



Physical, psychological and emotional benefits of green physical activity: An ecological dynamics perspective

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1 **Physical, psychological and emotional benefits of green physical activity: an ecological dynamics**
2 **perspective.**

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26 Running Header: Green physical activity and ecological dynamics

1 **Abstract**

2 Increasing evidence supports the multiple benefits to physical, psychological and emotional wellbeing, of green
3 physical activity, a topic of increasing interest in the past decade. Research has revealed a synergistic benefit of
4 green physical activity, which includes all aspects of exercise and physical activity in the presence of nature.
5 Our theoretical analysis suggests that there are three distinct levels of engagement in green physical activity,
6 with each level reported to have a positive effect on human behaviours. However, the extent to which each level
7 of green physical activity benefits health and wellbeing is assumed to differ, requiring confirmation in future
8 research. This elucidation of understanding is needed because previous literature has tended to focus on
9 recording empirical evidence, rather than developing a sound theoretical framework to understand green
10 physical activity effects. Here we propose an ecological dynamics rationale to explain how and why green
11 physical activity might influence health and wellbeing of different population groups. This framework suggests
12 a number of unexplored, interacting constraints, related to types of environment and population groups, which
13 shape reported levels of benefit of green physical activity. Further analysis is needed to clarify the explicit
14 relationship between green physical activity and health and wellbeing, including levels of engagement, types of
15 environmental constraints, levels of physical activity, adventure effects, skill effects and sampling of different
16 populations.

17

18 **Key points**

- 19 • Previous literature has typically provided an operational analysis of the benefits of physical activity
20 undertaken in nature and future work needs to understand how and why green physical activity might
21 influence health and wellbeing with a multidisciplinary rationale.
- 22 • Further investigation of interacting constraints on green physical activity effects is needed, including
23 levels of engagement, types of environment, level of physical activity, adventure, skill effects and
24 groups.
- 25 • An ecological dynamics framework has the potential to provide principles for the design of green
26 physical activity programmes as well as experiments on this topic.

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1 **1. Introduction**

2 Maintaining human physical and mental health are major global concerns, with physical activity (PA) widely
3 acknowledged as determining factors [1] in ensuring physical, psychological and emotional wellbeing. Physical
4 inactivity has been identified as the fourth leading risk factor for global mortality, associated with approximately
5 3.2 million deaths each year, implicated in the prevalence of non-communicable diseases such as cancer and
6 cardiovascular defects [2]. Further, one in four people in the world is affected by mental or neurological
7 disorders at some point in their lives, which PA could alleviate [3].

8

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

17

18 **2. Green Physical Activity**

19 Evidence suggests that exercise environments have an effect on the quality of PA. With rapid urbanisation,
20 exercising indoors is becoming increasingly popular amongst active individuals, with proportionally less PA
21 undertaken outdoors, shifting to the use of gymnasias, sports halls or within homes [7]. However, there is
22 growing awareness that exercising in a natural environment could generate wider benefits than undertaking the
23 same exercise levels indoors [8]. This nature-based activity called “green exercise” was defined by Pretty et al.
24 [1] as undertaking PA whilst being directly exposed to nature, which includes three distinct levels of
25 engagement with nature.

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

33 A theoretical framework, ecological dynamics, is proposed to understand the nature of the constraints which
34 shape benefits of green PA, health and wellbeing. A theoretical analysis is needed to ascertain whether different
35 nature environments, providing opportunities for interactions with various layouts, surfaces, textures, objects
36 and terrains, might support the emergence of different physical outcomes, sensory perceptions, emotions and
37 feelings. In ecological dynamics, green PA is PA resulting from the utilisation of affordances that emerge from

1 people's direct interactions with natural environments. These interactions are proposed to lead to multi-
2 dimensional responses in humans [10].

3 **3. An Ecological Dynamics Framework: Key Ideas**

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

12

13 “The affordances of the environment are what it offers the animal, what it provides or furnishes, either good or
14 ill”, according to James Gibson [11 p.127]. Highly dynamic natural environments involve more perceptual
15 systems being used to detect olfactory, acoustic, haptic and visual information. That offers multiple
16 informational constraints on behaviours compared with indoor spaces, which typically include less dynamic
17 sources of information. In nature, one can feel wind, sunlight, rain, and perceive distinct textures, terrains and
18 surfaces, sounds from birds, water or smells from flowers, trees, bogs, and fields. One is continuously picking
19 up feedback from the plantar surface of the feet while walking/running/stepping on rocky, uneven surfaces or
20 from the hands while climbing. These invite richer psychological responses than when undertaking PA in more
21 static conditions of temperature-controlled, enclosed gymnasias, which have fewer affordances for behaviours.
22 These key ideas in ecological dynamics make it a powerful theoretical framework to guide green PA research.

