pretty et al. 2004; Pretty 2004):

- The first is viewing nature, as through a window, or in a painting (Moore 1981; Ulrich 1984; Tennessen & Cimprich 1995; Leather et al. 1998; Kaplan 2001; Kuo & Sullivan 2001; Diette et al. 2003).
- The second is being in the presence of nearby nature, which may be incidental to some other activity, such as walking or cycling to work, reading on a garden seat or talking to friends in a park (Cooper-Marcus & Barnes 1999; Hayashi et al. 1999; Ulrich 1999; Whitehouse et al. 2001).
- The third is active participation and involvement with nature, such as gardening or farming, trekking or camping, cross-country running or horse-riding (Rossman & Ulehla 1977; Hartig et al. 1991, 2003; Fredrickson & Anderson 1999; Frumkin 2001; Williams & Harvey 2001; Herzog et al. 2002).

In this study, we have tested the effect of the first of these three categories of engagement with nature (the view through the window) on mental and physical health. Studies on the effects of green exercise in the country include evaluations of green gyms in the UK (Reynolds 2002; Yerrell 2004), of the walking the way to health initiative (Countryside Agency 2003; Dawson et al. 2003), and of ten types of physical activity in the countryside (Pretty et al. 2005).

Studies to investigate the health benefits of the first category have tended to be of two types – either observational studies of the effects of different views on different cohorts of subjects, or experimental studies to test the effects of views on randomly selected groups of people. The first type includes studies that have demonstrated clear health benefits for both prisoners and hospital patients of windows overlooking green space compared with those facing brick walls (Moore 1981; Ulrich 1984), and for bronchoscopy patients exposed to a bedside landscape photograph before surgery (Diette et al. 2003). At home, a small amount of green in the view of a barren urban environment improves people's well-bring (Kuo et al. 1998; Taylor et al. 1998, 2001; Kuo & Sullivan 2001). Green views from home have a positive effect on the cognitive functioning of children (Wells & Evans 2003). Windows in the workplace buffer the stresses of work, and over long periods people with windows have fewer illnesses, feel less frustrated, and express greater enthusiasm for work (Tennessen & Cimprich 1995; Leather et al. 1998; Kaplan 2001). Indeed, those in offices without windows often compensate by putting up more pictures of landscapes or by keeping indoor plants (Heerwagen & Orians 1993).

The second type of study uses photographs to investigate the effects of different scenes on cognition and emotions (Coughlin & Goldstien 1970; Shafer & Richards 1974; Zube et al. 1974; Sorte 1975; Russell & Mehrabian 1976). For example, in a comparison of videos of different roadside corridors on a virtual drive to work, the urban drive was more stressful and drives through nature were more protective against stresses that subsequently arose during the working day (Parsons et al. 1998). Most studies of this type have used still photographs, mainly comparing urban with rural scenes (Honeyman 1992; Schroeder 1995; Purcell & Lamb 1998; Staats & Hartig 2004), and all have consistently shown reduced stress and

improved mental well-being in the presence of nature scenes. Relatively few studies have investigated the effects of exposure to different scenes on physiological measures such as heart rate and blood pressure (Ulrich 1999; Hartig 2003; Laumann 2003) and none have analysed the potential synergistic effects of physical activity.

The aims of this study were thus to determine the physiological and psychological effects of exercise conducted on a treadmill whilst exposed to rural and urban photographic scenes. Each of these was sub-divided into pleasant and unpleasant categories in order to explore, on the one hand the effect of rural scenes compromised with pollutants or other visual impediments, and on the other hand of clearly urban scenes enhanced by the presence of nearby nature in the form of green space.

In this study, we only investigated the effects of green exercise on individuals, and thus did not assess the value of social interactions in green spaces (Burgess 1988; Coley et al. 1997; Fredrickson & Anderson 1999; Ulrich 1999; Thompson 2002).

Materials and methods

Subjects

The effects of exercise whilst exposed to different rural and urban photographic scenes were studied on 100 adult subjects (55 female, 45 male). Their age range was 18–60, with a mean of 24.6 $\pm$ 0.99 (SE). Subjects were undergraduates and employees at the University of Essex or drawn from the local community in Colchester, UK.

Prior-assessment of photographs

Photographs were categorized as rural pleasant, rural unpleasant, urban pleasant or urban unpleasant by an independent panel of 50 people. A library of 309 photographs was viewed by each panel member as a powerpoint presentation and each scene was scored on a five point scale according to how well it represented a particular category (vaguely, slightly, typically, strongly or very strongly representative). Only where 95% of the panel assessed a scene as strongly representing the definition was the photograph selected for use in the experiment. In all, 30 photographs were selected for each category (see Photos 1a–1d for samples). These were entered into a powerpoint presentation and shown in random order for a period of 15 seconds each before rotation to the next picture.

Materials and design

The following materials were used in the experiment: (a) Powerjog Treadmill, JX200; (b) Gateway laptop computer, Solo 9300, Viglen Genie 2 computer with Powerjog Coach software package, Epson EMP 52 projector and screen; (c) Cardiosport heart rate belt, with Polar Accurex Plus heart rate monitor and belt; (d) Massage table; (e) Omron Digital Blood pressure monitor, HEM 704C; (f) Stadiometer, Seca 220; (g) Weighing Scales, Seca 770 Digital. Mean arterial blood pressure (MAP) was calculated as diastolic pressure + 0.33 (systolic – diastolic).

