GREEN EXERCISE AND CARDIOVASCULAR HEALTH: QUANTITATIVE EVIDENCE FROM A COMMUNITY CONSERVATION INTERVENTION IN THE UK

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Abstract

This paper aims to add to the fledgling body of work pertaining to the cardio-vascular benefits of self-motivated activity in naturalistic settings. Collecting results from a longitudinal study of a regional community conservation intervention in the UK, it is found that - across a wide range of age groups – simple engagement with a set of everyday horticultural tasks induces the *exact* levels of exercise that the medical and sport sciences define as optimal for the maintenance of everyday baseline fitness. It is further contended, in line with prior literature, that such capital-free initiatives, designed to improve a local social environment can, thereby, improve the core heath of individuals who may be averse to more conventional gym-type environments.

Keywords: Cardiovascular health, conservation, community, green exercise, exercise referral

Introduction

A decade ago, Pretty et al. (2005) produced one of the first genuinely systematic manifestos for the value of “green exercise” in the promotion and upkeep of physical and mental health. Although this original research, and that following from it (Pretty et al., 2007), was itself focused more extensively upon the psychological benefits of physical activity in rural environments, the authors centrally observed that there was a significant lack of pertinent quantitative evidence in both physiological and psychological domains. Today, this remains largely the case. Few studies have taken up the challenge of seriously examining the impacts of outdoor recreation upon public health (Carmona, Freeman, Rose, & Woolley, 2004;

Coon, Boddy, & Stein, 2011; Hale et al., 2011; Park, Lee, Lee, & Son, 2014b; Wichrowski, Whiteson, Haas, Mola, & Rey, 2005), and fewer still have done so *within* the specific environments of interest (Park, Lee, Lee, Son, & Shoemaker, 2013; Park, Lee, Lee, & Son, 2014a).

There are clear academic impediments to the production of this latter form of knowledge, however. In order to produce classically robust scientific findings, the bulk of pertinent studies (including those of Pretty and colleagues) have, quite logically, utilised controlled conditions, such as laboratory settings, to assess impacts (Herzog, Colleen, Maguire, & Nebel, 2003; Ivarsson & Hagerhall, 2008; Park, Lee, Lee, & Son, 2014b; van den Berg, Koole, & van der Wulp, 2003). For example, Pretty et al. (2005) exposed 20 participants to a sequence of 30 projected scenes (categorised as: rural pleasant, rural unpleasant, urban pleasant and urban unpleasant) during a session of running on a treadmill, using "no projection" as a control. Measuring blood pressure, self-esteem and mood, they found compelling evidence to suggest that green exercise does, indeed, have important public and environmental health consequences. Although such work has a legitimately high standing within the corpus of research on green exercise, it is vulnerable to challenges regarding its ecological validity. To what extent, might we ask, does an image on a wall *really* replicate the experience of the rural outdoors? Perhaps more importantly, it highlights a Catch-22 in researching the core phenomenon. Exploring the benefits of green exercise in-the-field necessarily sacrifices internal validity, control and some sense of "rigour" for the sake of ecological validity; to devise laboratory tests sacrifices ecological validity for internal validity, and control.

In this respect, researchers interested in the impacts of exercise in naturalistic settings fall foul of the same academic and medical orthodoxy as those investigating the impacts of exercise referral schemes (ERSs) on both physical and mental health (Crone, Johnston, Gidlow, Henley, & James, 2008). The gold standard for any health-related intervention remains that which is, or looks very much like, an RCT. Community-based interventions, such as ERSs, are inextricably bound up with contingent psychological, sociological and physiological concerns. Even though RCTs are simply "…not designed to answer such questions as they lack the external validity necessary to faithfully replicate practice" (James et al., 2008, p.218), however, there has been a general scientific and practice-based deprioritisation of ERSs themselves, because evaluation thereof inveterately cannot produce the right *kind* of evidence within established paradigms.

