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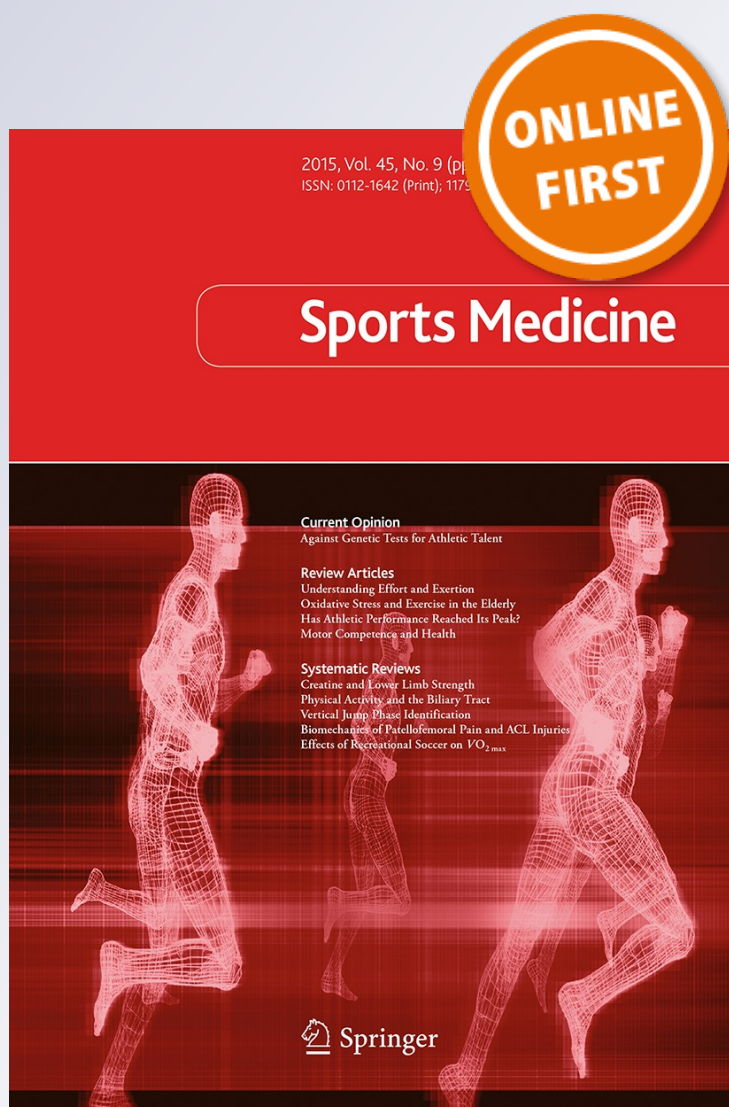
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# Physical, Psychological and Emotional Benefits of Green Physical Activity: An Ecological Dynamics Perspective

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**Abstract** Increasing evidence supports the multiple benefits to physical, psychological and emotional wellbeing of green physical activity, a topic of increasing interest in the past decade. Research has revealed a synergistic benefit of green physical activity, which includes all aspects of exercise and physical activity in the presence of nature. Our theoretical analysis suggests there are three distinct levels of engagement in green physical activity, with each level reported to have a positive effect on human behaviours. However, the extent to which each level of green physical activity benefits health and wellbeing is assumed to differ, requiring confirmation in future research. This elucidation of understanding is needed because previous literature has tended to focus on recording empirical evidence rather than developing a sound theoretical framework to understand green physical activity effects. Here we propose an ecological dynamics rationale to explain how and why green physical activity might influence health and wellbeing of different population groups. This framework suggests a number of unexplored, interacting constraints related to types of environment and population groups, which

shape reported levels of benefit of green physical activity. Further analysis is needed to clarify the explicit relationship between green physical activity and health and wellbeing, including levels of engagement, types of environmental constraints, levels of physical activity, adventure effects, skill effects and sampling of different populations.