The survey instruments for assessing psychological states were as follows: (a) Profile of Mood States Questionnaire (POMS) (McNair et al. 1984); (b) Rosenberg Self–Esteem Questionnaire (Rosenberg 1989); (c) Profile of Subject Questionnaire (designed for this study); (d) Par-Q General Health Questionnaire (Chisholm et al. 1975); and (e) Informed Consent form.

Subjects were randomly allocated to one of the five conditions (four with pictures, one control) and a multivariate data set of dependent variables was collated. A number of measures were used to assess the combined synergistic impact of the exercise and the photographic view. Physiological measures included blood pressure readings and continuous heart rate monitoring. Psychological tools incorporated the Profile of Mood States (POMS), which comprises 5 questions for each of the 6 mood states (McNair et al. 1984), and the Rosenberg Self-esteem questionnaire, which comprises ten questions (Rosenberg 1989) and in which a decrease in the score represents an improvement in self-esteem.

Experimental procedure

Initially subjects completed and signed an informed consent and the PAR-Q General Health Questionnaire. A Polar heart rate monitor and Cardiosport transmitter belt were used to record heart rate at five second intervals. Weight (kg) and height (m) were recorded and then a series of profile building questions were asked about the subject's exercise habits and their perspectives on the natural environment. On completion (5 minutes), subjects relaxed in a supine position, with eyes closed on the massage table for a further three minutes. Heart rate was monitored throughout this period and the lowest value attained was considered to represent the resting heart rate. Resting systolic and diastolic blood pressure was measured at the end of this period using an Omron Digital blood pressure monitor. Subjects then completed the POMS and self-esteem questionnaires, which were rotated at random.

Subjects were familiarized with a printed version of Borg's 20 point rating of perceived exertion (RPE) scale (Borg 1961) while stationary on the treadmill. Subjects were advised to exercise at level 12 ('fairly light'). The speed of the treadmill was controlled remotely by the tester via the software package according to oral feedback from the subject.

Subjects warmed up by walking at a moderate pace for 3 minutes. The speed of the treadmill was then steadily increased until the subject informed the tester that it had reached the specified 'fairly light' intensity that was relative to their level of fitness. For most of the subjects this intensity was achieved at a jogging pace, but for others it was a fast walk. Subjects could instruct the tester to alter the speed of the treadmill at any point during the exercise to ensure that the intensity remained consistent. During the 20 minute period of exercise, the randomly allocated set of pictures appeared sequentially, in randomized order, on the projector screen and heart rate data were continuously recorded. Subjects were instructed to concentrate on absorbing and assimilating as much about the individual pictures as they could. One set of participants acted as the control group, as they exercised with a blank white screen. Twenty subjects were tested for each of the five categories of photographs.

Following the 20 minutes of exercise, the treadmill speed was reduced to a standstill within twenty seconds. Subjects then completed both the POMS and self-esteem questionnaires immediately (randomly rotated), so that any effect of the pictures combined with the exercise would not be lost. Five minutes after the exercise, blood pressure was measured.

Results

Similarity of subjects

A one-way ANOVA test indicated that there were no significant differences in any of the measures between the groups before the interventions. Thus, any subsequent differences between them was due to the experimental intervention.

Effects of the exercise

Table I shows that there were significant reductions in both systolic and diastolic blood pressure following 20 minutes of 'fairly light' exercise when data for all five groups were pooled. Mean arterial blood pressure decreased from 90.1 ($\pm$ 0.89) to 87.7 ($\pm$ 0.98) mm Hg.

A one-way ANOVA test indicated no significant differences between groups in resting heart rates, heart rate following the warm up period and average heart rate during the last 15 minutes of the exercise. Thus there was no difference in average relative exercise intensity between the groups.

Table I confirms a significant increase in self-esteem (from 19.4 $\pm$ 0.4 to 18.1 $\pm$ 0.4; $p < 0.001$), significant reductions in two of the six mood measures (confusion, $p < 0.01$; and tension, $p < 0.001$), and a significant improvement in one mood measure (vigour, $p < 0.001$) following exercise. The changes in the other three mood measures were not significant.

Effects of the different views with exercise

The data for the 20 participants in each of the five groups were analysed separately (Table II and Figures 1 – 3).

As indicated in Table I, all three measures of blood pressure were significantly reduced by exercise. The largest change was in systolic blood pressure. When analysed by group, only those subjects viewing rural pleasant scenes experienced significant reductions in all three measures of blood pressure (systolic, diastolic and MAP; see Table II). Figure 1 shows the changes in mean arterial blood pressure normalised to the starting average for all five groups. There was also a decline for rural unpleasant pictures, but this was not significant. The urban pleasant pictures had no effect on MAP, whilst the urban unpleasant slightly increased it. As control subjects experienced a slight decrease in blood pressure, it is clear that both pleasant and unpleasant urban scenes increased blood pressure relative to the controls. The urban scenes therefore appear effectively to negate the marginal, but potentially beneficial impact of exercise on blood pressure.

Table I. Effects of exercise on physiological and psychological measures in all subjects ($n = 100$).

