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# A Comparison of the Magnitude of the Mental Health Benefits of Exercising Outdoors vs Exercising Indoors: A Review

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# A COMPARISON OF THE MAGNITUDE OF THE MENTAL HEALTH BENEFITS OF EXERCISING OUTDOORS VS EXERCISING INDOORS: A REVIEW

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Master of Science, Kinesiology

By

Greta M. Rueschmann

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## ABSTRACT

Many people in the United States suffer from poor mental health which can lead to suicide, self-harm, or negative effects on job performance and relationships. Not everyone can afford traditional therapy nor feels comfortable with it. With a greater emphasis placed on taking care of one's mental health during the COVID-19 pandemic, there should also be a greater emphasis placed on finding alternative types of therapy that can be matched to individuals based on their personalities and preferences. One such alternative is outdoor exercise. This review was conducted to examine whether exercising or performing physical activity outdoors results in greater mental health benefits than exercising or performing physical activity indoors. EBSCO host and internet website searches were used to find relevant journal articles, as well as the reference lists of systematic reviews/meta-analyses related to the topic. Both randomized and nonrandomized trials were included. Eligible studies compared the psychological benefits of exercising outdoors with those of exercising indoors. Eligible studies also included participants of at least 15 years of age. All included journal articles were published between January 2005 and May 2022. Thirteen studies consisting of a total of 6,522 participants were chosen for inclusion. Eight of these studies reported that exercising outdoors resulted in greater mental health benefits than exercising indoors. Performing physical activity outdoors may be an alternative option for those suffering from mental illness or looking to maintain good mental health.

**KEYWORDS**: green exercise, physical activity, indoor, outdoor, mental health, depression, anxiety

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# INTRODUCTION

As of 2020, suicide was reported as one of the top fifteen leading causes of death in the United States and ranked highest among persons between 10 and 34 years of age.[1] Rates were highest for males (three to four times that of females), particularly those classified as American Indian, Alaska Native, or white.[2,3] While overall suicide rates have declined over the past two years, they have risen for non-Hispanic American Indian or Alaska Native, non-Hispanic black, and Hispanic males.[3]

In 2018, 312,000 (standard error = 73,000) patients were admitted to U.S. hospital emergency departments by ambulatory care for self-harm.[4] Self-harm is the intentional harming of one's own body and most commonly occurs by females. It typically begins during adolescents or early adulthood and is a means by which some use to alleviate or cope with unwanted emotions.[5]

Causes of both suicide and self-harm include stress that is brought on by a variety of life factors (e.g., work, school, finances, relationships, etc.), mental illnesses such as anxiety and depression, chemical imbalances, trauma, or a combination of these.

Forty million U.S. adults suffer from a form of anxiety disorder (e.g., generalized anxiety disorder, social anxiety disorder, panic disorder, obsessive compulsive disorder).[6] Anxiety disorders may make it difficult to function normally in day-to-day living and hinder the ability to maintain a job. Furthermore, those diagnosed with an anxiety disorder are often diagnosed with depression as well.[6]

Over 16 million Americans suffer from depression. This means that they feel "down in the dumps" for an extended amount of time. Females are more likely than males to experience

depression, possibly due to hormonal changes each month, during pregnancy, after childbirth, or as a result of menopause. Depression can also result from abnormal levels of neurotransmitters in the brain, negative thinking, poor self-esteem, genetics, life situations, and medications. Depression can lead to negative consequences such as loss of relationships, higher risks of self-harm or suicide, and inability to function normally.[7] Major depressive disorder is the primary cause of disability in the U.S. for persons between the ages of 15 and 44.[6]

Traditional therapy can be too costly for some and is not always covered by insurance. In addition, it can be difficult for some to fit therapy into an already busy schedule, be granted time off from work, or lose a few hours of pay. Another factor to take into consideration is that not everyone feels comfortable meeting with a therapist due to personal or cultural views or they may find meeting with a therapist triggering. In fact, it is not unusual for persons seeing a therapist to engage more frequently in a maladaptive behavior right before their scheduled appointment.