## Key Points

Previous literature has typically provided an operational analysis of the benefits of physical activity undertaken in nature, and future work needs to understand how and why green physical activity might influence health and wellbeing with a multidisciplinary rationale.

Further investigation of interacting constraints on green physical activity effects is needed, including levels of engagement, types of environment, level of physical activity, adventure, skill effects and groups.

An ecological dynamics framework has the potential to provide principles for the design of green physical activity programmes as well as experiments on this topic.

This article is part of the Topical Collection on Designing environments to enhance physical and psychological benefits of physical activity: A multi-disciplinary perspective.

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## 1 Introduction

Maintaining human physical and mental health are major global concerns, with physical activity (PA) widely acknowledged as determining factors [1] in ensuring physical, psychological and emotional wellbeing. Physical

inactivity has been identified as the fourth leading risk factor for global mortality, associated with approximately 3.2 million deaths each year, and implicated in the prevalence of non-communicable diseases such as cancer and cardiovascular defects [2]. Further, one in four people in the world is affected by mental or neurological disorders at some point in their lives, which PA could alleviate [3].

Theoretical frameworks have been proposed to understand and explain determinants and correlates of PA, the four most prominent theories being the social cognitive theory, the theory of planned behaviour, the self-determination theory and the transtheoretical model [4]. These theories all tend to focus on the behaviour of the individual, providing limited examination of how interactions with the environment may influence health outcomes and behaviours. Health behaviour is a complex and multifaceted phenomenon, influenced by multiple, interacting constraints, including the environmental context within which PA takes place [5, 6]. A satisfactory theory of health behaviours should examine PA effects from a multilevel ecological approach focusing both on the individual and the environment.

## 2 Green Physical Activity

Evidence suggests that exercise environments have an effect on the quality of PA. With rapid urbanisation, exercising indoors is becoming increasingly popular amongst active individuals, with proportionally less PA undertaken outdoors, shifting instead to gymnasias, sports halls or homes [7]. However, there is growing awareness that exercising in a natural environment could generate wider benefits than undertaking the same exercise levels indoors [8]. This nature-based activity, called “green exercise”, was defined by Pretty et al. [1] as undertaking PA whilst being directly exposed to nature, which includes three distinct levels of engagement with nature.

We propose to adapt the current green exercise definition to recognise that it forms a part of wider PA [9]. Green PA can be defined as any bodily movement that (1) is produced by skeletal muscles resulting in energy expenditure from the utilisation of affordances (invitations for action), and (2) emerges from engagement with natural environments, e.g. gardening and walking in a park to recuperate from work. In comparison, green exercise is defined as green PA that is planned, structured, rigorous, repetitive and purposive, with the aim to improve or maintain one or more components of physical fitness [9]. The focus of the current article is on effects of green PA on physical, psychological, and emotional dimensions of health and wellbeing.

A theoretical framework, ecological dynamics, is proposed to understand the nature of the constraints that shape benefits of green PA, health and wellbeing. A theoretical analysis is needed to ascertain whether different nature environments, providing opportunities for interactions with various layouts, surfaces, textures, objects and terrains, might support the emergence of different physical outcomes, sensory perceptions, emotions and feelings. In ecological dynamics, green PA is PA resulting from the utilisation of affordances that emerge from people’s direct interactions with natural environments. These interactions are proposed to lead to multi-dimensional responses in humans [10].

## 3 An Ecological Dynamics Framework: Key Ideas

Ecological dynamics is the integrated framework of ecological psychology and dynamical systems theory, with three features of significance for understanding green PA: emergence of behaviours from multiple subsystems, interacting constraints, and affordances. Ecological dynamics suggests that constraints are related to each individual, task or the environment, which interact to shape behaviours, including perceptions, emotions, cognitions and actions [10]. Humans perceive affordances directly from their surroundings and pick up opportunities or invitations for behaviours. Affordances will emerge from the three interacting constraints to shape different dimensions of behaviours related to the health and wellbeing of each individual.