Measures	Before exercise	After exercise	Significance of difference
Physiological			
Systolic blood pressure	121.74 $\pm$ 1.25	118.02 $\pm$ 1.31	***
Diastolic blood pressure	74.22 $\pm$ 0.90	72.47 $\pm$ 1.01	*
Mean arterial pressure (MAP)	90.06 $\pm$ 0.89	87.65 $\pm$ 0.98	**
Psychological			
Self-Esteem	19.43 $\pm$ 0.40	18.09 $\pm$ 0.43	***
Psychological			
Mood			
Anger-Hostility	38.19 $\pm$ 0.25	37.86 $\pm$ 0.29	NS
Confusion-Bewilderment	36.94 $\pm$ 0.41	35.90 $\pm$ 0.40	**
Depression-Dejection	37.75 $\pm$ 0.17	37.55 $\pm$ 0.18	NS
Fatigue-Inertia	40.08 $\pm$ 0.54	39.92 $\pm$ 0.51	NS
Tension- Anxiety	35.10 $\pm$ 0.34	32.64 $\pm$ 0.28	***
Vigour-Activity	36.97 $\pm$ 0.62	39.91 $\pm$ 0.73	***

Values are means $\pm$ standard errors. Significance tested with 1-tailed t test (* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$).

Table II. Physiological effects of exercise whilst viewing different scenes ($n = 20$ in each group).

	Rural pleasant		Rural unpleasant		Urban pleasant		Urban unpleasant		Control	
Blood pressure (mm Hg)	Before	After	Before	After	Before	After	Before	After	Before	After
Systolic	127.95 ± 3.38	115.60 ± 2.97***	120.80 ± 2.67	119.95 ± 3.05 NS NS	118.55 ± 2.92	114.95 ± 2.93 NS NS	119.30 ± 1.99	121.30 ± 2.72 NS NS	122.10 ± 2.60	118.30 ± 2.97 NS NS
Diastolic	77.20 ± 2.14	70.90 ± 1.72***	76.60 ± 2.57	74.00 ± 2.17 NS NS	70.80 ± 1.57	72.60 ± 2.47 NS NS	73.00 ± 1.79	72.05 ± 2.37 NS NS	73.50 ± 1.69	72.80 ± 2.70 NS NS
Mean arterial	94.12 ± 2.36	85.80 ± 1.97***	91.33 ± 2.18	89.32 ± 2.23 NS NS	86.72 ± 1.69	86.72 ± 2.27 NS NS	88.43 ± 1.75	88.47 ± 2.05 NS NS	89.70 ± 1.79	87.97 ± 2.53 NS NS

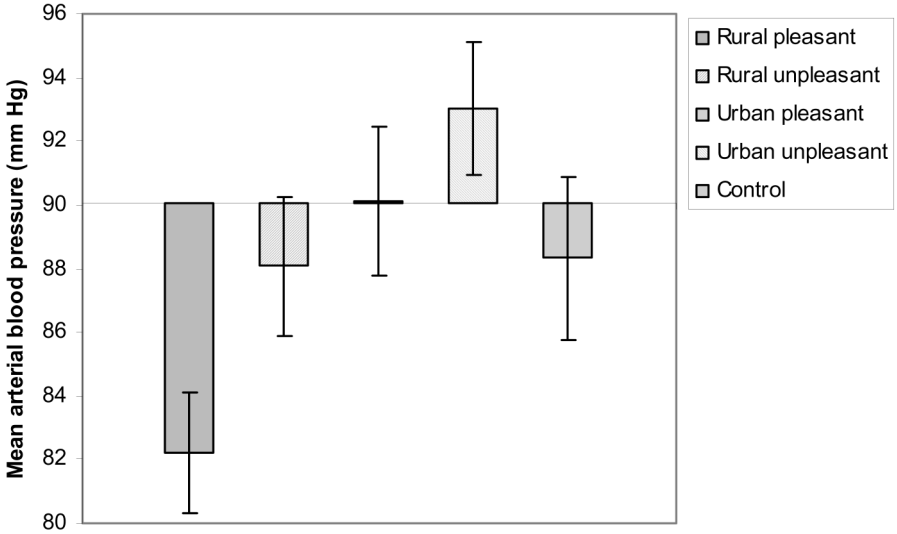

Figure 1. Change in mean arterial blood pressure after exercise whilst viewing different scenes ($n = 20$ in each group).

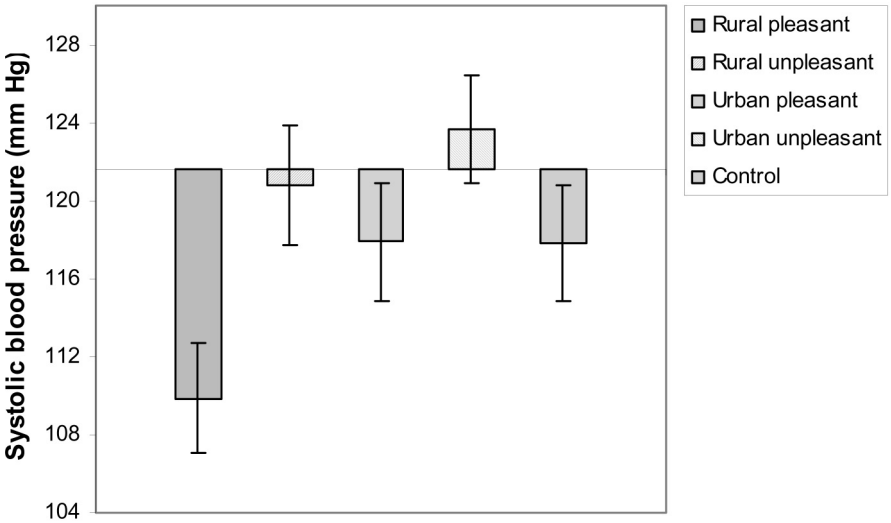

Figure 2. Change in systolic blood pressure after exercise whilst viewing different scenes ($n = 20$ in each group).