Medication can be costly, ineffective, have negative side-effects, and actually increase suicide risk for some.[8,9,10] Younger individuals are particularly at risk of increased suicidal thoughts and actions when using antidepressants.[8] There has also been debate on whether Americans are being over-medicated.[11]

Finding low-cost, low-risk alternative ways to improve mental health and decrease stress may provide relief for many who are afflicted with suicidal ideation, depression, anxiety, or other forms of mental illness. It would be counterproductive for the financial cost of treatment to further burden those already struggling. In addition, having a wider variety of treatment options available promotes better individualization of treatment plans that are conducive to recovery.

Quite a few studies have been conducted on the mental health benefits of being in nature and of exercising. There have also been several studies exploring the effects on mental health when these two factors are combined (the combination of these two is termed "green exercise").[12,13,14] A future increased interest in the mental health benefits of green exercise or outdoor exercise may stem from the shutdowns and social-distancing recommendations during the COVID-19 pandemic. Therefore, the purpose of this review is to examine the magnitude of the mental health benefits of exercising outdoors compared to those of exercising indoors.

## BACKGROUND

### Theoretical Foundations Related to Nature Exposure

Three theories that explain the reasoning behind the mental health benefits of being in nature are the Stress Reduction Theory, the Attention Restoration Theory, and the Green Mind Theory.

The Stress Reduction Theory by Roger Ulrich et al. (1991) theorizes that natural, unthreatening environments can promote stress reduction as they can reduce negative feelings and high physiological arousal.[15] This is particularly true of natural environments containing bodies of water.[16] It is believed that nature can provide a way to psychologically remove oneself from distractions and perceived stressors which reduces stress.[17]

The Attention Restoration Theory by Rachel and Stephen Kaplan (1989) states that nature can stimulate effortless attention providing the brain time to recover from focusing on direct attention. This is because it is no longer necessary to block task-irrelevant stimuli, which reduces the risk of mental fatigue.[17] Instead, the mind is allowed to wander freely as the individual takes in the natural setting.

The Green Mind Theory by Jules Pretty, Mike Rogerson, and Jo Barton (2017) theorizes that there are reciprocal relationships between the environment, brain, mind, and body. In other words, the environment affects the brain, mind, and body, and these in turn affect the environment.[18] This theory was based on findings from the field of neuroscience and findings related to brain elasticity. Pretty et al. believe that mental health is optimal when there is a good integration of the activation of portions of the brain that deals with the sympathetic nervous system and survival instincts (the brain stem) and that deals with the parasympathetic nervous

system, learning, and planning (the top-brain cortex). Green exercise can help achieve this balance.[18]

**Theoretical Foundations Related to Exercise**

Theories as to why exercise itself improves mental health include the Self-Efficacy Theory and the Self-Determination Theory.

The Self-Efficacy Theory implies that an individual's belief in their ability to perform an exercise successfully affects their motivation to exercise and their behavior. Self-efficacy in exercising can transfer to other situations that are similar and impact goal-setting.[19,20] For example, if an individual has high self-efficacy in running up a challenging hill, because they commonly do so as part of a work-out, this may translate to high self-efficacy in doing other challenging tasks such as studying for a big exam, as they relate this mental challenge to the mental and physical challenge that they were able to work to overcome while running up the hill. Making and meeting small exercise goals can increase self-efficacy in general and improve self-esteem.

The Self-Determination Theory theorizes that individuals have an innate desire for growth which includes feeling competent, having autonomy, and feeling a sense of belonging (aka relatedness).[21] This theory also relates to motivation of engaging in and maintaining behaviors. Reaching personally made exercise goals can result in feelings of competency and autonomy. If individuals engage with others who are exercising or are part of a specific group such as a running club, a sense of belonging could also occur, thus positively impacting mental health.

