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Physical exercise in natural environments and its influence on directed attention. Education implication. A systematic review

SALVADOR BAENA-MORALES*[1], OLALLA GARCIA-TAIBO**,
ANTONIO BAENA-EXTREMERA*** & FRANCISCO TOMÁS GONZÁLEZ-FERNÁNDEZ****

(*) *Department of general didactics and specific didactics. University of Alicante, Alicante, Spain*
(**) *Department of Physical Activity and Sport Sciences, Pontifical University of Comillas, CESAG. Palma de Mallorca*
(***) *Department of Education Sciences, Faculty of Education, University of Granada, Universitary Campus of Cartuja, s/n, 18071, Granada, Spain (ABE)*
(****) *Department of Physical Education and Sports, Faculty of Education and Sport Sciences, Campus of Melilla, University of Granada, 52006 Melilla, Spain (FTGF)*

Background: There is sufficient evidence to confirm that practice of physical exercise improves cognitive and emotional performance. This idea is also related to UNESCO's current trend of establishing connections with its Sustainable Development Goals (SDGs) and educational actions. Furthermore, the relationship of humans with nature seems to produce an improvement in different cognitive variables and specifically in directed attention. The mere presence of the human being in nature produces psychological, well-being and directed attention benefits. However, there is little research on the synergistic effect of physical exercise in natural environments, and how this affects directed attention, as a determining variable in academic performance.

Objective: The main objective is to show the effect of the physical exercise in natural environments on the directed attention in comparison with those performed in urban or built environments. The present systematic review analyzed studies that had evaluated the performance of directed attention when physical exercise in natural environments was practiced.

Methods: A systematic review of PUBMED, SCOPUS, SPORTDiscus, and Web of Science databases was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

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Authorship Contributions: SBM lead the project, established the protocol and wrote and revised the original manuscript. FTGF, OGT and ABE wrote and revised the original manuscript.

Correspondence to: Francisco Tomás González-Fernández. (E-mail: ftgonzalez@ugr.es)

Results: Twelve studies met the inclusion criteria of the review. Most of these studies were crossover or controlled trials investigating the effects of short-term exposure in natural environments during physical exercise. There is no consensus on the benefits of the physical exercise in natural environments for the directed attention.

Conclusion: The studies provide theoretical foundations that could explain some of the potential benefits. However, more rigorous research is needed to control the variables that may influence the improvement of directed attention.

Key Words: Directed Attention, physical exercise, natural environments, exercise.

1. Introduction

The relationship of human beings with the environment has been studied from multiple perspectives (Lahart et al., 2019; Norwood et al., 2019). Various epistemological studies have shown a correlation between spending time in green spaces and an improved sense of well-being (Pasanen et al., 2014). One example, the popular Japanese practice Shinrin yoku, or "bathing in the forest" which is based on spending time in the forest to improve health (Park et al., 2010). This practice has been extensively studied and has shown multiple benefits associated with overall health (Hansen et al., 2017). In recent decades, research has increased to examine the relationship of humans with nature from multiple perspectives (Bowler et al., 2010; Jo et al., 2019; Norwood et al., 2019; Pretty et al., 2007; Thompson Coon et al., 2011). This research has focused on several issues, correlating spending time in green spaces with an improvements sense of well-being (Pasanen et al., 2014), stress reduction (Gascon et al., 2015; Ulrich, 1981) an improvements in the immune system, metabolism, in cardiovascular disease and even better outcomes in pregnancy or an inverse relationship with mortality (Rojas-Rueda et al., 2019) or different cognitive variables (Berman et al., 2008; Bratman et al., 2012; Lahart et al., 2019).

According to Bratman et al. (2012), the benefits that natural environments have on cognition could be explained according to the Theory of Restoration of Attention (Kaplan, 1995). This is mainly due to the demands of attention in urban environments that overload the voluntary attention, exhausting the cognitive and psychological resources. Several studies have studied the effects that exposure to natural environments has on different cognitive variables as emotion (Fuegen & Breitenbecher, 2018; Gatersleben & Andrews, 2013), decreased anxiety and increased working memory performance (Bratman et al., 2015), attention control tasks (Geniole et al., 2016) or an increased executive processing (Tomporowski & Ganio, 2006).