“The affordances of the environment are what it offers the animal, what it provides or furnishes, either good or ill”, according to James Gibson [11]. Highly dynamic natural environments involve more perceptual systems being used to detect olfactory, acoustic, haptic and visual information. That offers multiple informational constraints on behaviours compared with indoor spaces, which typically include less dynamic sources of information. In nature, one can feel wind, sunlight and rain and perceive distinct textures, terrains and surfaces, sounds from birds, water, or smells from flowers, trees, bogs, and fields. One is continuously picking up feedback from the plantar surface of the feet while walking/running/stepping on rocky, uneven surfaces or from the hands while climbing. These invite richer psychological responses than when undertaking PA in more static conditions of temperature-controlled, enclosed gymnasias, which have fewer affordances for behaviours. These key ideas in ecological dynamics make it a powerful theoretical framework to guide green PA research.



#### 4 Potential Benefits of Green Physical Activity

Green PA is important for children, as natural environments are stimulating arenas for general learning and motor development [12]. Engagement with nature through imaginative play in children can provide benefits, such as providing a manifold of affordances or possibilities for action, human interactions and learning of social skills [13]. This might explain why children, particularly boys, tend to display greater moderate–vigorous PA levels in green spaces than in urban environments [14]. Viewing virtual nature and natural scenes has been linked to increases in autonomic control of the heart, with an increase in vagal activity in adults [15]. Self-esteem improvements have been observed when walking in green spaces compared with attending social club activities [16]. People walking on farmland tend to perceive less stress and negative affect compared with walking in an urban environment [17]. Furthermore, reduced levels of state anxiety have been reported following green exercise experiences [18], and correlations have been observed between active involvement in environmental groups and positive health, wellbeing and social connectedness [19]. A meta-analysis revealed that a walk/run in a natural environment, (e.g. public parks) provides more psycho-emotional benefits, i.e. revitalisation and feelings of tranquillity, than exercising in a synthetic environment [20]. Therefore, extant data show that green PA has been increasingly recognised as providing positive contributions to health and wellbeing. This may constitute a valuable treatment for mental health problems [21]. However, few comprehensive rationales have been provided to explain how and why these contributions may arise.