Diastolic and systolic blood pressure changes were of broadly similar magnitude and direction within groups except for subjects exposed to urban scenes. For urban pleasant scenes, average systolic blood pressure fell whilst diastolic rose, whereas for urban unpleasant scenes the opposite occurred (Figures 2 and 3). Thus there was no net change in mean arterial blood pressure for groups exposed to urban scenes (Figure 1).

When blood pressure effects were expressed as a percentage change from pre-exercise levels there was a statistically significant effect of picture category (one way ANOVA) on systolic blood pressure ($p < 0.01$), and mean blood pressure ($p < 0.05$) but not on diastolic blood pressure. Post hoc Tukey tests showed that the significant differences in percentage change in

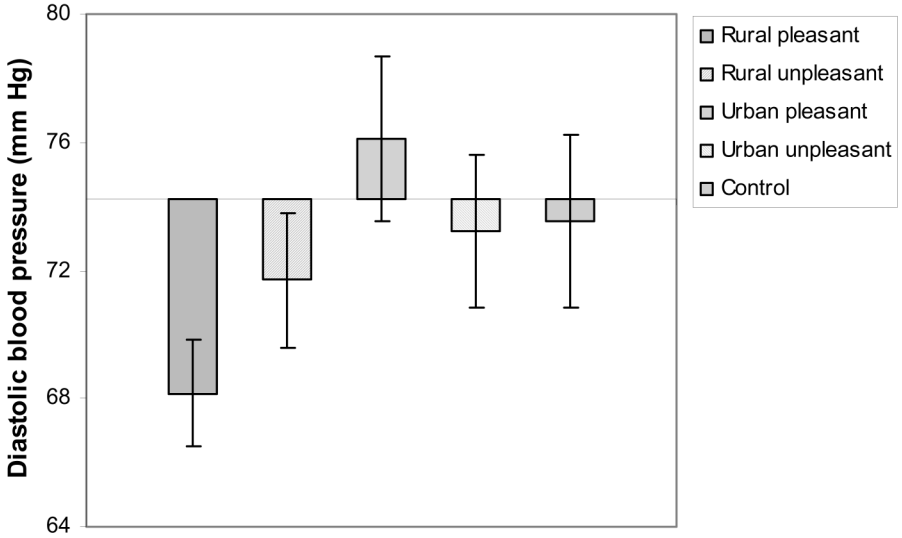

Figure 3. Change in diastolic blood pressure after exercise whilst viewing different scenes ($n = 20$ in each group).

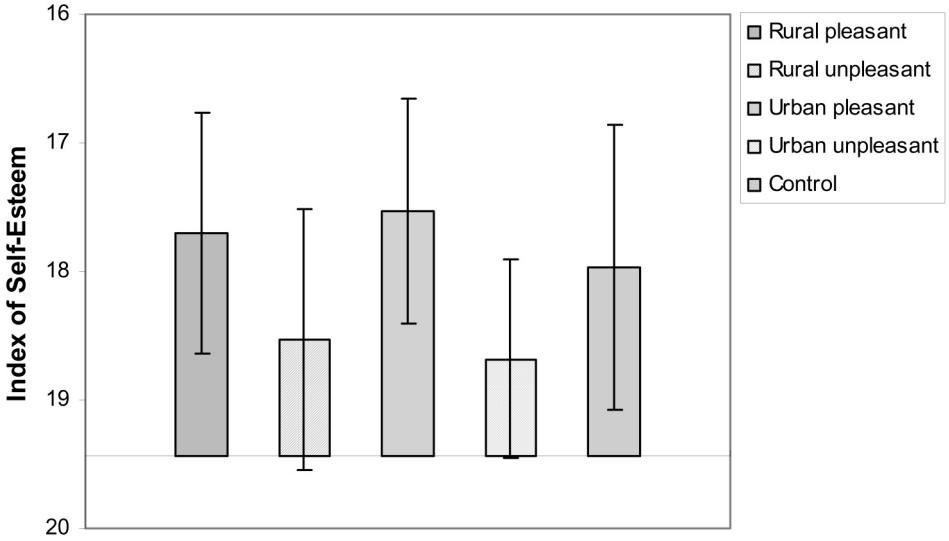

Figure 4. Change in self-esteem after exercise whilst viewing different scenes ($n = 20$ in each group).

systolic blood pressure were between the rural pleasant and urban unpleasant groups ($p < 0.001$) and between rural pleasant and rural unpleasant groups ($p < 0.05$). For changes in mean blood pressure, there were significant differences between rural pleasant and urban pleasant ($p < 0.05$) and between rural pleasant and urban unpleasant ($p < 0.05$).

Figure 4 shows the changes in self-esteem in the five groups (as measured before and after exercise using the Rosenberg questionnaire) with starting self-esteem averaged for all groups. Self-esteem was significantly improved in all five groups ($p < 0.001$ for rural pleasant; $p < 0.01$ for rural unpleasant, urban pleasant and control; $p < 0.05$ for urban unpleasant).