All the research that studies the effects of the relationship of the human

being with the environment on cognition, can be ordered in three levels of interaction. Graduating from the simple observation of a natural environment, being present in nature and finally having active participation within a natural environment such as agriculture, gardening or physical exercise (PE) are included on this third level (Pretty, 2004). Regarding the first level, several studies with students have shown the attention-enhancing effects of spending time in nature (Berto, 2005; Kuo et al., 2019; Pretty et al., 2007). In Li & Sullivan's research (2016), students who studied with vegetation view had better results in concentration than those who observed buildings or studied without windows. In relation to these findings, Kuo et al., (2019), emphasizes how nature improves variables related to academic performance. At the second level, exposure to green spaces reduces inattention and produces improvements in the working memory of elementary students (Gascon et al., 2015).

Regarding the third level of interaction, and specifically in relation to the cognitive effects of realizing physical exercise or exercise in natural environment (PENE), Berman et al. (2008) found how PE as a walk-in nature can improve executive attention. Students who learnt in a natural environment showed healthier daytime cortisol rhythms than those who were in an artificial environment (classroom). However, Becker et al. (2017) emphasized that the reduction in cortisol during the school day was due to the forest environment, so these effects cannot be attributed to PE by itself. In addition to nature contact, the physical practice has also shown clear contributions to cognitive development (Bowler et al., 2010; Erwin et al., 2012). Hillman et al. (2011) highlighted how PE influences brain health and cognition, leading to better school performance and effective overall functioning throughout life. Furthermore, a review with the meta-analysis by Álvarez-Bueno et al. (2017) showed how PE could significantly improve children´s academic performance and classroom behavior. Among the physical variables that influence the improvement of academic performance, cardiorespiratory fitness is one of the components most clearly related to cognitive improvement (Santana et al., 2017). Therefore, during exercise, a decrease in activity in the prefrontal cortex affects cognitive performance, which could be explained by higher demand in the motor cortex related to movement (Dietrich, 2006). After completion of the exercise, this hypofrontality leads to a restoration of the prefrontal cortex which restores cognitive performance (Labelle et al., 2013). In addition, PE positively affects mental well-being and academic performance, as well as increased satisfaction, enjoyment and overall attention (Bowler et al., 2010). Thus, a synergistic benefit of engaging PE in nature could occur (Berman et al., 2008), according to a study that associated PENE

with a reduction in negative emotions and fatigue and an increase in energy (Bowler et al., 2010; Thompson Coon et al., 2011).

Within the cognitive variables, attention is characterized by having different functions and not being a single process; therefore, attention can be controlled both voluntarily and involuntarily. With respect to voluntary processes, a distinction is made between sustained, altered and directed attention (Maureira Cid & Flores Ferro, 2017). Natural environments generate innumerable stimuli that constantly put sensory systems on alert (Kaplan & Berman, 2010). In this context, the DA[1] involves the ability to select the important stimuli and discriminate the irrelevant (Gomez-Ramirez et al., 2016). Depending on the individual level of DA, the effectiveness of certain tasks may be affected by the presence of too many distracting elements. From a psychological point of view, improvements in directed attention may result in an increased sense of well-being and peace of mind (Kaplan & Berman, 2010). Therefore, all these acute benefits produced by PENE on psychological variables may be one of the foundations that explain the improvement of directed attention in comparison with PE in urban or artificial environment PEAE (Kaplan & Berman, 2010). As can be observed, there are a number of theoretical reasons that can defend the hypothesis of an enhancing effect on directed attention with the mixture of physical exercise and natural environments. However, there is no clear agreement on this hypothesis in the scientific literature. To the best of our knowledge, there is no review that compiles whether there is a differentiator of performing PE in natural or artificial environments on AD. Therefore, the main objective of this research is to compile the scientific evidence found in previous literature regarding the effect of PENE on DA in the general population.