23

24 **4. Potential Benefits of Green Physical Activity**

25

26 Green PA is important for children, as natural environments are stimulating arenas for general learning and
27 motor development [12]. Engagement with nature through imaginative play in children can provide benefits,
28 such as providing a manifold of affordances or possibilities for action, human interactions and learning of social
29 skills [13]. This might explain why children, particularly boys, tend to display greater moderate-vigorous PA
30 levels in green spaces than in urban environments [14]. Viewing virtual nature and natural scenes has been
31 linked to increases in autonomic control of the heart with an increase in vagal activity in adults [15]. Self-esteem
32 improvements have been observed when walking in green spaces compared to attending social club activities
33 [16]. People walking on farmland tend to perceive less stress and negative affect compared with walking in an
34 urban environment [17]. Furthermore, reduced levels of state anxiety have been reported following green
35 exercise experiences [18] and correlations have been observed between active involvement in environmental
36 groups and positive health, wellbeing and social connectedness [19]. A meta-analysis revealed that a walk/run in
37 a natural environment, (e.g. public parks) provides more psycho-emotional benefits, i.e. revitalisation and
38 feelings of tranquillity, in comparison to exercising in a synthetic environment [20]. Therefore, extant data
39 shows that green PA has been increasingly recognised as providing positive contributions to health and

1 wellbeing. This may comprise a valuable treatment for mental health problems [21]. However, there have been
2 few comprehensive rationales provided to explain how and why these contributions may arise.

3 **5. Three Levels of Green Physical Activity**

4 Green PA includes three levels of engagement with nature: (i) viewing nature through a window or as an image,
5 (ii) being in the presence of nature when nature is incidental to PA experiences, and (iii), actively interacting
6 with nature [1]. The first level of green PA includes viewing PA in virtual nature settings (in laboratories) and
7 real nature environments [1]. From an ecological dynamics viewpoint, these contexts provide different
8 affordances which might generate different effects for people in maintaining or improving health and wellbeing,
9 especially over the longer term. However, it remains unclear whether psychological and emotional benefits
10 emerge from exercising with different levels of engagement in varying environments (e.g. urban districts and
11 nature). The majority of existing experiments have been conducted in laboratories to control extraneous
12 environmental variables, rather than making a direct comparison with exercising in the outdoors, emphasising
13 visual information sources which do not simulate those available outdoors. When comparisons are to be made
14 between indoor and outdoor environments, a more rigorous experimental design may be required since many
15 parameters will differ, e.g. energy expenditure.

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

28 **6. Ecological Dynamics: A Suitable Framework for Green Physical Activity.**

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

1 affordances for behaviours that emerge from undertaking adventurous physical activities in natural outdoor
2 environments.

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

10 To further understand the link between affordances and green PA, it is worth discussing some examples
11 explaining how natural environments represent dynamic and variable playscapes that challenge motor activity.
12 Terrain topography, like slopes, ledges and rocks, afford natural obstacles for people to jump over, clamber or
13 step on and meadows are for lying down, running and tumbling [12]. Natural environments contain various
14 layouts, surfaces, substances, objects and places to explore which invite diverse behaviours and enable social
15 interactions. The diversity of habitats (e.g. wooded area, natural habitat and garden) enables individuals to
16 accept behavioural opportunities that they find most appealing. The ever-changing variety of information
17 enables individuals to select locations that hold their fascination and attention and contribute to feelings of
18 respite [22].

19 Hence, affordances are invitations for behaviours that exist in an environment and depend on an individual's
20 capacities for actions [23]. The state or need of an individual is of relevance in constraining the choice of action
21 modes to achieve a particular goal [24]. As an individual moves with respect to his/her surroundings,
22 opportunities for action persist, emerge and dissolve, even though the surroundings analysed as objects, and the
23 relations among them, remain stable [25]. Individuals directly perceive information and behave according to
24 their capabilities and needs. For example, a lawn is a comfortable surface for resting when people are tired or is
25 a smooth surface for kicking a ball when they want to be active. A gap between rocks may afford stepping over
26 for adults, but jumping over for young children. Moreover, being opportunities for action, affordances do not
27 cause behaviour, but constrain it in multiple ways leading to effects on physiological outcomes, psychological
28 feelings and emotions. In summary, affordances exist everywhere in a landscape of opportunities for activity
29 and are specific for individuals and situations. Existing data on green PA can be interpreted to suggest that
30 diverse affordances may offer more varied opportunities for physical interactions, better social interactions;
31 positive psychological responses and emotional feelings compared to indoor environments with limited
32 affordances. Environments with more natural features tend to be preferred and associated with more positive
33 physical and mental health outcomes [18]. Some parameters may be stable attractors which encourage
34 emergence of specific behaviours or may provide information for action possibilities or positive emotional
35 feelings. The engagement of the individual with nature environments may be higher because of the involvement
36 of more perceptual systems in behaviour. This is a different expectation from performing PA in indoor
37 environments or viewing images and videos of nature, while walking on a treadmill, (which relies heavily on the
38 visual system).

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

17 **7. Research Considerations**

18 **7.1 Green Physical Activity Research: Four Core Components**

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

1 examine green PA effects when the relationship between participants and tasks in each session is specific and
2 unique.

3 7.2 Focus of Research

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

21 **8. Conclusions**

22 By offering a sound theoretical explanation from an ecological dynamics perspective and by developing the
23 practical principles of designing green PA, more research and clinical applications are needed to examine
24 influential factors on the topic of green PA of the link between green PA, health and wellbeing.

25

26 **Compliance with Ethical Standards**

27 No sources of funding were used to assist in the preparation of this article. H.P. Yeh, J. A. Stone., S. M.
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- 1 **Figure 1.** The theoretical model of principles for GPA research from an ecological dynamics perspective.
- 2 GPA=green physical activity.
- 3