#### 5 Three Levels of Green Physical Activity

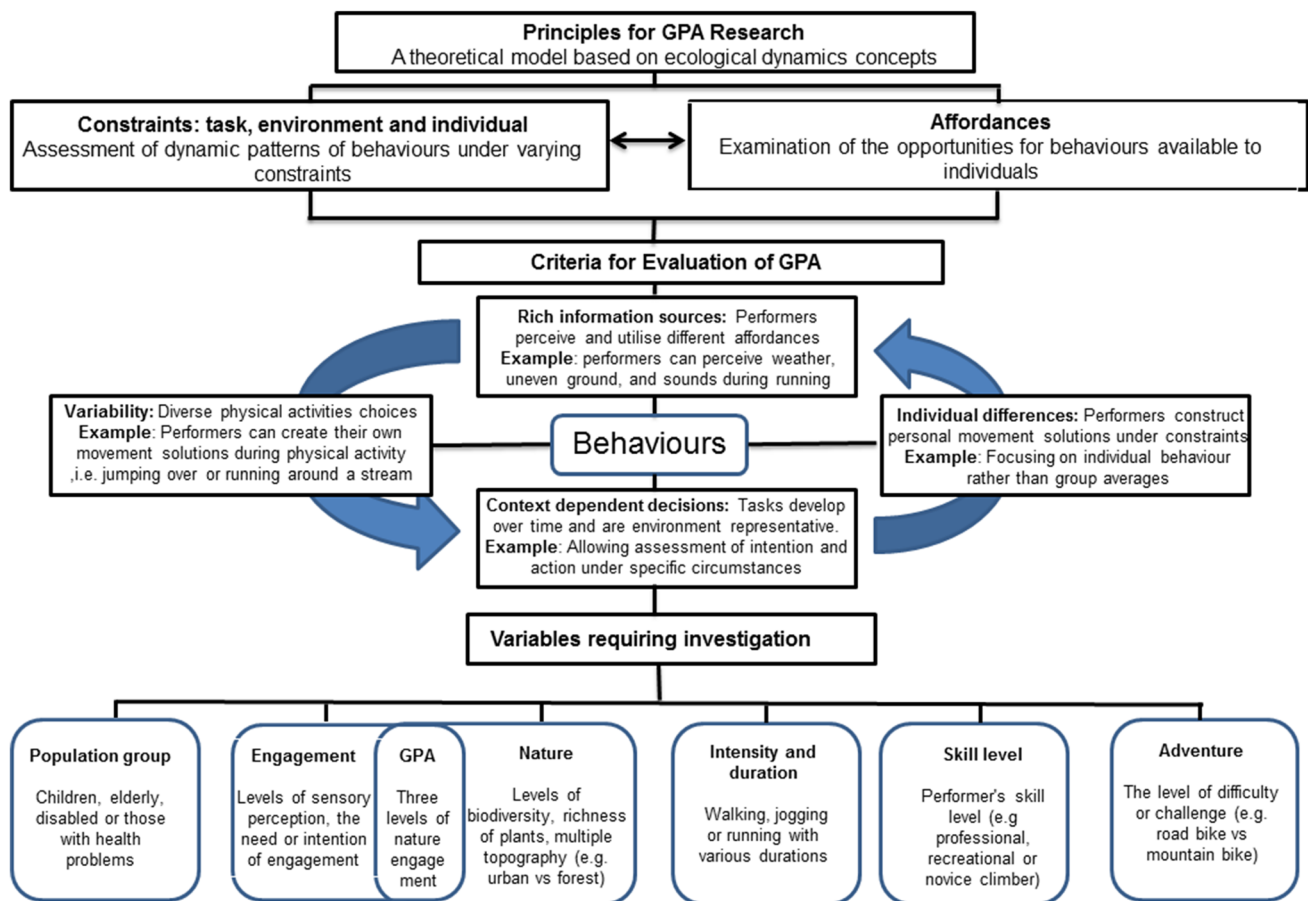
Green PA includes three levels of engagement with nature: (1) viewing nature through a window or as an image, (2) being in the presence of nature when nature is incidental to PA experiences, and (3) actively interacting with nature [1]. The first level of green PA includes viewing PA in virtual nature settings (in laboratories) and real nature environments [1]. From an ecological dynamics viewpoint, these contexts provide different affordances that might generate different effects for people in maintaining or improving health and wellbeing, especially over the longer term. However, whether psychological and emotional benefits emerge from exercising with different levels of engagement in varying environments (e.g. urban districts and nature) remains unclear. The majority of existing experiments have been conducted in laboratories to control

extraneous environmental variables, rather than making a direct comparison with exercising in the outdoors, emphasising visual information sources that do not simulate those available outdoors. When comparisons are to be made between indoor and outdoor environments, a more rigorous experimental design may be required, since many parameters will differ, e.g. energy expenditure.

Engagements can involve physical, psychological and emotional dimensions of behaviour. Therefore, level of engagement should be specified when interpreting effects of green PA, because the criteria for classifying different levels of green PA will be obscured. For example, a person may cycle to work through a city but pay attention to all the nature elements on the way; conversely, a runner may concentrate on external problems, such as a difficult work assignment, instead of focusing on nature features during a run through a forest. The level of green PA will differ in these examples depending on whether we classify the nature of engagement (i.e. involving physical, psychological and emotional dimensions). Simply classifying green PA based on physical engagement will lead to the first example fitting into the second level of green exercise. The latter example will be classified into the third level of green PA. However, classifying green PA based on psychological engagement will lead to the first example fitting into the third level of green PA. The latter example will be classified into the second level of green PA. Hence, level and type of engagement must be considered carefully during green PA research.