This paper, with respect to the concerns above, reports findings from a field-based study of the cardiovascular impacts of physical recreation within an active, community-based "green gym" in the UK. The monitoring of heart rates during green exercise, as with the core data reported herein, may not be subject to quite the same range of validity-concerns as those pertinent to *mental* health. Nevertheless, it is the core contention herein that naturalistic studies of exercise physiology, although they lack some of the inherent rigour of their laboratory-based counterparts, have a significant role to play in responding to the concerns of Pretty et al. (2005; 2006) regarding a lack of quantitative evidence on the matter. Given the inherent difficulty in assembling a scientifically compelling corpus of data around any naturalistically-contexted form of exercise, a synergistic corpus of research drawing on both laboratory work and fieldwork is the strongest means of validating the broader enterprise.

Physical activity and cardiovascular health

The World Health Organisation (2014) estimates that, today, one in three adults worldwide is failing to achieve physical activity sufficient for the maintenance of "good" levels of overall health. In Western societies such inactivity is even more widespread, with 63.3% of adults in the UK (the third least active country in Europe) failing to meet recommended minimum healthy levels (Heath et al., 2012). Moreover, there is overwhelming evidence to indicate that physical inactivity within the adult population is a major causal factor in the development of a number of chronic diseases including coronary heart disease, stroke, cancer, obesity, type II diabetes, musculoskeletal conditions and mental health problems (Booth, Roberts, & Laye, 2012; O'Donovan et al., 2010).

There has, for some time, been strong academic consensus regarding the positive role of regular exercise in the upkeep of basic physical health (Garber et al., 2011)[146]. Consequently, policy makers have been charged with developing clear evidence-based guidelines on what constitutes a minimum healthy level of activity. The UK's Chief Medical Officer (Department of Health, 2011), for a typical example, stipulates that in order to develop and maintain physical fitness and health, exercise should include a cardiovascular component, equivalent to "moderate intensity," for a total of $\geq$150 min.wk^{-1}. Moderate intensity exercise, in this context, is quantified as that which raises the heart rate to 64-76% of the age-predicted maximum (HR_{max}). Regular activity at this specific level is in many population studies directly correlated with lower rates of cardiovascular disease (CVD), including heart attack and stroke, which account for around one third of all deaths in the European Union, and around 160 000 deaths per year in the

[146] In addition to its well-documented benefits for social connectedness and mental wellbeing (Liu, 2009; Sempik, Aldridge, & Becker, 2009).

UK alone (British Heart Foundation, 2015). It is valuable to note, however, that while the "optimal" zone for cardiovascular health benefits is commonly equated with this 64-76% of HR_{max} (Garber et al., 2011), merely extending exercise duration at lower intensity levels (as low as 60% HR_{max}) has also been shown to induce significant improvements in physical wellbeing for otherwise sedentary individuals with poor baseline aerobic fitness (Lee & Skerrett, 2001; Manson et al., 2002). Indeed, The American College of Sports Medicine (2014) has proposed that in the case of deconditioned individuals, exercise intensities of only 55% to 64% HR_{max} may facilitate improvements in cardiorespiratory fitness.

It is clear that, in Europe and the USA at the very least, governments and other pertinent agencies have made limited headway in delivering a consistent upward trend in sport and physical exercise participation to date, in respect of both adults and children, and particularly within specific population groups with historically lower participation rates (Jiménez-Pavón et al., 2013; Ortega et al., 2013). This has led to widespread concerns that CVD and other chronic diseases may only have an increasing profile in pertinent populations in years to come. Moreover, in turn, it further highlights the need for more concerted efforts to boost engagement with the kinds of moderately intense exercise activities that will *sustain* participation. If such efforts were successful, it has been estimated that premature mortality rates within Europe could be cut by nearly 7.5% - or the equivalent of 676,000 deaths - a figure twice that of targeting obesity alone (Ekelund et al., 2015). Given that healthy physical activity can encompass a range of even the simplest activities endemic to daily living, such as gardening, walking and climbing stairs, and also job-related tasks including active movement between home and workplace (Dugdill, Crone, & Murphy, 2009), there are potentially numerous strategies for promoting uncomplicated means of boosting health among inactive members of the population (Hubley & Copeman, 2009). Some of these may involve traditional "facility" settings, while others may well involve more extensive utilisation of natural environments.