2. Method

The systematic review strategy was conducted according to PRISMA (Preferred Reporting Items for Systematic Reviews) guidelines (Moher et al., 2009). The P.I.C.O.S. can be found in Table I. The protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols with the number 202130038 and DOI: 10.37766/inplasy2021.3.0038

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[1] Directed attention: "The effortful, conscious process of bringing cognitive resources to bear in order to focus on selected stimuli, while avoiding distraction from unrelated perceptual inputs. Assessment of this ability involves tests used to measure concentration, impulse inhibition and memory" (Bratman et al., 2012).

TABLE I
The picos presentation

Population	All people from any age or sex, with normal vision, no partial/chronic injury or illness and no history of neuropsychological impairment.
Intervention	Exposure to nature was in outdoor environments containing natural elements or through virtual scenarios in nature.
Comparator	Similarity in training components in terms of volume, duration, intensity and mode. Physical exercise and directed attention test must be accurately determined
Outcomes	Any result comparing directed attention between environments
Study design	We considered randomised crossover trials (RXT) or controlled/comparative trials (RCT), quasi-RXT and quasi-RCTS (acute and longitudinal trials were considered).

THE INCLUSION AND EXCLUSION CRITERIA CAN BE FOUND IN TABLE II.

TABLE II
Inclusion And Exclusión Criteria.

	Inclusion criteria	**Exclusion criteria**
Population	People from any age, sex or fitness level with no injury or illness, with normal vision, no partial/chronic injury or illness	Not applicable
Intervention	Any physical exercise intervention. The dose of the intervention must be specified. At least the minutes, intensity or type of exercise performed.	Research that has shown the dose of their exercise or is not clearly specified.
Comparator	Passive control conditions	Other intervention conditions than passive
Outcome	Cognitive tests that measure directed attention	Other cognitive test not related to the included outcomes
Study design	Counterbalanced cross-over design (randomized and non-randomized can be included, since all revealing no significant differences in control conditions)	Other study designs that do not allow comparisons within-subjects for the two conditions (physical exercise in natural environments and physical exercise in artificial environments)
Additional criteria	Only original and full-text studies written in English.	Written in other language than English. Other article types than original (e.g., reviews, letters to editors, trial registrations, proposals for protocols, editorials).

The screening of the title, abstract and reference list of each study to locate potentially relevant studies was independently performed by the two authors (FTGF and SBM). Additionally, they reviewed the full version of the included papers in detail to identify articles that met the selection criteria.

An additional search within the reference lists of the included records was conducted to retrieve additional relevant studies. A discussion was made in the cases of discrepancies regarding the selection process with a third author (OGT). Possible errata for the included articles were considered.

Information Sources and Search

Electronic databases (PubMed, Scopus, SPORTDiscus, and Web of Science) were searched for relevant publications prior to 20 February 2021. In Web of Science was searched filtering by "sport sciences". The search was conducted from 1 January 2000 to 31 December 2019. In addition to the database search, references included in the selected articles were also checked for eligibility. Search strategies such as those performed by (Bowler et al., 2010; Lahart et al., 2019; Thompson Coon et al., 2011). The Preferred Reporting Items for Systematic reviews (PRISMA) Guidelines, incorporating the risk of bias and strength of recommendations were used as a methodological template for this review (Moher et al., 2009). Keywords and synonyms were entered in various combinations in the title, abstract or keywords: (physical exercise OR green exercise OR physical activity) AND ("physical activity in natural environment" OR "directed attention" OR "attention" OR "cognitive" OR "indoor exercise" Additionally, the reference lists of the studies retrieved were manually searched to identify potentially eligible studies not captured by the electronic searches. Finally, an external expert has been contacted in order to verify the final list of references included in this scoping review in order to understand if there was any study that was not detected through our research. Possible errata were searched for each included study.

