**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 social wellbeing, of green physical activity, a topic of increasing interest in the past decade. Evidence 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 that 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 each level of green physical activity benefits health and wellbeing is assumed to differ and requires 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 that there are a number of unexplored 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 levels and sampling of different populations.

Key points

- Previous literature has typically undertaken 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 levels 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.

## 1. Introduction

Maintaining human's physical and mental health are major global concerns, with physical activity (PA) widely acknowledged as a determining factor [1] in ensuring physical, psychological and emotional wellbeing. Physical inactivity has been identified as the fourth leading risk factor for global mortality, responsible for approximately 3.2 million deaths each year, 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 [3].

Theoretical frameworks have been proposed to understand and explain determinants and correlates of PA, with four of the most prominent theories being: The Social Cognitive Theory, The Theory of Planned Behaviour, The Self-Determination Theory and The Transtheoretical Model [4]. These theories focus on the behaviour of the individual with limited examination of how the environment influences health outcomes and behaviours. Rather, health behaviour is a complex and multifaceted phenomenon influenced by multiple constraints, including the environment within which PA takes place [5, 6]. A satisfactory theory of health behaviours should examine physical activity effects from a multilevel ecological approach focusing not just on the individual, but also the environment with which each individual interacts.

## 2. Green Physical Activity

Evidence suggests that exercise environments have an effect on the quality of physical activity. With the rapid development of urbanisation, exercising indoors is becoming increasingly popular amongst active individuals, with proportionally less PA undertaken outdoors, shifting to the use of gymnasia, sports halls or within 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 physical activity 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 [6]. *Green PA* can be defined as any bodily movement produced by skeletal muscles that result in energy expenditure from the utilisation of affordances (or opportunities for interactions) that emerges from engagement with natural environments. In comparison, Green Exercise is defined as PA that is planned, structured, rigorous, repetitive and purposive and aim to or maintaining one or more components of physical fitness, from the utilisation of affordances that emerges from interacting with natural environments. The focus of the current article is on effects of green PA on physical, psychological, and emotional dimensions of health and well-being of people.

A theoretical framework, Ecological Dynamics, was proposed to understand the nature of the constraints which shape benefits of green PA, health and wellbeing. A theoretical analysis is needed to ascertain whether different physical environments, providing various layouts, surfaces, textures, objects and terrains, might support the emergence of different physical outcomes, sensory perceptions, emotions and feelings. From an Ecological Dynamics viewpoint, 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 [24].

## 3. An Ecological Dynamics Perspective

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 [24]. Humans perceive affordances directly from their surroundings and pick up opportunities or invitations for behaviours. In green PA, 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 [26 p.127]. Highly dynamic natural environments involve more perceptual systems being used to detect olfactory, acoustic, haptic and visual information, which offer multiple informational constraints on behaviours compared with indoor spaces, which typically include less dynamic sources of information. For example, in nature, one can feel wind, sunlight, rain, and perceive distinct textures, terrains and surfaces, sounds from birds, water or smell from flowers, trees. One is continuously picking up feedback from the plantar surface of the feet while walking/running/stepping on rocky surfaces or the hands while climbing which invite richer psychological responses than when undertaking PA in more static conditions of temperature-controlled, enclosed gymnasia. 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 seems especially important for children, as natural environments are stimulating arenas for general learning and motor development [28]. Additionally, engagement with nature through imaginative play among children can provide benefits, such as providing a manifold of affordances or possibilities for action, human interactions and learning of social skills [23]. For example children, particularly boys, tend to display greater moderate-vigorous PA levels in green spaces than in urban environments [10]. Adults, also gain many benefits, for example, viewing virtual nature and natural scenes has been linked to increases in autonomic control of the heart, specifically with an increase in vagal activity [15]. Improvements in self-esteem have also been observed when walking in green spaces compared to attending social club activities [19]. People who walked on farmland tended to perceive less stress and negative affect compared with walking in an urban environment [20]. Furthermore, reduced levels of state anxiety have been reported following green exercise experiences [21] and correlations have been observed between active involvement in environmental groups and positive health, wellbeing and social connectedness [22]. A meta-analysis revealed that a walk/run in a natural environment, (e.g. public parks) provides more psycho-emotional benefits, such as revitalisation and feelings of tranquillity, in comparison to exercising in a synthetic environment, such as indoors or in built environments [11]. Therefore, green PA has been increasingly recognised as providing important positive contributions to health and wellbeing

and may comprise a valuable treatment for mental health problems, acting as a buffer against the development of depression and anxiety disorders [13].