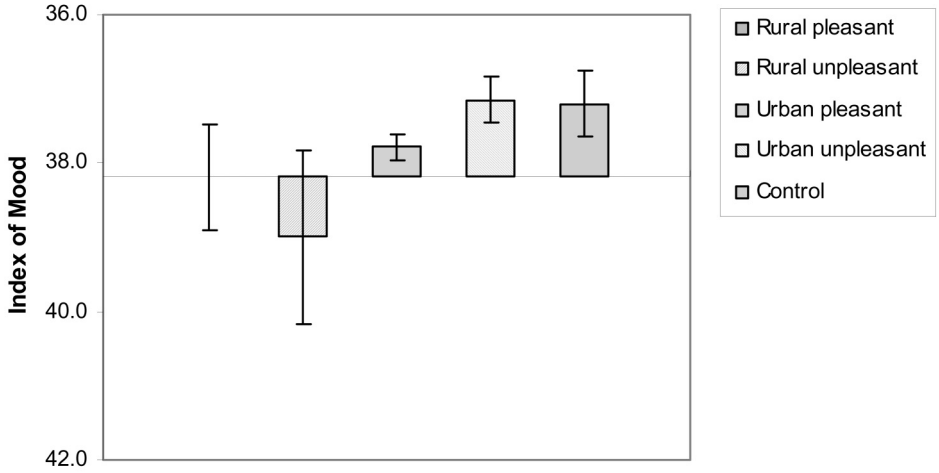

Figure 5. Change in anger-hostility mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

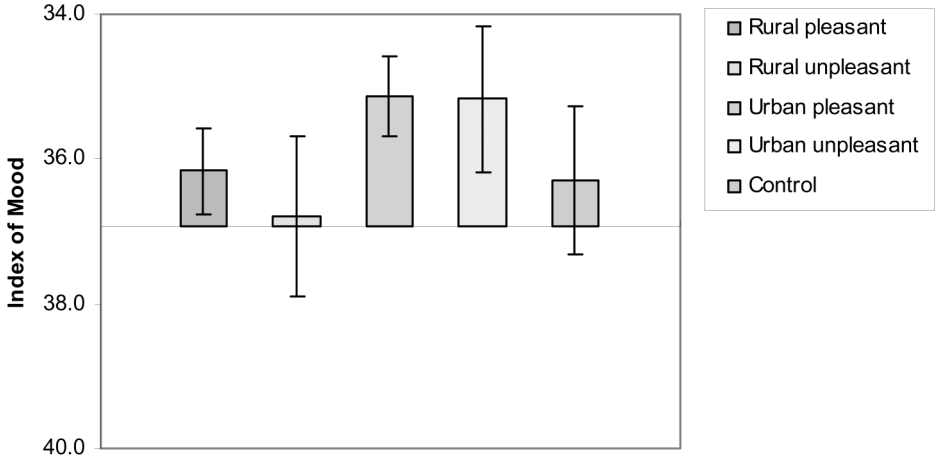

Figure 6. Change in confusion-bewilderment mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

The control treatment (exercise with no scenes) produced a greater improvement in self esteem than the two unpleasant treatments (rural and urban), implying that the latter have a depressive effect on self-esteem relative to exercise alone. Both pleasant treatments, however, produced the greatest increases in self-esteem. In the original Rosenberg study of 2294 participants, mean self-esteem for the population at large was found to be 34.73 on the index. It is possible, therefore, that our population of 100 subjects was starting from a higher base of self-esteem relative to the wider population, and that a cohort selected from the general population would show larger changes in self-esteem with these treatments.

Figures 5 to 10 show the changes in the six mood criteria measured with the POMS questionnaire. For each treatment group, mood score following exercise was compared with mood score before exercise using a paired t test. The main findings are as follows:

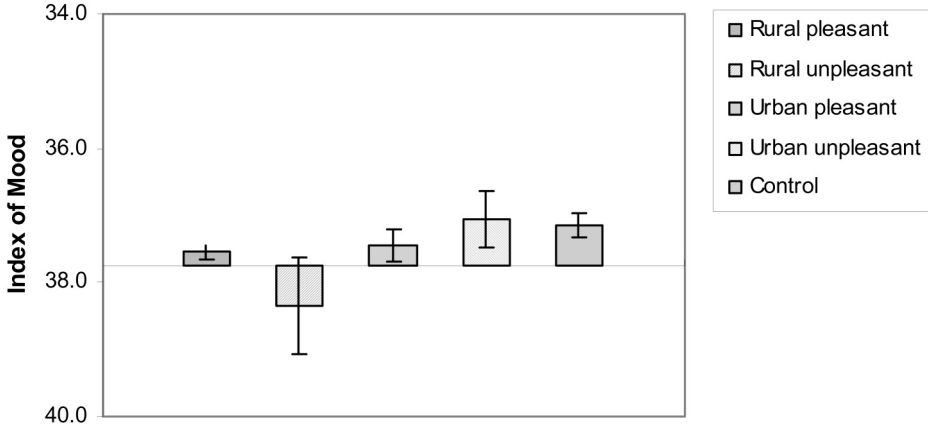

Figure 7. Change in depression-dejection mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

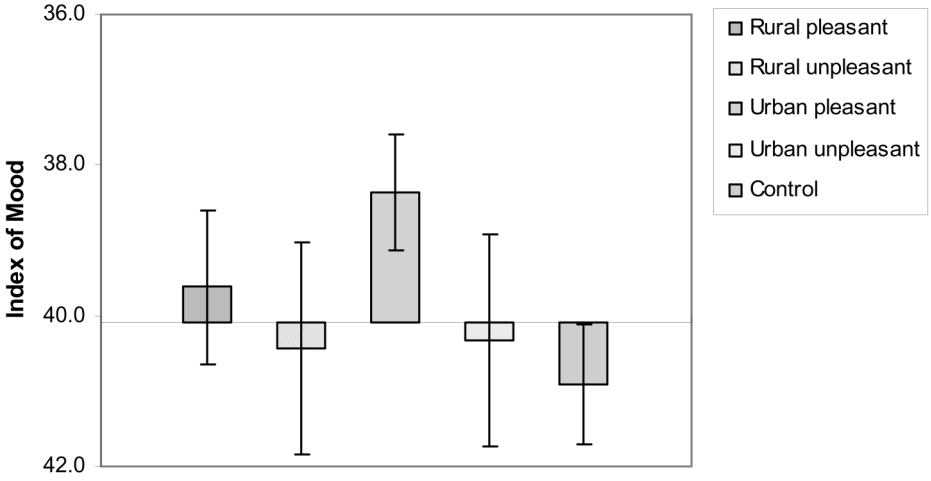

Figure 8. Change in fatigue-inertia mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

(a) Anger-hostility (Figure 5): there were significant reductions in this measure during exposure to the urban unpleasant scenes ($p < 0.05$) and for the exercise-only control ($p < 0.05$). Changes in the presence of the other scenes were not significant, but there appeared to be an increase in this measure after viewing rural unpleasant scenes.