Activity in natural settings

Even the most basic physical activity in green environments has been associated with demonstrable health benefits (Coon et al., 2011). In a longitudinal study involving 4000 adults aged over 60 years, for example, Ekblom-Bak et al. (2014) found that significant reductions in the risk of heart attacks can be facilitated through regular activities of daily living, such as gardening, with consequential extensions in life expectancy. Park et al. (2014a), meanwhile, used portable telemetric calorimeters and heart rate monitors with a small sample (N=15) of men and women undertaking a range of gardening tasks in South Korea. The participants, all young adults (mean age = 24.7 ± 1.4 years), were found to consistently work at moderate or higher exercise intensities commensurate with corollary cardiovascular health benefits. Corresponding studies, involving children (Park et al., 2013) and older adults (Park, Lee, Lee, & Son, 2014b) undertaking tasks such as digging, raking, mulching, hoeing, weeding, sowing and watering, found similar results. In the UK, meanwhile, Yerrell (2008) empirically illustrated numerous fitness benefits (in strength, flexibility, stamina and enhanced daily activity levels) gained from working outdoors in an evaluation of the "Green Gym" initiative, which has now become firmly established (having been launched in 1997), with at least 70 community-based projects reported in action across the UK by 2011. Findings suggested that activities were of sufficient duration and intensity to improve general cardiovascular fitness amongst participants, promoting significant improvements in physical health scores after six months of regular involvement. A significant number of similarly-designed green exercise schemes have emerged within the UK in the last decade, including numerous charity-led "Thrive" projects (Page, 2008). In many cases these projects are directly supported by health services, involve multi-agency partnerships across the voluntary and public sectors, and are designed to bring patients and the broader local community together, often with National Health Service (NHS) land being given over to the projects for use as an active space. Increasingly, hospital and care settings are using gardens for therapeutic purposes with a range of patients and needs (Fieldhouse, 2003; Wichrowski et al., 2005). Such schemes are variously described as horticultural therapy; therapeutic horticulture; and community horticultural/gardening programmes, depending on their setting and the nature of participation (Sempik et al., 2009)[147].

In terms of broad public health, the primordial problem for healthcare professionals working in this domain remains the effective promotion of *initial* engagement with physical activity among otherwise inactive populations (Birch, 2005; Morgan, 2005). Secondarily, however, even where individuals are successfully engaged in sport and other "moderately intense" forms of active recreation, research indicates that rates of adherence in many countries are low. A detailed systematic review of UK-relevant studies has demonstrated that up to 80% of participants fail to maintain their engagement with formal exercise referral programmes (Gidlow, Johnston, Crone, & James, 2005). Moreover, patterns of adherence vary substantially within and across different settings, e.g. workplace, community and commercial, core explanations for which have, to date, included a difficulty

[147] Findings reported in this paper emerge from an initiative best described as a "community horticultural / gardening programme," with specific focus upon conservation activity.

and/or discomfiture in sharing physical environments with regular/dedicated exercisers, communal changing areas, and the perception of others simply being "more" fit and athletic (Hubley & Copeman, 2009; Naidoo & Wills, 2009).

Finding modes of activity that not only engage but also retain participants is, therefore, a key consideration in the initial design of any physical activity programme, and a matter for continual monitoring among those that lead them. Programmes that can demonstrate relatively immediate, personalised results have been demonstrated to be particularly successful in retaining participants (Fieldhouse, 2003). An evaluation of a Green Gym project conducted by Birch (2005), for example, highlight a range of intrinsic adherence-motivators articulated by participants in interventions that are oriented around task-oriented or process-oriented goals, such as effort, personal achievement and/or satisfaction, and problem solving (see also Carron, Hausenblas, & Estabrooks, 1999; McArthur, Dumas, Woodend, Beach, & Stacey, 2014). There is also evidence that group-based activities are likely to facilitate commitment and retention (Burke, Carron, Eys, Ntoumanis, & Estabrooks, 2006), through the development and maintenance of social support mechanisms, and the use of activities that people can co-ordinatively find enjoyable, fun and varied (Trost, Owen, Bauman, Sallis, & Brown, 2002; Whaley & Schrider, 2005). Other variables of importance in this domain include the quality of exercise leadership (Seguin et al., 2010) and a regular routine (McArthur et al., 2014).