**5. Three levels of green physical activity**

Green PA includes three levels of engagement with nature: (i) viewing nature through a window or as an image, (ii) being in the presence of nature when nature is incidental to PA experiences, and (iii), actively interacting with nature [1] and all have led to positive links to human health and wellbeing. The first level of green PA includes PA in virtual nature settings (in laboratories) and real nature environments [1]. From Ecological Dynamics viewpoint, these are different affordances which might generate different effects for people in maintaining or improving health and wellbeing, especially over the longer term. However, it remains unclear whether psychological and emotional benefits emerge from exercising with different levels of engagement in varying environments (e.g. urban districts and nature). In fact, the majority of existing experiments have been conducted in laboratories to control the environment rather than making a direct comparison with exercising in the outdoors, emphasising visual information sources which are not likely to match that found 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, for example energy expenditure.

Engagements can involve one or more of 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 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 both with the current understanding of results and aid with 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. It is important to note that analysis of human behaviours should include physical actions and psychological responses such as thoughts, emotions, feelings and social interactions [24]. 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. Below, we outline how affordances guide actions in green PA and present future direction for research using an Ecological Dynamics framework. 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 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 PAs in natural environments. From the standpoint of affordances, previous definitions of green PA are the tendency to downplay effects of action components of behaviour [1]. In fact, indoor exercise provides a highly stable physical environment (e.g., controlled lighting, atmosphere, ambient temperature, less variable conditions) which 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 rough playscapes that challenge motor activity. Terrain topography, like slopes and rocks, afford natural obstacles for people to cope with and meadows are for lying down, running and tumbling [28]. Natural environments contain various layouts, surfaces, substances, objects and places to explore which 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 [29].

Hence, affordances are opportunities for action that exist in an environment and do not depend on an individual's ability to perceive [27].The state or need of an individual is of relevance in constraining the choice of action modes to achieve a particular goal [30]. 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 [32]. 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. Moreover, being opportunities for action, affordances do not cause behaviour, but *constrain* it in multiple ways including 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 physical possibilities, better social interactions; positive psychological responses and emotional feelings compared to indoor environments with limited affordances. Environments with more natural features tend to be preferred and associated with more positive physical and mental health outcomes [21]. Some parameters may be stable attractors which encourage emergence of specific behaviours or may provide information for action possibilities or positive emotional feelings. The engagement of the individual 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 (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 compared to 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 effects on physical and psychological aspects. 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. Furthermore, different target groups, e.g. children and elderly people will utilise different affordances and behave differently while performing green PA, because of their own experiences and action capabilities. Affordances invite feelings of connection with nature compared to exercising in an urban area. The relation between people's capabilities and environmental properties not only determine what actions can be performed but also what actions are invited. After all, action capabilities also determine the ease with which affordances can be utilized [27], 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 as young as possible, so that they remain prominent and promote future health and wellbeing.

## 7. Future research and predication

### **7.1** Green physical activity research

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 by 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 principle components of Ecological Dynamics to aid with the design and evaluation of green PA. Here, we use running in a forest, compared to on a treadmill in a gym, to highlight each of the four points. (i) 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 to gym facilities, (ii) By sampling rich and functional information sources, forest runners can experience weather and temperature changes, different topography, slope or rocks, and interaction with other animals which formulate richer information sources in nature compared to temperature-controlled, weather free and limited changes in topography in gym environment. (iii) Recognising individual differences means that each individual will have varying preferences for activity environments. 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 compared to running on a standard gym treadmill. (iv) Context dependent decisions will need efforts to carefully design training schedules during green PA allowing users to build up their capabilities over time. It is important for designers or researchers to examine calibrate each session of green PA using the four components to confirm the dynamic and specific relationship to each participant and task.

