Chapter 3

Green exercise for health

A dose of nature

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Introduction

A strong body of evidence now shows that exposure to nature has positive health and well-being benefits. Nature promotes stress recovery, protects from future stresses and improves concentration and ability to think clearly. It is also well established that regular physical activity has both physical and psychological health benefits. Therefore, knowing that both physical activity and nature independently enhance health, the term Green Exercise was coined to signify the synergistic health benefits derived from being active in green or natural places (Pretty et al., 2005).

Here we describe theories linking nature and health which underpin the green exercise concept. We then summarise some of the key green exercise research findings to date and discuss the notion of an ‘optimal dose’ of green exercise for maximum health gain. We identify what further research is required to inform the optimum dose and associated prescriptive guidelines to influence future policy decisions. This chapter mainly focuses on psychological outcomes.

Theories linking nature, green exercise and health

For many thousands of years humans have had regular engagement with nature; from their roles as hunter-gatherers and farmers to, in more recent times, actively seeking natural spaces to reduce the stress of modern life (Fawcett and Gullone, 2001). Whilst research seems to support the biophilia hypothesis discussed in Chapter 2 (Kellert and Wilson, 1993; Kahn, 1997; White and Heerwagen, 1998; Fawcett and Gullone, 2001; Joye, 2007; Grinde and Patil, 2009; Windhager et al., 2011), it is unclear exactly how it might work, which genetic mechanisms are involved and how they are affected by behaviours and external environments.

The Psycho-Evolutionary Stress Reduction theory hypothesises that exposure to nature promotes stress recovery (Ulrich, 1981; Herzog and Strevey, 2008; Ewert et al., 2011). Natural environments provide positive distractions from daily stresses and invoke feelings of interest, pleasantness and calm, thereby reducing stress symptoms and promoting positive affect (Ulrich, 1981, 1984;

Herzog and Strevey, 2008; Ewert et al., 2011). This stress reduction restores an individual's physical and mental well-being through affective or emotional changes. Studies supporting this theory report reductions in stress measures such as blood pressure, heart rate and stress hormones following exposure to nature (Ulrich 1991, 1993; Hartig et al., 1996, 2003; Laumann et al., 2003; Herzog and Strevey, 2008; Ward Thompson et al., 2012). The Attention Restoration Theory (Kaplan and Kaplan, 1989; Kaplan 1995) defines two types of attention: directed attention and involuntary attention. Directed attention requires mental effort and concentration and if overused leads to directed attention fatigue (Kaplan, 1995; Taylor et al., 2002; Berman et al., 2008; Herzog and Strevey, 2008; Taylor and Kuo, 2009; Ewert et al., 2011; Rogerson and Barton, 2015). We regularly engage in this type of attention in everyday lives, often resulting in mental fatigue. However, natural environments promote the use of involuntary attention, providing an opportunity for recovery from mental fatigue (Berman et al., 2008 Taylor and Kuo, 2009; Rogerson and Barton, 2015). For example, Ottoson and Grahn (2005) reported that resting for one hour in an outdoor garden resulted in greater improvements in directed attention than equivalent rest indoors; whilst nature views or the presence of plants within the workplace have been demonstrated to reduce mental fatigue (Kaplan, 1993; Berto, 2005; Raanaas et al., 2011).

Physical activity has also been linked with attention restoration via the transient hypofrontality hypothesis (Dietrich and Sparling, 2004; Dietrich, 2006; Rogerson and Barton, 2015). This suggests that directed attention is associated with prefrontal cortex activation and that physical activity results in prefrontal cortex restoration; as activation of the prefrontal cortex lessens in order to facilitate greater activation of the brain structures concerned with movement (Daffner et al., 2000; Miller and Cohen, 2001; Dietrich and Sparling, 2004; Dietrich, 2006; Rogerson and Barton, 2015). Whilst this decreased prefrontal cortex activity may be detrimental to cognition during physical activity (Dietrich and Sparling 2004; Labelle et al., 2013) the opportunity for restoration is likely to result in improved executive function and cognitive performance following physical activity (Yangisawa et al., 2010; Byun et al., 2014). Considering the individual benefits of both physical activity and contact with nature for cognition, green exercise provides greater opportunities for restoration due to interaction of the two disparate influences (Rogerson and Barton, 2015). This interaction might account for the additive psychological health benefits of green exercise.