**Mental Health Benefits of Green Exercise**

Even just five minutes of low-intensity or high-intensity green exercise have been shown to improve mental health with the most improvement in mood for adults between 51 and 70 years of age.[16] Green exercise has also been shown to positively impact the mental health of those who are mentally ill, physically inactive, under a lot of stress, or are anticipating surgery.[22]

According to Mind, for some, green exercise can be equally effective as the common antidepressant fluoxetine without the negative side effects.[18] It is inexpensive, accessible to many, and provides physical and cognitive benefits as well.[23] It can also serve as an alternative treatment option for those suffering from anxiety and depression who prefer to deal with their problems in a more private or less traditional manner.[24]

The choice of natural environment in which to engage in green exercise should be made by individuals according to their preference. This is because different people feel more comfortable in different settings and, therefore, would reap greater mental health benefits exercising in natural environments that they prefer.[25]

# METHODS

## Search Strategy

To identify studies for the review, the EBSCO host electronic database available via the Missouri State University library website was used. Keywords searched using the advanced search option included: green exercise OR physical activity OR exercise AND indoor* OR outdoor* OR outside OR inside AND mental health OR depression OR anxiety. Limiters included full-text, peer reviewed, academic journals, Boolean/Phrase, written or translated in English, and a date of publication between January 2005 and May 2022. No expanders were used. This advanced search generated 341 results. One additional study was obtained from Research Gate after conducting a website search and six more studies were collected after reviewing citations from the excluded systematic reviews and meta-analyses and the final seven articles selected for inclusion from the advanced search results.

## Study Selection and Data Extraction

Studies were checked for relevancy and for whether they investigated mental health benefits derived from exercise or physical activity in both indoor and outdoor settings. Inclusion criteria included reported psychological outcomes such as mood, anxiety, depression, stress, affect, and well-being or physiological outcomes such as cortisol levels. Studies with subjects under the age of 15 years were excluded as were studies in which subjects only experienced outdoor environments virtually or visually by means of video or photography. Systematic reviews and meta-analyses were also excluded. The Preferred Reporting Items for Systematic

reviews and Meta-Analyses (PRISMA) 2020 flowchart template was used to illustrate the exclusion and inclusion process.[26] (See Figure 1.)

Data from the 13 studies selected for inclusion were extracted into an Excel worksheet. Data extracted included author of the study and year in which the study was published, sample size, participant characteristics (age range or mean and gender), intervention type (mode of exercise/physical activity and environment), duration of the study or exercise/physical activity and relevant outcomes. (See Table 1.)

## RESULTS

The 13 included studies were published in 11 different journals with the most (two studies each) in *International Journal of Environmental Health Research* and *Psychology of Sport and Exercise* and the rest (one study each) in *PLoS ONE*, *Social Science & Medicine*, *Applied Psychology: Health and Well-Being*, *Clinical Medicine: Oncology*, *International Journal of Stress Management*, *International Journal of Fitness*, *Open Journal of Medical Psychology*, *Environment and Behavior*, and *Research Quarterly for Exercise and Sport*. The majority of the selected studies were published within the last five years. (See Table 2.) Part of the reason could be due to the interest arising from the need to exercise either indoors at home or in nature during the COVID-19 shut-downs.

The main type of exercise performed both indoors and outdoors in the selected studies were walking and running. (See Table 2.) Three of the studies looked at different outdoor environments when comparing the mental health benefits of exercising outdoors to those of exercising indoors.[27,28,29]

### Participant Characteristics

From the 13 studies, there was a total of 6,522 participants. Sample size was 10 to 2,070. Participants were at least 15 years of age. Four of the studies used female participants only, whereas one of the studies used male participants only. Of the eight studies that included both female and male participants, three reported a higher female to male ratio, four reported a higher male to female ration, and one did not state the number or percentage of females and males who participated. Five of the studies used university students as participants and one study used only

post-menopausal females. Furthermore, five of the 13 studies included participants deemed as being physically active by the studies' researchers.