The use of nature-based activity environments for physical recreation – whether an urban park, community farm or open countryside – provides, thus, an easy access, low cost setting that has the clear potential, according to the limited evidence-base available, to deliver effective and measurable health improvements (Fieldhouse, 2003; Wichrowski et al., 2005). Encouraging outcomes have been observed in numerous projects (Sempik et al., 2009) but, and as aforementioned, there remains a dearth of research that can robustly demonstrate the quantitative health benefits of green exercise and other nature-based initiatives *within* those actual environments.

Materials and methods

The "Greenfingers" community conservation initiative (from which extant findings are drawn) began as a six week pilot in October 2010, designed and delivered by the University of Cumbria in partnership with the local City Council. Greenfingers was initially focused primarily upon the clearance of invasive, non-native plant species (such as rhododendron) from a section of a large local park, and their replacement with native plants and trees. The project attracted a consistent base of volunteers, and was consequently extended indefinitely with a new recruitment drive undertaken each subsequent September (although the project was accessible all year round to newcomers and regular participants)[148]. This paper reports findings based exclusively on data collected between the immediate post-pilot stage and the end of autumn 2014.

Participants

Heart rate responses were recorded from three age-partitioned populations (a random stratified sample selected in direct proportion to the divisions in overall participant-base) taking part in the initiative, to assess the likelihood of the pertinent activities being of sufficient sustained intensity to improve physical fitness.

Table 1: Sample characteristics

Population Label	Age mean ± SD (range) years	N
"Young"	21.4±2.8 (19-28)	25
"Middle"	42.3±8.8 (30-49)	8
"Older"	65.0±5.4 (56-73)	9

Participants were required to complete a health screening questionnaire to assess their suitability for participation and, as such, all were determined to be of sufficiently good physical health to take part in potentially moderate-to-vigorous physical activity[149].

Procedure

Participants were encouraged to engage with activities "at their own pace," and tasks involved included a variety of outdoor tasks such as sawing branches, digging, clearing away debris, pruning small and large plant stems, and lifting, raking, and dragging bundles of plant debris in sacks. There was also some walking involved between the meeting point and the activity areas.

Initial resting heart rates were obtained from participants following a 5 minute rest period in which they were asked to (a) sit still, (b) engage in no animated conversation, and (c) neither eat nor drink. Heart rate data collection took place for a continuous period of 55 minutes immediately following this resting measurement, with measurements taken at five minute intervals. Participants then engaged in a further rest period of five minutes, using the same conditions as the first, such that a passive recovery measurement could be made on 60 minutes. Polar® Heart Rate Monitors

[148] University students also engaged with the project across a number of weeks every autumn, and local authority park staff supervised the volunteers and students.

[149] All subjects also completed an informed consent form, and full ethical approval was granted by the pertinent institutional Ethics Committee. All participants - and collected data - were handled in strict accordance with the conditions of this ethical approval.

(Polar T31, Polar, Kempele, Finland), which measure transmission of electrical impulses from the heart via a chest belt to a wristwatch monitor, were used throughout.

Analysis

Resting heart rate for each participant was recorded at 0 min (following the statutory rest period); passive recovery was given for 5 minutes before the final heart rate reading at 60 min. The absolute heart rate response ($bts.min^{-1}$) was recorded, and HR_{max} (%) was calculated as a percentage of age-adjusted maximum heart rate, using the the current ACSM (2014) standard of 220 minus participant age. All data were normally distributed in terms of skewness and kurtosis. Thus, data were analysed with a one-way ANOVA for the mean absolute heart rate response and mean HR_{max} from minutes 0-55. An alpha level of 0.05 was used for all statistical comparisons and *post hoc* comparisons (Bonferroni) were performed where appropriate (SPSS, v.15). Data are given as mean ± standard deviation (SD).

Results

Figure 1 illustrates that, over the 55 minutes of self-motivated activity, all groups worked at a relatively similar heart rate (the mean HR of the 55 minutes was 123.7 ± 15.6 $bts.min^{-1}$ for the young group, 119.7 ± 15.9 $bts.min^{-1}$ for the middle group, and 115.7 ± 11.1 $bts.min^{-1}$ for the older age group.