Green exercise research approaches

Green exercise research has predominantly adopted three methodological approaches: (i) comparing outcomes of built versus nature-based outdoor exercise (Berman et al., 2008; Brown, et al., 2014; Hartig et al., 2003; Lee et al., 2011; Park et al., 2010); (ii) comparing outcomes of indoor exercise to those of outdoor exercise (Focht, 2009; Ryan et al., 2010; Teas et al., 2007; Thompson-Coon et al., 2011); (iii) employing ergometers in laboratory settings to control the exercise component and examine the importance of the visual exercise-environment (Akers et al., 2012; Pretty et al., 2005; Rogerson and Barton, 2015; Wood et al., 2013).

Urban/built versus nature-based outdoor exercise

The main strength of this research is that it represents an ecologically valid comparison, in that individuals may often exercise in one of these two environments. Therefore, such research findings can be understood and applied to real-world settings. The workplace offers a typical contextual example. Brown et al. (2014) asked office workers to undertake two lunchtime walks per week for eight weeks using one of two routes; while some of the office workers always walked a nature route (centered around trees, maintained grass, and public footpaths), others walked a built route (pavements around housing estates and industrial areas). Self-reported mental health improved for those who completed the eight weeks of nature walking, but significant improvements did not occur in the built environment. Berman et al. (2008) found that although walking in a downtown environment and a botanical garden both facilitated improvements in directed attention (a measure that might be described as a psychological resource for, or temporal ability of concentration), the improvement after botanical garden walking was statistically significant; however, the improvement via downtown walking was not. Additionally, walking in a botanical garden elicited greater mood improvements compared to walking in the downtown environment. These results suggest mood and cognitive attention benefit from nature-based exercise environments. Other built versus nature-based walking studies report similar results (Hartig et al., 2003).

A review by Bowler et al. (2010) reported that exercise in natural, compared to man-made, environments was associated with lower negative emotions such as anger and sadness and greater levels of attention. Mitchell (2013) found that people who regularly used the natural environment for physical activity (defined as at least once per week) had about half the risk of poor mental health compared to those who did not do so. Additionally, each extra weekly use of the natural environment for physical activity was identified to reduce the risk of poor mental health by a further 6%. Walking in natural environments compared to environments lacking nature was found to be associated with less perceived stress and negative effect and more positive well-being (Roe and Aspinall, 2011; Marselle et al., 2013). Evidence also suggests that green exercise results in greater improvements in self-esteem and mood, via reductions in tension, depression, anger and confusion and increases in vigor (Barton et al., 2009; Rogerson et al., 2015) and reduced levels of frustration and arousal and higher levels of meditation (Aspinall et al., 2013).

Individuals' choices of built or nature exercise environments may also be important to physiological health outcomes (Brown et al., 2014; Lee et al., 2012; Li et al., 2011). However, these are not discussed here as this topic receives greater attention in Chapters 8 (Li) and 14 (Gladwell and Brown). Despite the merits of this methodological approach, a main limitation is that it often lacks rigorous control of the exercise component, which is important, as exercise characteristics such as duration and intensity themselves influence a number of outcomes (Ekkekakis and Petruzzello, 1999; Ekkekakis et al., 2011).