**Methods of Studies Included**

Three of the 13 included studies utilized surveys to collect or analyze data.[27,29,30] Seven of the studies were randomized trials and three of the studies were nonrandomized trials. Only two of the studies included a control in which participants neither exercised nor were exposed to nature.[31,32] All 13 studies included a type of questionnaire or emotional well-being/mood rating scale. For the purposes of this study, physiological outcomes other than cortisol sample results were not investigated by the author while perusing the journal articles nor included in Table 1. This is due to the knowledge that factors such as heart rate and blood pressure can be affected by variables other than emotional state or stress.

**Findings of Studies Included**

Eight out of the 13 articles indicated that exercising or performing physical activity outdoors had greater mental health benefits than exercising or performing physical activity indoors. However, Plante et al. based its conclusion on the finding that participants who exercised outdoors enjoyed exercising more than participants who exercised indoors ($F(1, 84) = 6.59$, $p < .05$). They speculate that exercise enjoyment may contribute to an increase in positive mood after exercising. Despite their speculation, they did not report a significant difference in Activation-Deactivation Adjective Check List (AD-ACL) scores for exercising outdoors vs exercising indoors.[33]

Focht found that Feeling Scale (FS) responses were significantly greater during outdoor walking ($d = .43$) as were Felt Arousal Scale scores ($d = .41$). Both the FS and FAS are dimensional measures of affective responses. The FS evaluates an individual's feelings of pleasure and displeasure, while the FAS evaluates an individual's activation. The Exercise-Induced Feeling Inventory (EFI) was also used to assess participants' feelings of revitalization, tranquility, positive engagement, and physical exhaustion. Revitalization and positive engagement scores were significantly greater during outdoor walking ($d = .42$ and $d = .58$, respectively).[34] Like Plante et al., Focht reported greater exercise enjoyment for those who exercised outdoors ($t(34) = 5.12$, $p < .001$; $d = 1.03$).[33,34]

Olafsdottir et al. reported significantly lower cortisol levels for participants who walked in nature than for those who merely watched a video of nature ($p = .044$). Those who walked in nature also had significantly higher positive affect scores during both exam and exam-free periods than those who walked on a gym treadmill ($p = .004$ and $p = .016$, respectively). After controlling for baseline values, a significant difference was still found (both $p < .05$). Walking in nature was concluded to improve mood more than walking on a gym treadmill ($p < .05$) or watching nature scenes without engaging in physical activity ($p < .001$).[35]

Navalta et al. found significantly higher comfort scores for participants who exercised outdoors in green and brown areas ($p = .001$). The green condition was designated as Mt. Charleston Bristlecone Trail at the Spring Mountains National Recreation Area and the brown condition was designated as the Moenkopi Trail at Red Rock Canyon National Conservation Area. There was no significant difference in perceived stress scores between environmental conditions, however.[28]

Teas et al. used the Positive Affect Scale (PAS) and the Negative Affect Scale (NAS) to assess six mood states. They found significantly higher scores for feeling pleased ($p = .03$) and delighted ($p = .05$) and significantly lower scores for feeling frustrated ($p = .03$) and worried ($p = .02$) for those who exercised outdoors compared to those who exercised indoors. There was no significant difference in the levels of cortisol or log alpha amylase (stress hormones) between the two conditions, however. It may be of interest that this study used only post-menopausal female participants.[36]

Pasanen et al. found that engaging in physical activity in nature positively affected emotional well-being ($B = 0.21$, $SE = 0.03$, $p = < .001$) as did engaging in physical activity in a built outdoor environment ($B = 0.10$, $SE = 0.04$, $p < .01$). By contrast, performing physical activity indoors was not found to have a significantly positive effect on emotion well-being.[29]