Data Extraction

A data extraction was prepared in Microsoft Excel sheet (Microsoft Corporation, Readmon, WA, USA) in accordance with the Cochrane Consumers and Communication Review Group's data extraction template (Group CCCR, 2016). The Excel sheet was used to assess inclusion requirements and subsequently tested for all selected studies. The process was independently conducted by the two authors (OGT and ABE). Any disagreement regarding study eligibility was resolved in a discussion. Full text articles excluded, with reasons, were recorded. All the records were stored in the sheet.

DATA ITEMS

The outcomes chosen for this Systematic review included directed attention (DA). Additionally, the following data items were extracted: (i) author and year; (ii) sample (n); (iii) Cognitive testing and physical and environmental testing; (iv) main results and conclusions of each study.

METHODOLOGICAL ASSESSMENT

Methodological assessment process was performed by two authors (OGT and SBM) by an instrument to measure the likelihood of bias (Jadad et al., 1996). Each article was assessed based on 7 specific criteria attending to randomization, double blinded and withdrawals and dropouts. The inclusion of each criteria was scored with 1 point, otherwise 0 point was registered. Additional points were given if the randomization (+1R) or double blinded (+1DB) was described and it was appropriate. One point was deducted if randomization (-1R) or double blinded (-1DB) was inappropriate (see Table III). Thus, each article was scored with a maximum of 5 points.

TABLE III
Measurement Of Risk Of Bias.

	Randomization	Double blinded	Withdrawals and dropouts	+ 1r	+1DB	- 1R	- 1DB	Total score
Bodin y Hartig, 2003	1	0	0	-	-	-	-	1
Hartig et al., 2003	1	0	1	-	-	-	-	2
Berman et al., 2008	1	0	0	-	-	-	-	1
Mayer & Bruehlman (2008)	1	0	0	-	-	-	-	1
Taylor y Kuo, 2009	1	0	1	-	-	-	-	2
Gatersleben y Andrews, 2013	1	0	0	-	-	-	-	1
Bratman et al., 2015	1	0	1	-	-	-	-	2
Rogerson y Barton, 2015.	1	0	0	-	-	-	-	1
Rogerson et al., 2016	1	0	1	-	-	-	-	2

(*Continued*) - Table III

(*Continued*) - Table III

	Randomization	Double blinded	Withdrawals and dropouts	+ 1r	+1DB	- 1R	- 1DB	Total score
Fuegen & Breitenbecher, (2018)	1	0	0	-	-	-	-	1
Bailey et al., 2018	1	0	0	-	-	-	-	1
deBrito, 2019	0	0	1	-	-	-	-	1

3. Results

Study identification and selection

The searching of databases identified a total of 1680 titles. These studies were then exported to reference manager software (EndNote™ X9, Clarivate Analytics, Philadelphia, PE, USA). Duplicates (958 references) were subsequently removed either automatically or manually. The remaining 31 articles were screened for their relevance based on titles and abstracts, resulting in the removal of a further 31 studies. Following the screening procedure, articles were selected for in depth reading and analysis. After reading full texts, a further 18 studies were excluded due to not meet the eligibility criteria (Figure 1). A total of 13 investigations passed the inclusion criteria. Three reviews were also added since they studied the relationship between PENE and different physiological and cognitive variables, including DA. Nine investigations were found that advocated the additional value of PE to improve DA when practiced in natural environments compared to PEAE (Berman et al., 2008; Faber Taylor & Kuo, 2009; Gatersleben & Andrews, 2013; Hartig et al., 2003; Mayer et al., 2009; Rogerson et al., 2016; Rogerson & Barton, 2015)which is filled with intriguing stimuli, modestly grabs attention in a bottom-up fashion, allowing top-down directed-attention abilities a chance to replenish. Unlike natural environments, urban environments are filled with stimulation that captures attention dramatically and additionally requires directed attention (e.g., to avoid being hit by a car. In contrast, five studies found no significant difference between PENE and PEAE (Bayley et al., 2018; Bodin & Hartig, 2003; Bratman et al., 2015; de Brito et al., 2019; Fuegen & Breitenbecher, 2018).