#### 6 Ecological Dynamics: A Suitable Framework for Green Physical Activity

Guiding principles of ecological dynamics can help with the current understanding of results and support the formulation of research projects into green PA programmes. Figure 1 outlines the core concepts for understanding effects of green PA. This theoretical framework does not describe a linear process. Rather, behaviour develops as a result of multiple interacting sub-systems in human beings. Human behaviours analysis should include physical actions and psychological responses such as thoughts, emotions, feelings and social interactions [10]. For example, when people swim in the ocean, the environment offers a cooling place to swim in hot weather, but may bring out feelings of excitement, fear and exhaustion. The ‘take home’ messages are that effects of green PA on human behaviours can be explained from several interacting constraints related to the individual, environment and task. The interactions between the three categories of constraints will influence affordances for behaviours that emerge from undertaking



**Fig. 1** The theoretical model of principles for green physical activity research from an ecological dynamics perspective

adventurous physical activities in natural outdoor environments.

In terms of green PA, affordances provided in indoor environments, even viewing natural images, differ in actual physical experiences gained from performing PA in natural environments. From the standpoint of affordances, previous definitions of green PA have tended to downplay effects of action components of behaviour [1]. In fact, indoor exercise provides a highly stable physical environment (e.g., controlled lighting, shade, atmosphere, ambient temperature, less variable conditions) that provides a limited landscape of affordances to invite physical, psychological or emotional behaviours. In this way, viewing natural scenes in stable gymnasium conditions may only add visual affordances for individuals' perceptions.

To further understand the link between affordances and green PA, it is worth discussing some examples explaining how natural environments represent dynamic and variable playscapes that challenge motor activity. Terrain topography, like slopes, ledges and rocks, afford natural obstacles for people to jump over, clamber or step on and meadows are for lying down, running and tumbling [12]. Natural

environments contain various layouts, surfaces, substances, objects and places to explore that invite diverse behaviours and enable social interactions. The diversity of habitats (e.g. wooded area, natural habitat and garden) enables individuals to accept behavioural opportunities that they find most appealing. The ever-changing variety of information enables individuals to select locations that hold their fascination and attention and contribute to feelings of respite [22].

Hence, affordances are invitations for behaviours that exist in an environment and depend on an individual's capacities for actions [23]. The state or need of an individual is of relevance in constraining the choice of action modes to achieve a particular goal [24]. As an individual moves with respect to his/her surroundings, opportunities for action persist, emerge and dissolve, even though the surroundings analysed as objects, and the relations among them, remain stable [25]. Individuals directly perceive information and behave according to their capabilities and needs. For example, a lawn is a comfortable surface for resting when people are tired or is a smooth surface for kicking a ball when they want to be active. A gap between rocks may afford stepping over for adults, but jumping over

for young children. Moreover, being opportunities for action, affordances do not cause behaviour, but constrain it in multiple ways, leading to effects on physiological outcomes, psychological feelings and emotions. In summary, affordances exist everywhere in a landscape of opportunities for activity and are specific for individuals and situations. Existing data on green PA can be interpreted to suggest that diverse affordances may offer more varied opportunities for physical interactions, better social interactions, positive psychological responses and emotional feelings than indoor environments with limited affordances. Environments with more natural features tend to be preferred and associated with more positive physical and mental health outcomes [18]. Some parameters may be stable attractors that encourage emergence of specific behaviours or may provide information for action possibilities or positive emotional feelings. The engagement of the individual with nature environments may be higher because of the involvement of more perceptual systems in behaviour. This is a different expectation from performing PA in indoor environments or viewing images and videos of nature while walking on a treadmill, (which relies heavily on the visual system).