Flowers et al. stated that exercising outdoors evokes greater psychological benefits than exercising indoors. Benefits can be improved further if one is exposed to promotional content on the benefits of green exercise prior to engaging in outdoor exercise. Although this study mainly focused on the impact of green exercise promotional footage on psychological benefits of outdoor and indoor exercise, outdoor exercise was reported to improve vigor ($M = 2.00$, 95% *CI* 1.06-2.94) more than indoor exercise ($M = 0.60$, 95% *CI* -0.46-1.66). However, time x treatment interaction did not significantly affect self-esteem ($F(1, 28) = 0.31$), $p = .58$, $\eta_p^2 = 0.01$).[37]

Niedermeier et al. investigated the acute effects that mountain hiking and indoor treadmill walking had on affective responses when engaged in the activity for approximately three hours. They found that mountain hiking resulted in significantly greater scores in activation ($d = 0.81$, $p = .004$), affective valence ($d = 1.21$, $p < .001$), calmness ($d = 0.84$, $p = .004$), and elation ($d = 1.07$, $p < .001$). Mountain hiking also significantly decreased feelings of

anxiety ($d$ = -0.79, $p$ < .001) and fatigue ($d$ = -1.19, $p$ < .001). When compared to walking on a treadmill indoors, mountain hiking had significantly greater positive effects on fatigue, affective valence, and activation.[32]

Two studies provided inconclusive results. Mitchell determined that performing physical activity in natural environments lowers the risk of poor mental health by 6% per data analyzed from the General Health Questionnaire (GHQ). Moreover, exercising in woods or forests at least twice a week was found to protect participants the most ($p$ = .010). Nevertheless, being active in natural environments was not found to have a significant association with greater well-being. Exercising in non-natural environments (including gyms, sports centers, etc.) was found to be significantly linked with greater well-being per data analyzed from the Warwick Edinburgh Mental health and Wellbeing Score (WEMWBS), but not with lowering the risk of poor mental health. According to his results, Mitchell stated that participating in physical activity in different variations of outdoor environments can result in diverse types of positive psychological effects.[27]

Hug et al. reported a significant interaction effect between exercise environment and restoration ($F$(2.8, 696.6) = 3.03, $p$ = .03). Participants reported higher feelings of being mentally well-balanced with outdoor exercise and less distress from everyday hassles. On the other hand, participants reported less with indoor exercise ($M$ = 1.37, $SD$ = 1.28 compared to $M$ = 1.18, $SD$ = 1.35 with outdoor exercise).[30]

## DISCUSSION

The purpose of this review was to explore whether outdoor exercise results in greater mental health benefits than indoor exercise. Thirteen articles were identified as eligible for inclusion in this review, all of which were published after January 2005. Data of psychological outcomes such as positive affect, negative affect, calmness, vigor, tranquility, and stress were examined, in addition to data related to stress hormone levels. A meta-analysis was not performed on account of the heterogeneity of the outcome measures used by the 13 selected studies.

The results of this review agreed with the results of Coon et al. in that outdoor exercise may provide a larger magnitude of mental health benefits when compared to indoor exercise.[38] Bowler et al. also found that exercising in nature could result in greater mental health benefits.[39]

It is interesting to note that the four studies conducted in the United States were all deemed to support the idea that exercising outdoors results in greater mental health benefits than exercising indoors. Reasons as to why this may be grounds for future research.

### Limitations

The articles were searched for and selected by only the author. Furthermore, this was the author's first attempt at conducting a review. The author developed the process for reviewing and analyzing the selected 13 studies by perusing published systematic reviews found online. Inexperience could have affected the results of this review.

The chosen studies were not assessed for risk of bias. The majority of the included studies did state that the measurement tools used (questionnaires, surveys, etc.) were shown to be valid and/or reliable, however.