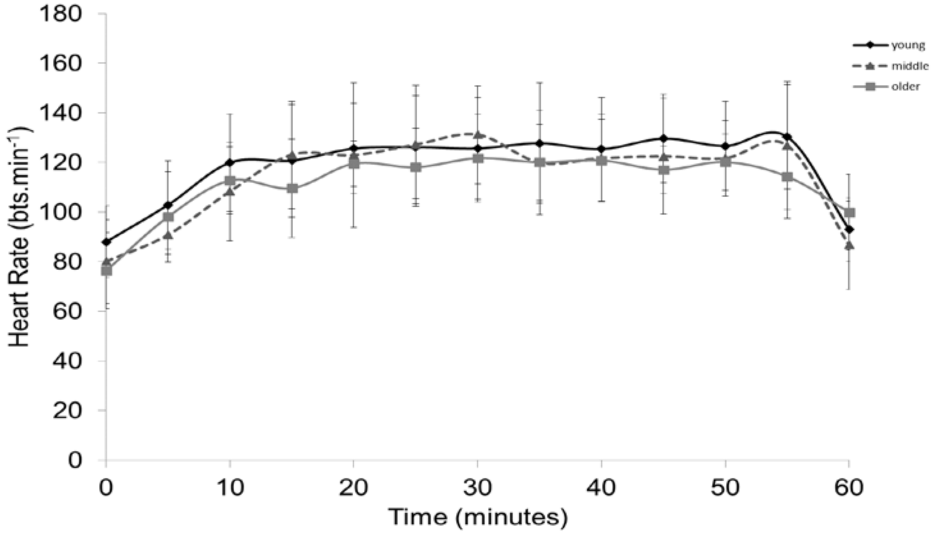

Figure 1: Heart Rate response ($bts \cdot min^{-1}$) in young, middle and older adults. Values are mean ± SD

Although the *absolute* heart rate was similar for all three groups, when this data is normalised using percentage of HR_{max}, as shown in Figure 2, the older group worked at a significantly higher HR_{max} than the young group ($p<0.001$). The mean $\%HR_{max}$ for the full 55 minutes being 62.3 ± 8.0 % for the young group, 67.4 ± 9.3 % for the middle group and 74.9 ± 9.0 % for the older group.

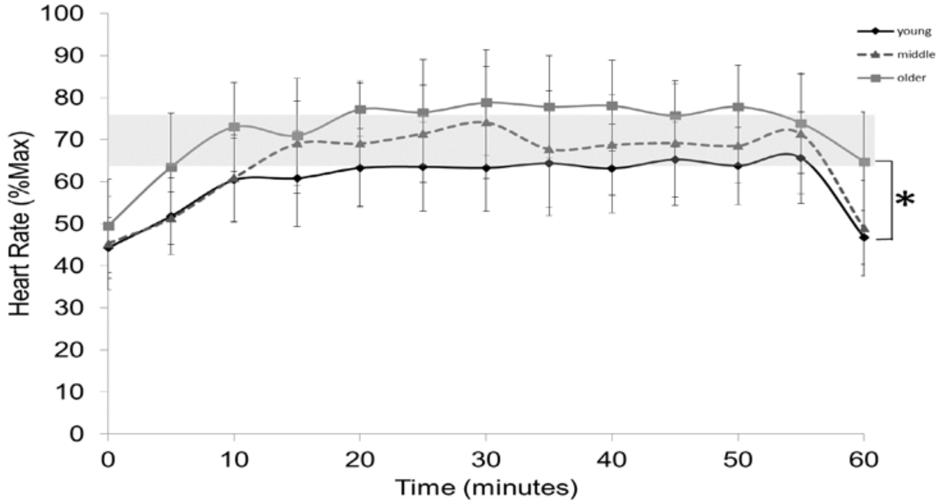

Figure 2: Percentage of HR_{max} in young, middle and older adults. Values are mean ± SD. The grey band indicates the moderate intensity training zone. * indicates significant difference ($p<0.05$) between the mean of the young and older group

After 10 minutes, all groups were working at the exercise intensity defined by Garber at al. (Garber et al., 2011) as “moderate” (between 64 and 76 $\%HR_{max}$, shown by the grey band). The young group, however, remained at the lower end of the banding and never increased above this moderate intensity while the older group, on occasion, were working at an intensity which would be classified as “vigorous” (American College of Sports Medicine, 2014).