There are numerous activity possibilities outdoors, with the diversity of physical environments affording opportunities for different behaviours. For example, running on a flat trail on an urban street may be less engaging and challenging than fell running on a wild, windy slope, which may be more variable, demanding and joyful. When performing the same PA, the level of adventure captured in specific environments will bring out various physical, emotional and psychological behaviours. The various levels of PA, such as walking and jogging, will require different levels of energy expenditure. The different senses of performers will have an effect on the quality of PA undertaken. Furthermore, different target groups, e.g. children, young adults and elderly people will utilise different affordances and behave differently while performing green PA, because of variations in intentions, perceptions, experiences and action capabilities. The relation between an individual's capabilities and environmental properties not only constrain what actions can be performed but also what actions are invited. After all, action capabilities also constrain which affordances can be utilized [23], which can be ascribed to levels of adventure. By enhancing behavioural familiarity, people might be more willing to engage with nature or take habitual exercise in natural environments, which will lead to further advantages for maintaining or promoting health and wellbeing. These ideas suggest the importance of having these positive experiences at as young an age as possible, so that they remain prominent and promote future health and wellbeing.

## 7 Research Considerations

### 7.1 Green Physical Activity Research: Four Core Components

Current research has focused most attention on establishing benefits of green PA in an operational manner, with few, tentative theoretical explanations proposed for how green PA effects may emerge. An important task for psychologists is to develop a comprehensive theoretical platform for understanding how green PA effects emerge and for developing principles for the design of valid green PA programmes. An ecological dynamics perspective emphasises the multiple dimensions of behaviours to satisfy constraints of activity environments, which provides affordances for individuals actively interacting with nature. Figure 1 outlines four principles of ecological dynamics to aid with the design and evaluation of green PA. Here, we use the example of running in a forest compared with on a treadmill in a gym to highlight each of the four points, as follows. (1) Embracing variability highlights that activity environments can provide varying levels of variability such as running in a forest with diverse options for running routes. The variability of each route will present different affordances compared with gym facilities. (2) By sampling rich and functional information sources, forest runners can experience different ambient conditions induced by weather and temperature changes, different topography, slope, ledges, surfaces, gaps or rocks, and interaction with other animals, which formulate richer information sources in nature than the temperature-controlled, 'weather-free' and limited changes in topography of a gym environment. (3) Recognising individual differences means that each individual will have varying preferences for activity environments due to variations in behavioural capacities. Hence, these must be considered in examining green PA. For example, runners with different skills will create varying actions to run on different running paths (clambering on steep trails and loping on downhill slopes) compared with running on a standard gym treadmill. (4) Context-dependent decisions will need effort to carefully design training schedules during green PA, allowing users to build up their action capabilities over time. It is important for designers or researchers to examine green PA effects when the relationship between participants and tasks in each session is specific and unique.

### 7.2 Focus of Research

We have argued that natural affordances may provide a variety of opportunities for behaviours from physical, psychological and emotional dimensions, which may lead to

better maintenance of health and wellbeing. Ecological dynamics provides a comprehensive theoretical framework to examine effects of green PA and other influential factors, such as different age groups, various levels of engagement, diverse nature environments, activity duration, type and degrees of PA and skill levels of performers. Any one of these subsystem interactions will change the relationship between performers and environments during interactions. Consequently, the quality of PA, psychological effects and physical efforts will differ. In all individuals, experience and exploration in nature environments can stimulate their cognitions, emotional wellbeing, psycho-social skills and physical competencies across the lifespan [10]. Figure 1 outlines key variables to be examined in future work on green PA, based on four principles of ecological dynamics. We propose that future work needs to examine effects of different affordances systematically by increasing the level of functional information from visual, olfactory, haptic and acoustic sources. Research will need to recognise multiple dimensions such as utilising different affordance landscapes in indoor spaces compared with outdoor and nature spaces, viewing one static image versus dynamic images of diverse durations, different types and levels of PA among various age groups, and various timescales. Furthermore, studies will need to be more ecological in design, with controls that are more representative of real activity conditions, e.g. running on treadmill while watching TV or listening to music in a gym.

## 8 Conclusions

More research and clinical applications are needed to examine the influential factors on the topic of green PA and on the link between green PA, health and wellbeing. We offer a sound theoretical explanation from an ecological dynamics perspective and develop the practical principles of designing green PA.

### Compliance with Ethical Standards

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