Many of the studies also included a relatively small sample size and several did not consist of both female and male participants. Nevertheless, attempts were made to obtain appropriate sample sizes indicated by priori power analyses or other calculations.

Participants for several of the studies were university students. The use of a convenience sample may make it unwise to attempt to make generalizations for the population.

Data analyzed consisted primarily of self-reported information. Participants could have misrepresented how they felt before, during, or after the experiments.

**Applications**

Outdoor exercise can be prescribed to patients expressing mental health concerns or undergoing treatment for a mental illness such as depression and anxiety. Those who are considered mentally ill are believed to be more likely to benefit from exercising outdoors than their mentally healthy counterparts.[16] However, exercise in general should be recommended to those who have a mental illness as not everyone benefits more from exercising outdoors.[31]

It is important to consider preferences when recommending outdoor physical activity. Those who do not enjoy exercising outdoors are not likely to reap the same benefits as those who do enjoy exercising outdoors. Moreover, possible environmental or social barriers to outdoor exercise need to be addressed with clients when prescribing outdoor exercise.[25] Lastly, engaging in long durations of outdoor physical activity is not necessary to obtain mental health benefits.

As stated previously, just five minutes of outdoor exercise can result in significant improvements in self-esteem ($d = 0.6$, $p < .0001$) and Total Mood Distress scores ($d = 0.7$, $p < .0001$).[16]

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**ALL TABLES**

Table 1. Characteristics of Studies Included

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Mitchell, 2013[27] | Observational; survey | 1890 (GHQ models); 1860 (WEM-WBS models) | 16 and older | Female and male (counts not provided) | -Woods/forest<br>-Open space/park<br>-Non-tarmac paths<br>-Beach/water-side<br>-Sports field/ outdoor courts<br>-Swimming pool<br>-Gym/sports center<br>-Pavements or local streets<br>-Home or garden | Data from Scottish Health Survey 2008 | -General Health Questionnaire (GHQ12)<br>-Warwick Edinburgh Mental Health and Well-being Score (WEMWBS) |

Table 1. Continued

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Navalta et al., 2021[28] | Randomized; crossover | 10 | *M* = 29.2 ± 7.3 | 7 female; 3 male | -Indoor walk in laboratory (30 min)<br>-Outdoor walk in urban environment (30 min)<br>-Outdoor walk in green environment (30 min)<br>-Outdoor walk in brown environment (30 min)<br>-Outdoor walk in below sea level environment (30 min) | Seven days | -Comfort scores<br>-Feelings of calm<br>-Perceived stress questionnaire |

Table 1. Continued

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Pasanen et al., 2014[29] | Survey | 2,070 | 15-74; *M* = 45.2 ± 14.8 | 55.6% female; 44.4% male | -Indoor physical activity<br>-Outdoor physical activity (in built environment)<br>-Outdoor physical activity (in nature) | Winter and spring 2009 | -Emotional Well-Being subscale (in RAND 36-item health survey 1.0) |
| Hug et al., 2008[30] | Survey; quasi-experiment | 269 | 15 and older | 45% female; 55% male | -Outdoor exercise in forest<br>-Indoor exercise in fitness center | Single visit | -Restorative effect of physical activity questionnaire |
| Askari et al., 2017[31] | Nonrandomized; quasi-experiment | 46 | 20-50; *M* = 33.39 ± 7.81 | Female | -Indoor group aerobic exercise in gym (1 hr)<br>-Outdoor group aerobic exercise (1 hr)<br>-No exercise (control) | 36 sessions held three times each week | -Beck Depression Inventory-II (BDI-II; Persian version)<br>-Perceived Stress Scale (PSS-10; Persian version) |