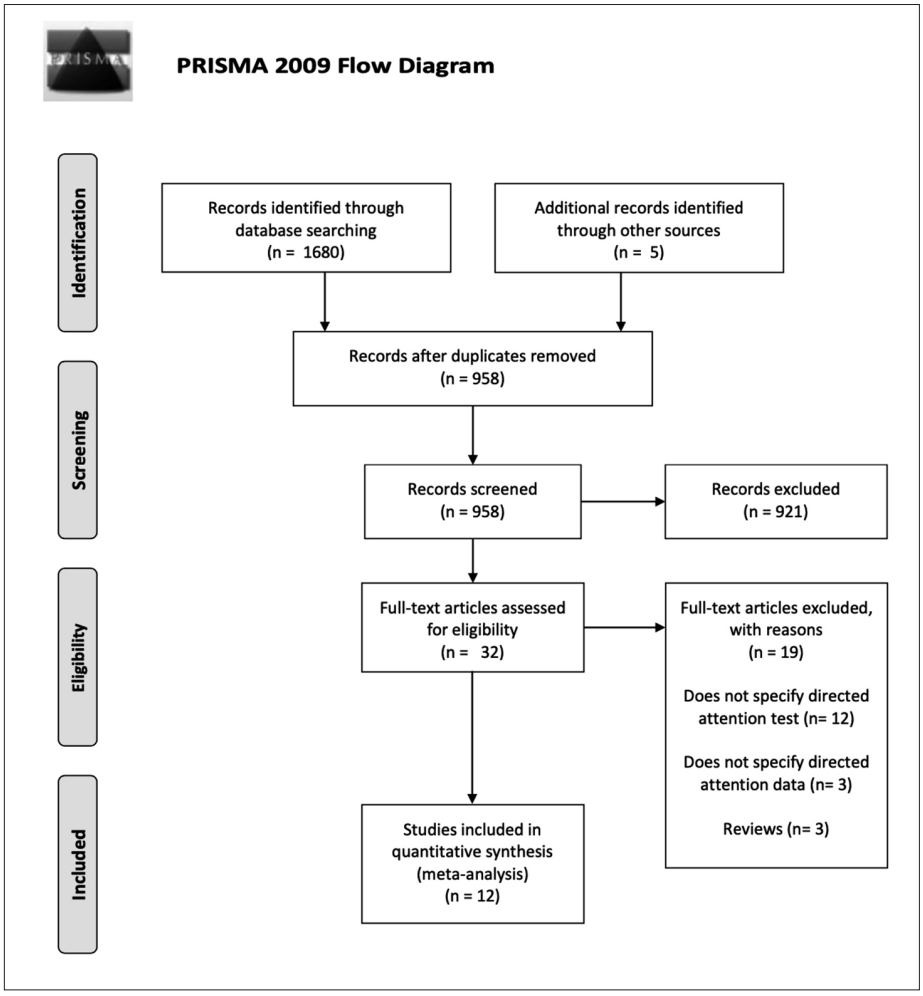

Fig. 1. - PRISMA flow diagram of literature search for physical exercise interventions in the natural and artificial environments on directed attention. The PRISMA flow diagram depicts the flow of information throughout the different phases of this systematic review. It includes the number of records identified, included and excluded and the reasons for exclusions.

Characteristics of the studies

MMost research included college students as samples, except for one that studied athletes (Bodin & Hartig, 2003), adult volunteers (Bratman et

al., 2015; de Brito et al., 2019) and studied children with attention deficit (Faber Taylor & Kuo, 2009). Regarding the tests used to measure DA, most cases included the Digital Span Backward test; three studies opted for Necker Cube Pattern Control (NCPCT) (Gatersleben & Andrews, 2013; Hartig, Evans, Jamner, Davis, & Gärling, 2003). With respect to the main physical tests performed, these were walking between 15 and 50 minutes (Bayley et al., 2018; Berman et al., 2008; Bratman et al., 2015; de Brito et al., 2019; Fuegen & Breitenbecher, 2018; Gatersleben & Andrews, 2013; Hartig et al., 2003; Mayer et al., 2009), running (Bodin & Hartig, 2003; Rogerson & Barton, 2015) or cycling (Rogerson et al., 2016).