Indoor versus outdoor exercise

In comparisons of indoor and outdoor activities, it is often difficult to ensure comparability of the exercise component, therefore, it is challenging to infer respective contributions to reported outcomes, of environmental differences and exercise differences. In a review of studies comparing indoor and outdoor physical activity, Thompson Coon et al. (2011) found that compared with walking indoors, outdoor walking was associated with more positive mood, increased self-esteem, vitality, energy and pleasure; alongside reductions in frustration, worry, confusion, depression and tiredness. Running outside was also associated with less anxiety, depression, anger and hostility than running indoors (Thompson Coon et al., 2011). Consistent with this, Focht (2009) found that female participants experienced greater pleasant affective states after an outdoor walk compared to an equivalent indoor walk. They also enjoyed the outdoor walks more and reported a greater intention to continue this behaviour in the future. Such findings are of note for policy-makers in public health, as this suggests a role for green exercise in increasing physical activity participation levels, in utilizing links between affective responses to exercise, intentions, and future exercise behaviours (Ekkekakis et al., 2011; Kwan and Bryan, 2010a; 2010b; Williams et al., 2008).

Ryan et al. (2010) controlled the speed of walking exercise and prohibited verbal social interaction during a comparison of indoor (whereby participants were led through a series of underground hallways and tunnels that were devoid of living things, although there were many objects, posters, physical changes, and colours present) versus outdoor walks (participants led along a largely tree-lined footpath along a river). Greater improvements in feelings of vitality were reported in the outdoors condition, suggesting that exercise environments are important beyond their potential influences on physical exercise and on social interactions. However, the environment may influence social experiences of exercise sessions. Teas et al. (2007) noted that in addition to promoting significantly greater improvements in mood compared to indoor exercise (in a sample of post-menopausal women), outdoor exercise also facilitated participants' engagement in verbal interaction during group exercise. Importantly, this suggested that there are additional social benefits to be gained from green exercise participation in groups.

Urban/Built versus nature views in the laboratory

The strength of this approach is that the exercise component can be rigorously controlled. The limitation is that it does not provide the full-sensory experience of green exercise participation, therefore, it requires further investigation so as to conclude whether laboratory-based findings are fully applicable to the real world.

Pretty et al. (2005) analysed the effect of exercising on a treadmill whilst viewing either rural pleasant, urban pleasant, rural unpleasant or urban unpleasant scenes on self-esteem, mood and blood pressure. There was also an exercise-only condition whereby participants exercised whilst viewing a blank screen. Whilst exercise alone resulted in improvements in self-esteem and mood, viewing urban and rural pleasant scenes during exercising produced greater effects. The unpleasant scenes had a depressive effect on both self-esteem and mood. The response patterns for physiological health outcomes displayed a similar pattern. Blood pressure improved immediately following participation in the exercise-only condition, but significant improvements were only reported after viewing rural pleasant scenes. Exercise whilst viewing the urban unpleasant scenes increased blood pressure relative to the control condition and, therefore, seemed to undo the beneficial effects of exercise for blood pressure (Pretty et al., 2005).

Akers et al. (2012) similarly focused on the role of the visual exercise environment on the outcome of mood, during cycling exercise. After viewing colour-filtered scenes of a first-person movement through a woodland road environment (in a counter-balanced order) during moderate intensity cycling, participants reported greatest improvements in mood following the unedited ‘green’ video, compared to achromatic- (grey) filtered and red-filtered video. Participants’ perceived exertion was also lowest in the unedited video condition, suggesting that environmental colour may contribute to the reported psychological benefits of green exercise. Other research using this methodology reported that during treadmill exercise, compared with viewing either a blank screen, video footage of a built environment or viewing video footage of a nature environment, facilitated restoration of depleted directed attention (Rogerson and Barton, 2015). This finding complements the findings of Berman et al. (2008) and Hartig et al. (2003), demonstrating the way in which findings from different methodologies together contribute to a greater understanding of this topic. Again focusing on treadmill exercise, Wood et al. (2013) found that manipulation of environmental scenes viewed during exercise did not significantly influence self-esteem and mood outcomes in a sample of adolescents, suggesting that age may be an important variable to consider in applications of green exercise.

Is there an ‘optimum dose’ of green exercise?