Table 1. Continued

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Niedermeier et al., 2017[32] | Randomized; crossover | 42 | *M* = 32 | 48% female; 52% male | -Outdoor mountain hike (~170 min)<br>-Treadmill walk in fitness center (~170 min)<br>-Sitting (~170 min) | Three waves; one to 14 days between conditions | -Feeling Scale (FS)<br>-Feeling Arousal Scale (FAS)<br>-Mood Survey Scale (MSS)<br>-State Trait Anxiety Inventory (STAI; German version) |
| Plante et al., 2007[33] | Randomized; parallel group | 88 | 18-22; *M* = 19.31 ± 0.94 | Female | -Outdoor walk alone (20 min)<br>-Outdoor walk with a friend (20 min)<br>-Treadmill walk alone in fitness facility (20 min)<br>-Treadmill walk with a friend in fitness facility (20 min) | Single visit | -Activation-Deactivation Adjective Check List (AD-ACL) |

Table 1. Continued

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Focht, 2009[34] | Randomized; counterbalanced crossover | 35 | 20-29; *M* = 22.14 ± 1.73 | Female | -Outdoor walk (10 min)<br>-Treadmill walk in laboratory (10 min) | Two single visits spaced at least 48 hrs apart | -Exercise-Induced Feeling Inventory (EFI)<br>-Feeling Scale (FS)<br>-Felt Arousal Scale (FAS) |
| Olafsdottir et al., 2020[35] | Randomized; mixed factorial | 67 | 20-33; *M* = 24.39 ± 2.61 | 46 female; 21 male | -Outdoor walk (40 ± 5 min)<br>-Treadmill walk in gym (40 ± 5 min)<br>-Video of nature on color TV in laboratory while sitting (40 min) | Two waves: January to March 2014 and April to May 2014; two single visits | -Saliva samples (cortisol assays)<br>-Positive and Negative Affect Scale (PANAS) |
| Teas et al., 2007[36] | Nonrandomized; crossover | 19 | *M* = 58 ± 4 | Female | -Outdoor walk (1 hr)<br>-Treadmill walk in gym (1 hr) | Two single visits about one week apart | -Positive Affect Scale (PAS)<br>-Negative Affect Scale (NAS)<br>-Saliva samples (cortisol and log alpha amylase) |

Table 1. Continued

| Study | Study design | Sample size | Age (range or mean) ± 1*SD* | Gender | Interventions | Duration | Relevant outcomes |
|---|---|---|---|---|---|---|---|
| Flowers et al., 2018[37] | Randomized; mixed-model | 60 | 18-51; *M* = 19.9 ± 4.26 | 19 female; 41 male | -Indoor cycling in laboratory (using ergometer; 15 min)<br>-Outdoor cycling (using ergometer; 15 min)<br>-Promotional green exercise video viewing (3 min) | Single visit | -Rosenberg's Self-Esteem Scale<br>-Profile of Mood States (30-item version) |
| Kerr et al., 2006[40] | Nonrandomized; crossover | 44 (22 per group) | *M* = 21.7 | Male | -Outdoor run (5 km)<br>-Treadmill run in laboratory (5 km) | Two single visits spaced one week apart | -Tension and Effort Stress Inventory (TESI; Japanese version) |
| Turner & Stevinson, 2017[41] | Randomized; counterbalanced | 22 | 18-51 | 8 female; 14 male | -Outdoor run (in woodland area; 6000-m)<br>-Treadmill run in gym (6000-m) | Two single visits with at least 24 hrs between each visit | -Feeling Scale (FS)<br>-Felt Activation Scale of the Telic State Measure |

Table 2. Frequency of Included Studies Published Between January 2005 and May 2022

| Publication Years | Articles Published (N) | Articles Published (%) |
|---|---|---|
| 2005 – 2007 | 3 | 23.1% |
| 2008 – 2010 | 1 | 7.7% |
| 2011 – 2013 | 2 | 15.4% |
| 2014 – 2016 | 1 | 7.7% |
| 2017 – 2019 | 4 | 30.8% |
| 2020 – 2022 | 2 | 15.4% |