Summary Of Results

The following summary presents the selected investigations, highlighting the study of the sample, attention test, PENE performed and the main results and conclusions (Table IV).

Discussion

In the present we analyzed by systematic review (across 12 experimental studies) that had evaluated the performance of DA when PENE was practiced. As mentioned previously, the benefits of PE on cognitive functions have been highly contrasted (Álvarez-Bueno et al., 2017; Hillman et al., 2011)"ISSN":"15275418","abstract":"Objective The objective was twofold: to assess the effect of physical activity (PA, so the practice of PENE may be even healthier for the brain than exercising indoors or in urban environments (Bodin & Hartig, 2003; Bowler et al., 2010; Erwin et al., 2012; Thompson Coon et al., 2011). In fact, natural environments provide encouragement of PE, improve sociability or decrease stress (Hartig et al., 2014). These benefits also translate into psychological improvements such as feeling more energetic and in better shape, as well as increasing the intention to repeat the activity later (Thompson Coon et al., 2011). Therefore, interactions with natural environments have been found to be beneficial to cognitive functions, especially on executive functions (Bratman et al., 2015) with high demands on DA (Kaplan & Berman, 2010).

The literature have shown that benefits encountered may be partially explained by the age-old relationship between humans and nature (Song et al., 2016), in this sense, the small number of studies carried out have been conducted indicate that we are not yet evolutionarily adapted to urban envi-

TABLE IV
Studies That Analysed The Effect Of Physical Exercise In Natural Environments On Attentional Variables.

Author and year	Sample (n)	Cognitive Testing	Physical and environmental testing	Main Results	Main Conclusions
Bodin & Hartig (2003)	12 regular runners (50% female). 39.7 years	Digit Span Forward Digit Span Backward	Maximum of 14-kilometers or 60-min running in two conditions (PENE and PEAE)	Time-environment interaction showed a not significant moderate effect. Time-gender did not reveal statistical significance but a large effect size.	PENE showed an increased performance in men but a decrease in women. In contrast PEAE revealed an increased performance in women but a decrease in men.
Hartig et al., (2003)	112 university students (50% female). 20,8 years	Necker Cube Pattern Control	50-min walking in two conditions (PENE and PEAE)	NCPCT did not show any significant effect of environment or task, independently or interactively	Reported a decrement in attentiveness during the experiment, which was not affected by environment or task condition.
Berman et al., (2008)	38 university students (23 women, 15 men). 22,62 years	Digit Span Backward.	50 or 55-min walking in two conditions (PENE and PEAE)	PENE showed significant improvements compared to PEAE. Mood or weather conditions did not affect the obtained results.	Interactions with nature improved directed attention skills assessed with a backwards digit-span task. This finding is consistent with ART.
Mayer & Bruehlman (2008)	76 students (51 females, 22 males, 3 unidentified)	Ten-minutes timed memory loaded search task, adapted from Hartig, et al. (1996)	15-min walking in two conditions (PENE and PEAE) and watching videos recordings of natural and urban environments	PENE registered significantly less error (M = 1.18, SD = 0.47) that the urban condition (M = 1.60, SD = 0.74).	The analysis showed that positive effects of nature exposure are partially related to contact with the nature instead of increased attention capacity