Although many physiological outcomes of green exercise have been reported, we will focus here more on psychological outcomes. In order to maximise potential benefits from green exercise participation, it is necessary to know the optimal ‘dose’ of this experience. This applies equally for either particular outcome measures alone, or for combined mental and physiological health outcomes overall. Dose-response modeling is an analytical technique often used for informing guidelines for health interventions (Shanahan et al., 2015). The effects of different doses

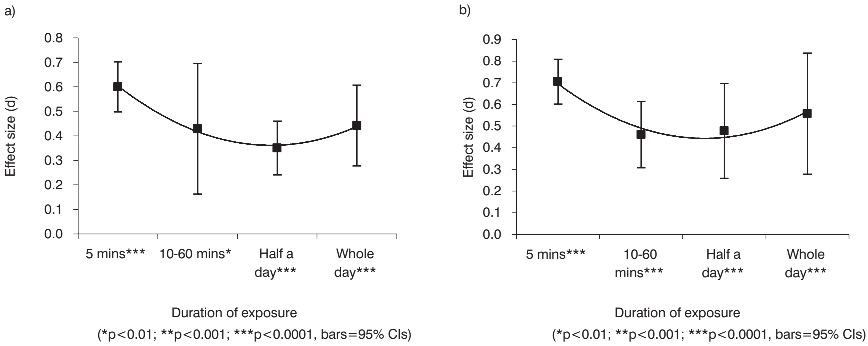

Figure 3.1 a: Dose response data for the effect of exposure duration on self-esteem. b: Dose response data for the effect of exposure duration on Total Mood Disturbance (TMD) (Barton and Pretty, 2010)

of an activity (or substance) on causally linked health responses are modeled; that is, shown by a curve on a graph (Altshuler, 1981; Shanahan et al., 2015). To date, very little research has directly sought to identify optimal characteristics for maximising desired outcomes of green exercise participation (Barton and Pretty, 2010; Rogerson et al., 2015).

A meta-analysis (n=1252) (Barton and Pretty, 2010) revealed distinct dose-response curves for the optimal duration, intensity and types of green exercise activities. For each outcome measure of interest (e.g. mood), a dose-response curve was calculated for each 'dose' variable upon which the measure was assessed (e.g. duration). Figure 3.1 shows curves for the outcome measures of self-esteem and overall mood for the 'dose' variable of duration. This indicates that the greatest benefits to mood and self-esteem occur within the first five minutes of exposure. However, these results may also represent differences in activity type, as this research focuses on a range of different activities (e.g. cycling, walking, gardening, fishing, etc.). Figure 3.2 suggests that for overall mood and self-esteem, 'light' intensity exercise may be most beneficial.

Green exercise participation comprises interactions between numerous environmental, exercise and individual-related variables (Figure 3.3) (Brymer et al., 2014; Rogerson et al., 2015). Therefore, knowledge of optimal doses of exercise per se and of nature exposure might also be considered together with green exercise research findings when attempting to identify an optimal dose of green exercise for health benefits. The three dose–response components for both nature and exercise would include: (i) intensity of exposure [i.e. quality (species richness, biodiversity, habitats, vegetation structure, etc.) and quantity (extent and type of vegetation) of nature]. The quantity and quality of available green space close to the home is correlated with longevity and a decreased risk of mental ill-health (Maas et al., 2006, 2009; Ward Thompson et al., 2012; White et al., 2013). Individual preferences and perceptions may also influence the dose response. This would also relate to the intensity of the exercise; (ii) frequency

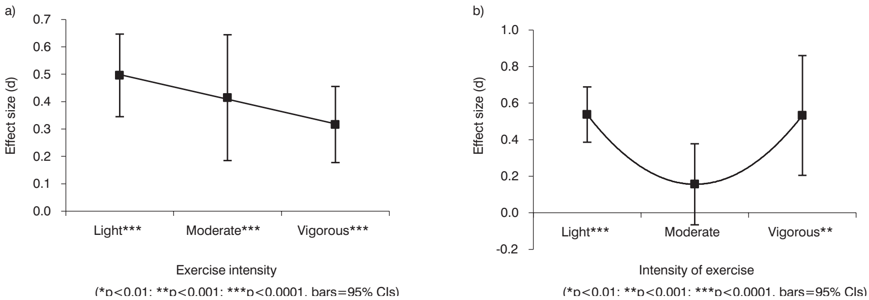

Figure 3.2 a: Dose response data for the effect of exercise intensity on self-esteem. b: Dose response data for the effect of exercise intensity on Total Mood Disturbance (TMD) (Barton and Pretty, 2010)