(b) Confusion-bewilderment (Figure 6): this measure fell following all treatments but the decrease was significant only for the urban pleasant ($p < 0.01$) and urban unpleasant scenes ($p < 0.05$).

(c) Depression-dejection (Figure 7): the changes were small for this mood measure with significant reductions occurring only for urban pleasant scenes ($p < 0.05$) and the exercise-only control ($p < 0.05$).

(d) Fatigue-inertia (Figure 8): none of the changes was statistically significant, but exposure to pleasant scenes appeared to reduce feelings of fatigue compared with exercise alone or in combination with other scenes.

(e) Tension-anxiety (Figure 9): all treatments improved this mood measure significantly. Exercise alone clearly reduced tension-anxiety ($p < 0.01$), but both rural ($p < 0.001$) and urban pleasant scenes ($p < 0.001$) reduced it further. Furthermore, the improvement was greater for pleasant scenes than for unpleasant scenes in the same category (11% more in the rural category and 47% more in the urban category).

(f) Vigour-activity (Figure 10): improvements occurred in all five treatments, and were significant for rural pleasant ($p < 0.05$), urban pleasant ($p < 0.01$) and exercise alone ($p < 0.001$). The largest improvements were for exercise alone and after exposure to urban pleasant scenes. The smallest improvement in this measure followed exposure to urban unpleasant scenes.

We further disaggregated the results by analysing the effects of the scenes on those individuals (i) whose blood pressure decreased; (ii) whose blood pressure increased; (iii) whose self-

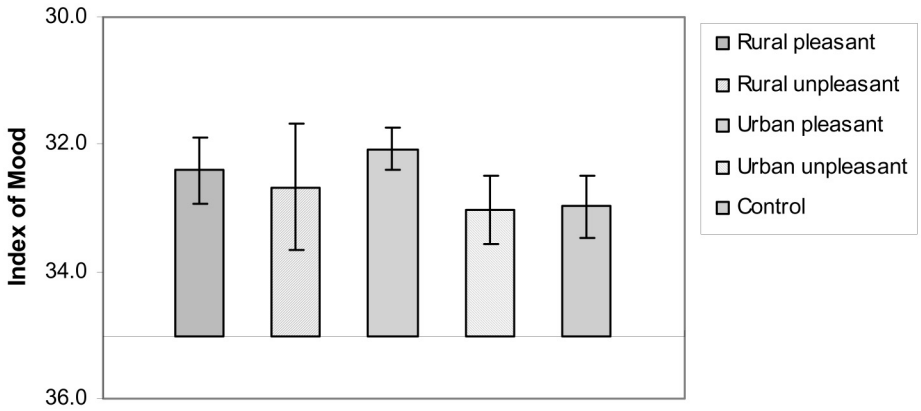

Figure 9. Change in tension-anxiety mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

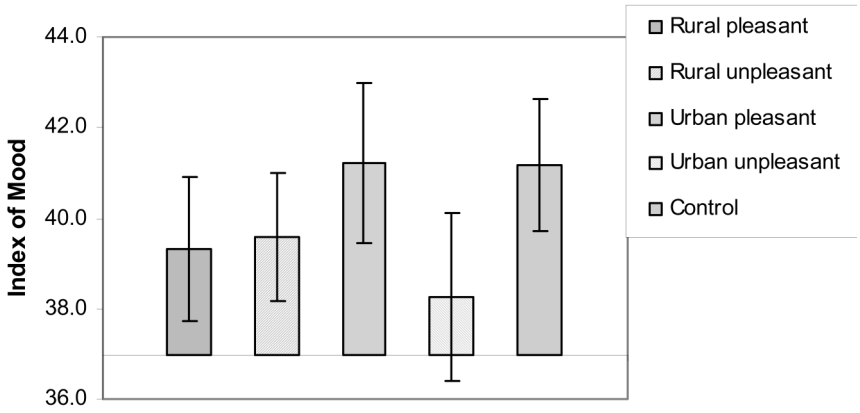

Figure 10. Change in vigour-activity mood measure after exercise whilst viewing different scenes ($n = 20$ in each group).

esteem improved; (iv) whose self-esteem began high, and still improved; and (v) whose self-esteem started low and improved.

Table III summarises the differences between subjects whose blood pressure either decreased or increased. Of all subjects, 70% experienced a decline in blood pressure, with the greatest proportion in the rural pleasant category. All subjects in the rural pleasant category experienced a decline in blood pressure, whereas only 60% of subjects experienced such declines in all other treatments. A total of 29 subjects experienced increases in blood pressure. There were no increases in blood pressure amongst subjects in the rural pleasant category, whereas an average 35–40% of subjects in the other scene categories experienced increases.