### 7.2 Current 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. Therefore, future work needs to examine other influential constraints in this multidisciplinary theoretical explanation for developing understanding of the link between green PA, health and wellbeing. In all individuals, experience and exploration in nature environments can stimulate their cognition, emotional wellbeing, psycho-social skills and motor development across the lifespan [24]. 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 be different. 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 works needs to examine effects of different affordances systematically by increasing the level of functional information form visual, haptic and acoustic sources. Research will need to recognise multiple dimensions such as different affordances from indoor spaces to outdoor and nature spaces, viewing one static image to dynamic images of diverse durations, types and levels of PA among various age groups, and over shorter and long timescales. Furthermore, studies will need to be more ecological is 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 gym. By offering a sound theoretical explanation from Ecological Dynamics and developing the practical principles of designing green PA, more research and clinical applications are needed on the topic of green PA.

**Compliance with Ethical Standards**

No sources of funding were used to assist in the preparation of this article. H.P. Yeh, J. A. Stone., S. M. Churchill., J. Wheat., E. Brymer., and K. Davids declare that they have no conflict of interest with the content of this review.

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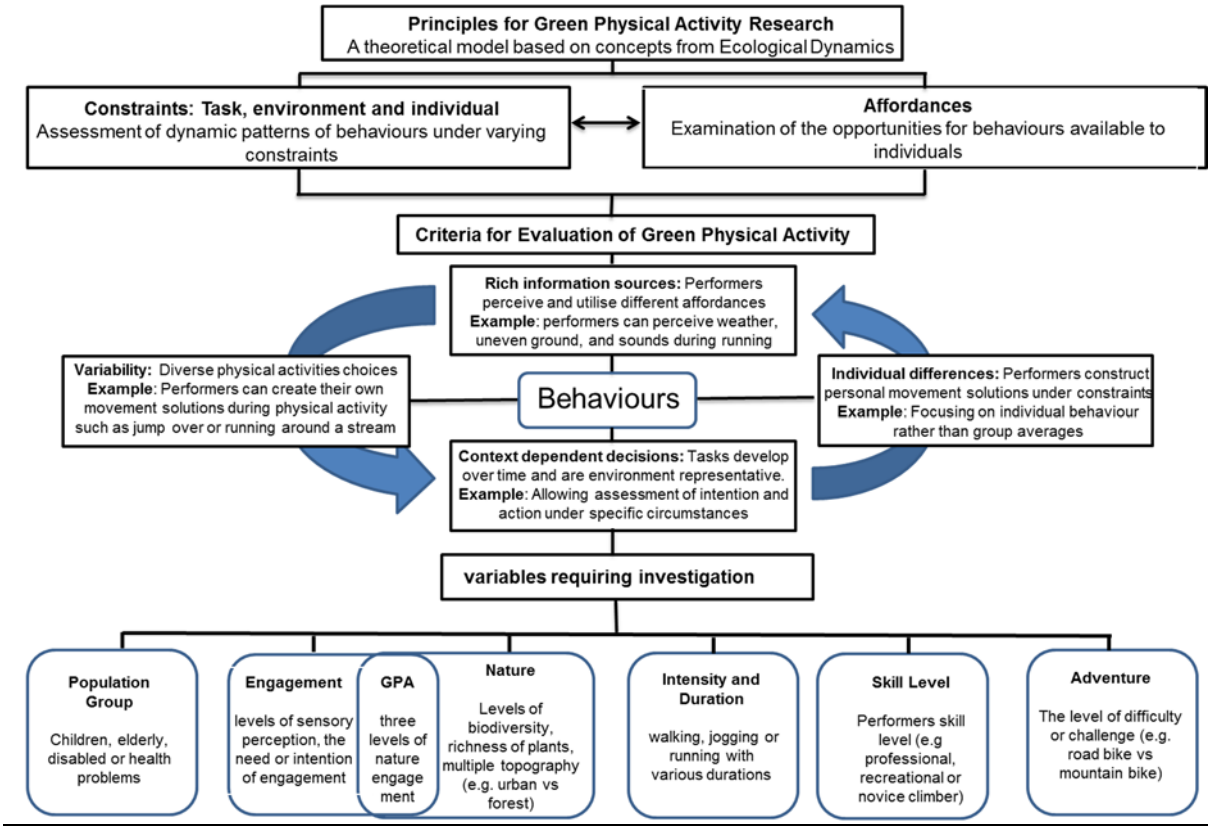


*Figure 1. The theoretical model of principles for green physical activity research from an Ecological Dynamics perspective.*