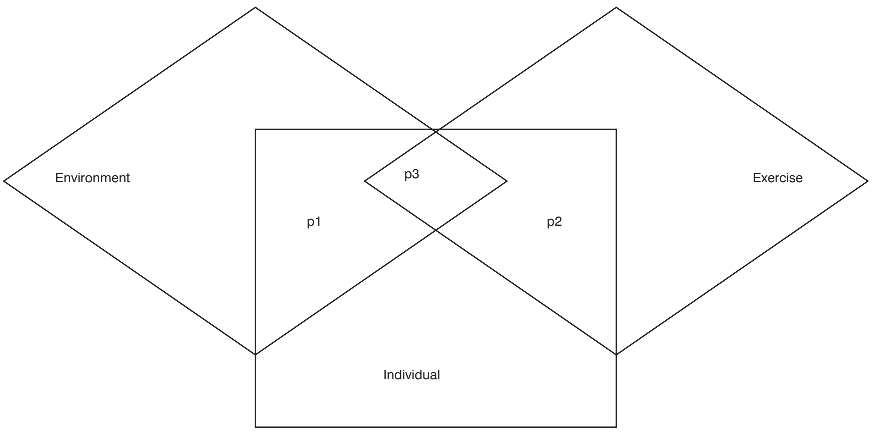

Figure 3.3 The four components (categories of variables) of green exercise: the three physical components, and the processes component (Source: Rogerson et al., 2015, pp. 1–3)

of exposure [how often you exercise or experience nature in a defined time frame. This may also be influenced by the pattern of exposure (e.g. intermittent, random, cumulative, etc.) and the outcomes measured (e.g. psychological or physiological health – frequent short bouts of nature exposure could cumulatively negate mental fatigue but have minimal impact on physiological health, whereas participating in repeated bouts of exercise over a longer time period might enhance cardiovascular health)]; (iii) duration of exposure [length of time of exercise bout and/or nature exposure].

Dose–response relationships for exercise have also been examined. For example, regarding the outcome measure of 'affect', greater pleasure tends to be experienced by individuals when exercise intensity is below lactate threshold, with supra-threshold intensities eliciting negative affect (Ekkekakis et al., 2011). Additionally, self-selected exercise intensity elicits greater positive affect than when intensity is imposed (Ekkekakis et al., 2011).

The notion of an optimal dose of exposure to nature has also received consideration. Shanahan et al. (2015) reviewed existing literature to analyse the potential shapes of dose-response curves for nature dose (duration of exposure) and a health outcome. They identified four potential shapes: (i) rapid increase after low dosage (e.g. cognitive function improved within 10 minutes of viewing natural images, Berto, (2005)), followed by a plateau; (ii) decline in health parameter (as dosage continues to increase); (iii) a more gradual increase (as dosage increases), followed by a plateau; and (iv) decline in health parameter. Attention restoration theory predicts that different types of nature may offer different scope for psychological restoration, as it is the presence of particular characteristics of nature environments which are important to their influence (for example, fascination; extent) (Kaplan, 1995). Concurrently, different types of nature provide different opportunities, or affordances, for individuals to gain health benefits (Brymer et al., 2014).

The presence of water within environments has been suggested to enhance affective outcomes of nature exposure (White et al., 2010), and this has also been shown to occur via green exercise participation (Barton and Pretty, 2010), although this influence may be less important at higher exercise intensities (Rogerson et al., 2015). Furthermore regarding exposure to nature per se, the 'dose' variables of: number of habitats in a given environment, duration of exposure to nature and overall environment type, have been considered in relation to the 'response' outcome measures of individuals' reflection scores, reductions in blood pressure, and stress reduction, respectively (Shanahan et al., 2015). These dose-response relationships are shown in Figure 3.4.