Discussion

As described above, it is widely stipulated that in order to develop and maintain physical fitness and health, exercise should include a cardiovascular component, equivalent to moderate intensity for a total of ≥ 150 $min.wk^{-1}$. This intensity of exercise is quantified as that which raises the heart rate to 64-76% of the age-predicted maximum (American College of Sports Medicine, 2014). For all three groups described, the horticultural activities involved induced exactly these intensities. The findings described for the young group are, moreover, highly conversant with those of analogous quantitative field-based studies (Park et al., 2013; Park, Lee, Lee, & Son, 2014a), demonstrating participant attainment of optimal levels of healthy cardiovascular activity in response to a variety of gardening tasks. Equally, the measurements reported here (made in a naturalistic setting, and with participants working at self-motivated rates) are also highly comparable with others collected in controlled laboratory environments. Park (2014b, p.229), for example, using a participant sample of N=18 older adults (mean age = 70.9 ± 3.3 years) found that activities such as "making a vegetable bed, and maintaining a garden" were commensurately "moderate intensity physical activities" for those individuals.

Although, as proposed by Dugdill, Crone, Murphy (2009), participant diaries (or an equivalent psychometric measurement tool) to assess participant mood-state, stress and so forth were not used as a means of improving internal validity, no significant outliers emerged in any of the three groups. It should also be noted that green physical activities such those documented here have been empirically reported to have stress-reducing qualities of their own (Page, 2008; Wichrowski et al., 2005). The results in their totality, and their synergy with those emergent of other studies in both naturalistic and laboratory settings, therefore, lend strength (albeit on a relatively small scale) to the hypothesis that the varied physical activities endemic to a community horticultural/gardening programme such as this could indeed prove as useful a method for cardiovascular health promotion as more conventional forms of facility-based sport or exercise among individuals of all ages (Coon et al., 2011; Dugdill et al., 2009; Ekblom-Bak et al., 2014).

It is clear that many governments (particularly in the Western world) face a profound, complex and long-term struggle to reverse a pandemic of inactivity (and, by association, increasing levels of ill-health and chronic diseases). Within Europe alone, inactivity has been reported to be responsible for twice as many deaths as obesity[150], with over 650 000 deaths attributable to this cause annually (Ekelund et al., 2015). Finding appropriate vehicles to engage people from different socio-economic backgrounds, age, gender, race and health status in appropriately intense forms of physical activity is essential in order to make both preventative and therapeutic management of a variety of chronic physical and mental health conditions possible (American College of Sports Medicine, 2014). Encouraging a range of individuals who are conventionally ill-disposed towards (or unable to afford or access) sports or conventional gym-work to participate in green tasks that facilitate a group dynamic, and improve the environment itself, may well not only be more likely to engage but also to *retain* their involvement in healthy cardiovascular activity than, for example, using a treadmill or recumbent bike for a similar

[150] Whereby individuals record a body mass index in excess of 30.

total duration each week (Fieldhouse, 2003; McArthur et al., 2014; Page, 2008; Sempik et al., 2009).

Conclusion

The results of this study are part of a growing and increasingly compelling corpus of evidence for the value of horticultural activity for cardiovascular health promotion. It remains the case, however, that studies of the benefits of cardiovascular activity conducted in actual naturalistic settings remain relatively few in number, and relatively small in scale. As noted above, this is connected to difficulties in robustly demonstrating the efficacy of community-based interventions within the dominant orthodoxies of healthcare science (James et al., 2008) – with corollary impacts on research funding opportunities. The specific domain, thus, remains largely bereft of the kinds of large-sample, quantitative and ecologically-valid primary research that has the full potential to convince medical professionals, and (thereby) actively direct health policy.

This is not to propose that the broader concerns of Pretty and colleagues (Pretty et al., 2005; Pretty et al., 2006) regarding the value of green exercise are going unexamined. Findings from constellation of different empirical approaches to the matters at hand, as herein described, continue to converge in a highly positive manner, as evidenced by recent systematic review (Coon et al., 2011). Ten years after their initial call for more quantitative evidence in the field, however, and as a result of a variety of practical, structural and academic factors, there remains a great deal of work to be done.

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