Table IV indicates that 62 of 100 subjects increased self-esteem. Both unpleasant categories resulted in fewer subjects increasing self-esteem (45% and 55%), whereas the rural pleasant scenes produced increases amongst 80% of subjects exposed to these scenes. Urban pleasant had the same effect on participants as the control. Some 29% of all subjects started with high self-esteem and went on to show increases. Once again, both the unpleasant categories had a smaller proportion of subjects showing such increases compared with the control. Some 80% of subjects in the rural pleasant category had increased self-esteem. There were 27 subjects starting with low self-esteem and increasing. Within treatments, rural unpleasant had the least effect, whereas all other scenes had a greater effect than the control.

Table III. Summary of effects on subjects whose blood pressure decreased or increased.

	Subjects for whom blood pressure decreased		Subjects for whom blood pressure increased	
	Proportion of total 70 subjects in each category (%)	Proportion of subjects within each category (%)	Proportion of total 29 subjects in each category (%)	Proportion of subjects within each category (%)
Rural pleasant	29	100	0	0
Rural unpleasant	17	60	24	35
Urban pleasant	17	60	28	40
Urban unpleasant	17	60	28	40
Control	20	70	21	30

Table IV. Summary of effects on subjects for whom self-esteem improved.

	All subjects with improved self-esteem		Subjects starting with high self-esteem		Subjects starting with low self-esteem	
	Proportion of total 62 subjects in each category (%)	Proportion of subjects within each category (%)	Proportion of total 29 subjects in each category (%)	Proportion of subjects within each category (%)	Proportion of total 27 subjects in each category (%)	Proportion of subjects within each category (%)
Rural pleasant	26	80	28	40	26	35
Rural unpleasant	15	45	14	20	11	15
Urban pleasant	21	65	21	30	22	30
Urban unpleasant	18	55	17	25	22	30
Control	21	65	21	30	19	25

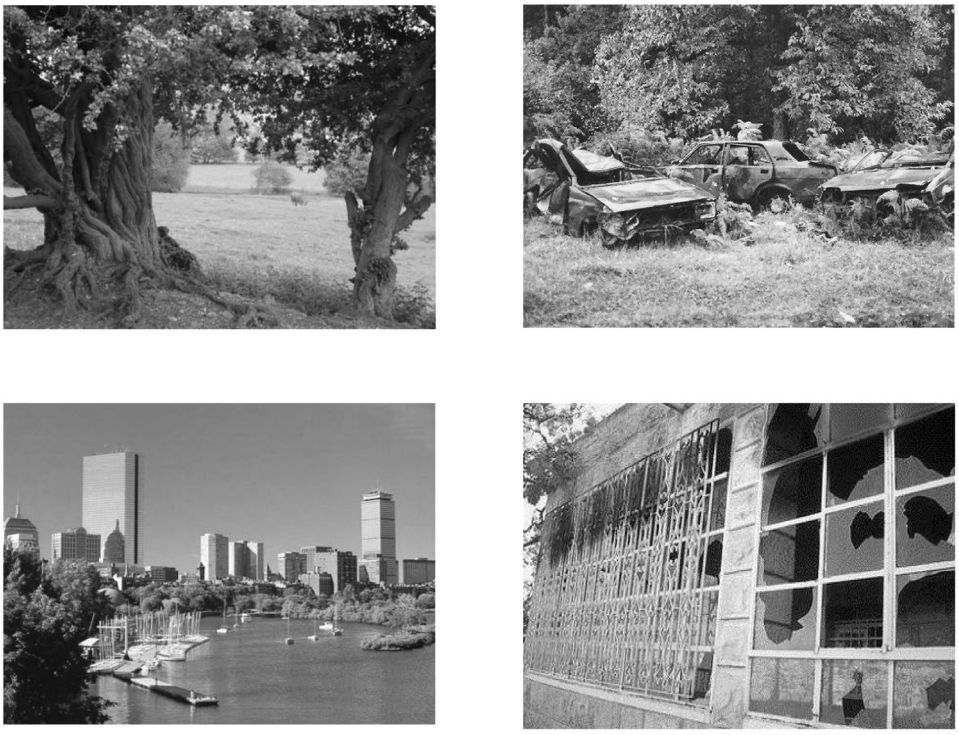

Photo 1a – 1d. Examples of photographs used in experiment (rural pleasant, rural unpleasant, urban pleasant, urban unpleasant).

Discussion

Elements in photographs

In the prior-assessment of photographs, we showed adults of different ages more than 300 pictures of rural and urban scenes to assess which they would assign to pleasant or unpleasant categories. Everyone was able to agree upon what constituted a rural pleasant scene. Complex landscapes with various habitats and mosaics, with trees, water, blue sky and clouds, were consistently said to be pleasant. Those with animals, such as lambs and calves, replaced the need for sky and water. Viewers did not, however, favour dark skies or thundery clouds, and always preferred greens over browns in the landscape.

Viewers commonly put themselves inside pictures, by saying they would like to visit or even live in the scene. Many people also struggled to say any rural scene was unpleasant. They agreed that a pile of rubbish or an abandoned car would make a rural scene unpleasant, but they also tended to assume that these problems were temporary. Again, green trees and other vegetation combined with blue skies or water seemed to over-ride unpleasant elements. Broken machinery, damaged trees, abandoned buildings, billboards, and pipes carrying effluents were all seen as unpleasant.