In order to understand the overall optimal dose across multiple health measures, responses for multiple outcomes (e.g. mental well-being, cognitive function, blood pressure) might be assessed for a given dose variable, in order to identify an average trend. Following calculation of dose–response curves for given outcome measures in relation to different 'dose' variables, these may either be considered disparately, or analysed to examine possible interactions between curves (e.g. duration by exercise intensity interaction). Although it is beyond the scope of the current chapter to calculate what an optimal dose of green exercise might comprise, this may be achieved increasingly accurately as the body of research evidence grows. To enable calculations of optimal green exercise doses, there is a need for researchers to present effect sizes for their data, to ensure comparability of results. Furthermore, separate dose–response curves will be required to identify optimal frequency of green exercise behaviours, as opposed to outcomes of acute bouts of green exercise.

In addition to identifying the optimum dose of green exercise, it is important to know *who* that dose may benefit most and least. Barton and Pretty's (2010) meta-analysis found that the health benefits of green exercise were greatest for

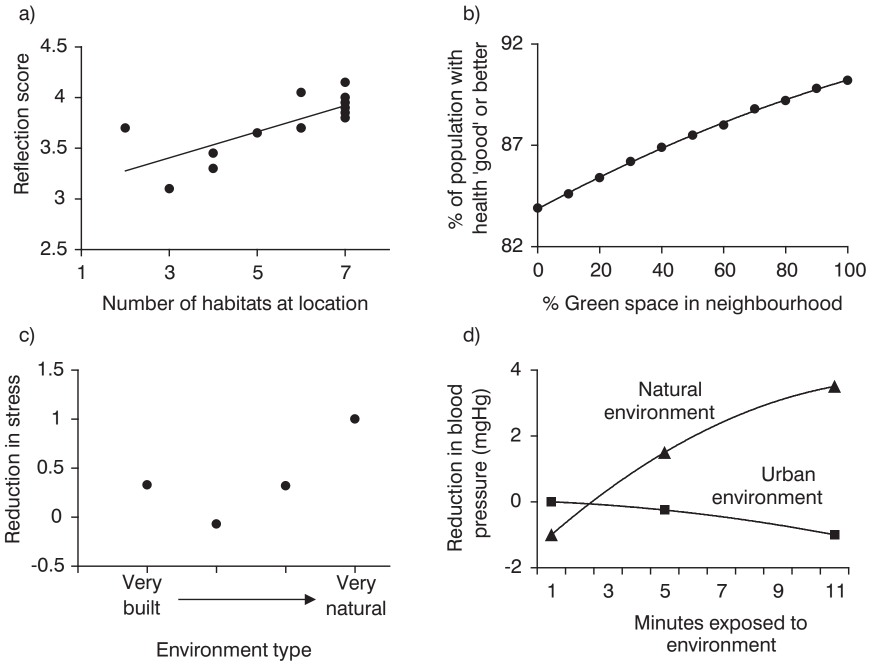

Figure 3.4 Examples of the dose–response relationship between nature and measures of health or well-being from previous studies

(a) psychological well-being ('reflection') in response to exposure to different numbers of habitat types in Sheffield, United Kingdom (Fuller et al. 2007); (b) the change in mean arterial diastolic blood pressure over time during exposure to urban and natural settings in California (adapted from Hartig et al. 2003 to show only the first section of the experiment where participants were not exercising); (c) the change in stress levels in response to different landscape types (adapted from Beil and Hanes 2013 to show inverse of stress measure originally presented) (Source: Shanahan et al., 2015).

those with declared mental health problems. Concurrently, Roe and Aspinall (2011) found that people with mental health problems experienced greater reductions in stress following a rural walk than people with a good level of mental health. These findings suggest that green exercise should also play an important role in improving the health and well-being of people suffering from mental ill-health.