**ALL FIGURES**

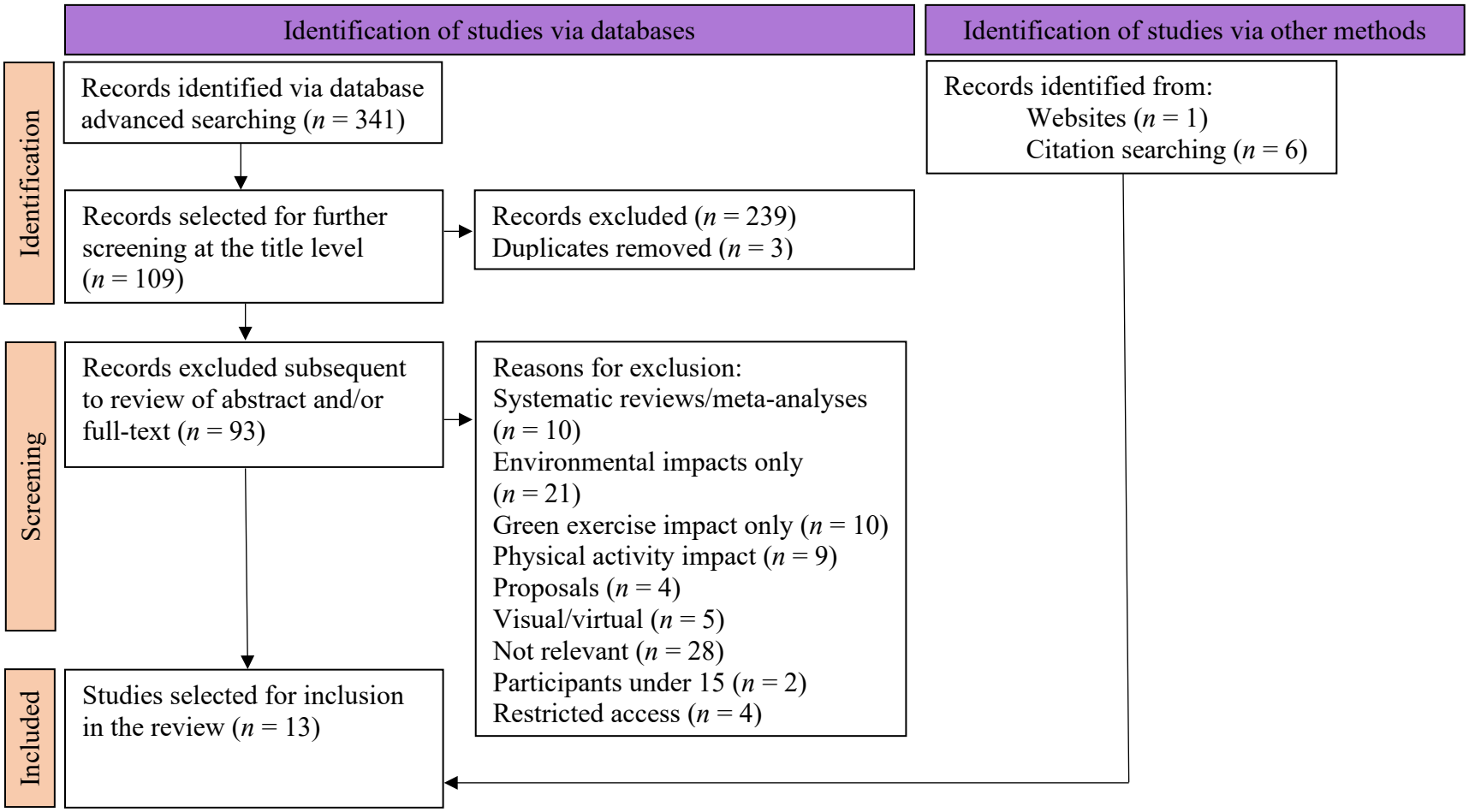


Figure 1. Selection of Studies Included Flowchart