Both urban unpleasant and urban pleasant were relatively straightforward to categorise. Damaged, degraded environments were clearly unpleasant, as was graffiti, scaffolding, concrete blocks, rubbish and broken windows. Where places appeared abandoned or deserted, they were seen as unpleasant. However, skyscrapers and cityscapes tended to be

seen as pleasant, though many people commented they would be pleasant to visit rather than live in. Tall buildings became urban pleasant if there was water present, particularly if it reflected blue from the sky. In general, urban scenes with green, such as urban parks, domestic gardens or allotments, together with water and blue sky, were seen as pleasant. Allotments, though, were consistently selected as pleasant only by older people. These findings support the idea that the incorporation of water and green spaces into well-maintained urban environments might have a positive effect on public health (Frumkin et al. 2004).

Outcomes of green exercise

Our findings show clear effects of exercise and viewing different scenes during exercise on both blood pressure and two psychological measures (self-esteem and mood). Exercise alone slightly reduced blood pressure (systolic, diastolic and mean arterial), significantly increased self-esteem, and had a positive significant effect on 4 of 6 mood measures.

The four types of scenes viewed also had a variety of effects on subjects. We found that rural pleasant scenes have the greatest effects in reducing blood pressure – both in terms of the average reduction in mean arterial blood pressure in all subjects in this class (from 94.1 to 85.8 mm Hg), and also the fact that all participants in this class experienced declines in blood pressure (unlike all other treatments where, by contrast, 35—40% of subjects experienced increases in MAP). It is well established that exercise has a hypotensive effect, with long term reductions of 2—3 mm Hg being achieved in hypertensive patients even without weight loss (reviewed in Bacon et al. 2004). Although reductions in blood pressure were small in the current study, pre-exercise population mean values for all groups were in the normotensive range and there was little scope for further reduction. Further studies are planned that will test subjects with borderline hypertension.

Rural pleasant scenes also had a positive effect on self-esteem, which like urban pleasant scenes produced a greater effect than exercise alone. This shows the synergistic effect of exposure to both rural and urban pleasant environments, when combined with exercise. Although both rural and urban unpleasant scenes produced increases in self-esteem, this was to levels lower than the control. This indicates that both sets of unpleasant scenes had a depressive effect on self-esteem compared with exercise with no scenes.

We found that 62% of subjects in all conditions experienced an increase in self-esteem following exercise. For those starting with high self-esteem, a greater proportion of those subjects viewing rural pleasant scenes further increased their self-esteem, whilst a smaller proportion than the control viewing the rural and urban unpleasant scenes further increased their self-esteem. For those subjects starting on low self-esteem, a larger proportion in the rural pleasant showed increases.

For the six measures of mood, viewing rural pleasant scenes during exercise produced consistent, though not always significant, improvements relative to viewing other scenes. Viewing urban pleasant scenes also resulted in improvements in all six mood measures (5 of 6 were significant). Unexpectedly, exercise whilst viewing urban unpleasant scenes produced significant improvements, for anger-hostility, confusion-bewilderment and tension-anxiety. The rural unpleasant scenes had the most differentiated effect on mood measures. There were negative effects on three mood states ($p < 0.05$ for tension-anxiety), the most for any type of scene. It appears that views embodying threats to the countryside had a greater negative effect on mood than already urban unpleasant scenes. In summary, viewing scenes appears to modulate the effects of exercise on mood but consistent effects are difficult to discern. Some runners are said to have an internal focus, concentrating on how their body is responding to

exercise, whereas others have an external focus, preferring to concentrate on distractions (Sheehan 1978). These two populations of runners might be expected to respond in different ways to exposure to scenes, blurring any effect on mood states at a population level.

Conclusions

Our findings suggest that exercise in pleasant environments may have a greater effect than exercise alone on blood pressure, an important measure of cardiovascular health, and on measures that are relevant to mental health. We conclude that green exercise has important implications for public and environmental health. A fitter and emotionally more content population would clearly cost the economy less as well as reducing individual human suffering. Obesity and related conditions already cost more in public health terms than smoking (Kenkel & Manning 1999; Lang & Heasman 2004), and will overtake smoking as industrialized countries' biggest killer in 10–15 years if current trends persist. Thus increasing support for and access to a wide range of green exercise activities for all sectors of society should produce substantial economic and public health benefits. Such support could include the provision and promotion of healthy walks projects, exercise on prescription, healthy school environments, healthy travel to school projects, green views in hospitals, city farms and community gardens, urban green space, and outdoor leisure activities in the countryside.

It has been estimated that a 10% increase in adult physical activity would benefit the UK by £500 million per year, saving 6000 lives (DoH 2004). The potential economic impact of emotional benefits and improved mental well-being has not been quantified but would be additional to these physical health benefits, and might indeed outweigh them. If these benefits are achieved through 'green' activities that might also provoke long-term changes in attitudes to nature and the environment in both rural and urban contexts, then wider support for pro-sustainability policies is more likely to arise.

However, there is a distinct tension between these conclusions and existing drivers of economic development in both rural and urban regions. In urban areas, green spaces are often removed to keep down maintenance costs, and there is often a perception that well-vegetated places offer more opportunities for criminals and drug-dealers to hide – perhaps echoing centuries' old fears of the forests. In rural areas, modern agricultural development continues to put pressure on spaces where people can enjoy green exercise opportunities.

In this study we have shown that, in a carefully controlled laboratory simulation, green exercise is more effective than exercise alone in improving measures relevant to cardiovascular and mental health. Further research is now required to investigate the effects of exposure to different scenes in real environments whilst engaging in different types, durations and intensities of physical activity. It will also be interesting to investigate if the effects of green exercise are consistent across different social groups and to determine its effects on subjects suffering from high blood pressure and low mental health status.

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