More evidence is required for differences in psychological green exercise benefits between sexes to become clear. Whereas Barton and Pretty's (2010) meta-analysis found both women and men similarly to gain benefits from green exercise participation, a more recent study reported that sex significantly explained 6.8% of variance in pre- to post-green exercise mood improvements (Rogerson et al., 2015). Age could also be a mediating factor as improvements in self-esteem declined with age, whilst the improvements in mood followed a U-curve shape with middle-aged participants experiencing the greatest degree of benefits (Barton and Pretty, 2010). Interestingly, influences of exercise environment on self-esteem and mood demonstrated in adult samples have not been found for children (Reed et al., 2013; Wood et al., 2013). This suggests that age is a factor that should be considered for green exercise interventions.

In addition to individual characteristics, other mediating factors might include specific individual–environmental and exercise-related variables, such as personal preferences, knowledge and memory, previous experiences and perceptions of nature (degree of perceived restorativeness of landscape), enjoyment and nature relatedness (Hartig et al., 2014; Shanahan et al., 2015). Perceived neighbourhood greenness is strongly associated with better mental and physical health; those living in highly green areas are between 1.37 and 1.6 times more likely to have better mental health (Sugiyama et al., 2008). Rogerson et al. (2015) reported that participants who were more connected to nature and who reported greater enjoyment of their green exercise activity experienced the greatest number of health benefits. Culture and socio-economic status may also influence nature provision (i.e. quantity and quality of nature) and the level of engagement with nature (i.e. duration and frequency of nature dose due to different cultural value systems and attachments to landscapes) (Keniger et al., 2013; Shanahan et al., 2015). Increased access to green space is associated with improved general health, regardless of socio-economic status; whilst income-related inequality in health is moderated by exposure to green space (Allen and Balfour, 2014). Ethnicity can also influence attitudes, greenspace use and motivation to engage in outdoor recreation (Ozguner, 2011).

Despite this discussion of who may benefit from optimal doses of green exercise, large proportions of the psychological benefits of green exercise appear to be universally obtainable and independent of demographic, performance level, climatic and other environmental characteristics (Rogerson et al., 2015). This indicates that green exercise is a valuable method for improving the health and well-being of a wide variety of different groups of people.

Conclusions

Engaging in green exercise provides a number of benefits for health and well-being including reductions in anxiety and stress; improved mood, self-esteem, attention, concentration and physical health. Natural environments promote physical activity and social contact which in turn also improve health and well-being. A lot of the existing evidence is correlational (Keniger et al., 2013), so in order to develop and promote effective public health interventions an ‘optimal dose’ of green exercise needs to be identified. This requires an understanding of the types and amounts of nature and exercise needed to maximise health gains. Developing appropriate dose–response curves would inform prescriptive guidelines and minimum dose recommendations similar to existing public health recommendations for physical activity (30 minutes of moderate activity per day, Powell et al., 2011) fruit and vegetable consumption (five a day).

Although these recommendations are simplistic in their nature they are straightforward to communicate, they provide guidance for self-regulating behaviours that enhance health outcomes and have substantial impact at a population level (Whitelaw 2012; Hartig et al., 2014). However, dose-response modeling is challenging because it is subjected to many influential factors, such as individual characteristics, personal preferences and experiences, culture and socioeconomic status. The dose response relationship may also differ when considering population or individual level studies. Population response curves could inform urban green space and cost-effective spatial planning to maximise health outcomes. Using an epidemiological approach to develop dose response curves enables confounding factors to be statistically controlled for but does not explain causality. Experimental studies at an individual level can help to demonstrate causality, but they need to be rigorous in their design and can often lack statistical power.

To date, dose–response modeling has shown the greatest benefits for self-esteem and mood occur after the first five minutes of green exercise, which should be of a light intensity. This represents an important public health message as it easier to engage sedentary individuals in light intensity exercise of a short duration. Although this will not have an immediate impact on their physical health, engaging individuals in green exercise is often the biggest challenge. The physiological health benefits will accrue as participation continues. Furthermore, green exercise is of most benefit for people with mental ill-health; suggesting that there may be potential for the therapeutic application of green exercise. If future experimental work continues to report effect sizes, then a meta-analysis can be conducted to build on the existing dose–response data. Public health policies can then consider the use of nature and green exercise for improving and preventing ill-health and provide regular opportunities for people to access natural spaces.