(*Continued*) - Table IV

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Author and year	Sample (n)	Cognitive Testing	Physical and environmental testing	Main Results	Main Conclusions
Taylor & Kuo, (2009)	17 children diagnosed with ADHD. (7 to 12 years)	Digit Span Backwards	20.min walking in two conditions (PENE and PEAE).	Walking in the park showed better results than walking through downtown ($p = .0229$) or the in the neighbourhood ($p = .0072$). The effect sizes were substantial (Cohen's $d = .52$ and .77, respectively)	Twenty minutes in a park setting were enough to raise attention performance compared to the same amount of time in other settings. The type of setting may improve attention not only in general population but also in populations with ADHD.
Gatersleben & Andrews (2013)	17 students (10 women) 18 ±6,23 years	Necker Cube Pattern Control Task	10-min walking in the open-air and virtual nature.	Statistical differences between walking in the open air versus walking in virtual nature ($p < 0.001$, $d = 1.77$).	The recovery of attention is faster in an open environment than in an indoors environment where it is exhausted faster, this difference is higher than in the simulated environment.
Bratman et al., (2015)	70 adults (33 female) 22,9 years	Digit Span Backward	50-min walking in two conditions (PENE and PEAE)	ANOVA results yielded a main effect of time, $F(1,58) = 8.40$, $p < .01$. No environment × time interaction $F(1,58) = 0.04$, n.s	There are many factors that differ between natural and urban environments. It is unclear which of these differences' accounts for the observed changes in cognition
Rogerson & Barton (2015)	12 healthy adults (6 men, 6 women) 27.8 years.	Digit Span Backward	50-min running in three conditions; open, closed environments and control condition	Significant differences were found in the nature condition ($P < 0.001$, 95% CI (0.87, 2.14)), but not in the urban condition ($P = 0.266$) or control ($P = 0.166$).	The effects of the exercise performed in different visual environments were shown after selective attention to exercise. Visualization of the nature facilitates restoration of attention during moderate-intensity exercise.

(*Continued*) - Table IV

(*Continued*) - Table IV

Author and year	Sample (n)	Cognitive Testing	Physical and environmental testing	Main Results	Main Conclusions
Rogerson et al., (2016)	24 university students and staff (19 women) 35,1 years	Digit Span Backward	15-min cycling Open and closed environments	Selective attention was worse indoors (-0.11, 0.94), $p > 0.05$ and improved outdoors ($p > 0.05$)	Exercise in a natural environment can promote selective attention. However, the results do not support the theory of restoration of attention.
Fuegen & Breitenbecher, (2018)	181 university students (108 women) 21,59 years	Digit Span Backwards	50- min walking in open and closed environments	No significant differences were detected in any of the environments for the DSB test ps> .17	PENE does not provide additional improvement of attention. It is suggested to analyze which environmental factors can draw people's attention.
Bailey et al., (2018)	10 university students (5 females) 20 years	Digit Span Backwards	30-min walking in open and closed environments	No significant main effect for the BDST for time ($F1,18 = 1.767$, $p = .200$) nor for the time x environment interaction ($F1,18 = 0.000$, $p = 1.000$).	The DSB did not yield significant result. The effect of the walk was depleted by the other tests, thus reducing the measurable influence.
de Brito et al., (2019)	23 middle-aged adults (19 female) 49,7 years	Digit Span Backwards	50-min walking in two conditions (PENE and PEAE)	Similar directed-attention scores for post-walk sessions between the green and suburban walking conditions (-0.1, 95% CI (-0.8, 0.5); $p = 0.6$).	Directed-attention did not improve from pre- to post-walk for either condition.

Note: PENE, Physical exercise in Natural Environment. PEAE, Physical exercise in Artificial Environment ART, Attention Restauration Theory. DSB, Digit Span Backwards. NC, Necker cube test. ADHD, Attention deficit Hyperactive disorder.

ronments as we have spent over 99.99% of our time living in natural environments. In fact, we can discuss starting from the idea that we have a 'natural brain' that not yet adapted chronologically to life on the city. For this reason, currently, we found a large number of psychological (Gascon et al., 2015; Pasanen et al., 2014) and social (Rojas-Ruedas et al., 2019) problems in large proportion population. The brain has evolved throughout history close to nature and the natural elements (Park et al., 2010). Therefore, due to the short period of adaptation to artificial environments, it could be a strange situation for our brain (Song et al., 2016). However, the literature reveals that when it is used in natural environments provides benefits by activating certain areas of learning (Carballo & Portero, 2018). Accordingly, the DA in one of these learning areas, as the ability to ignore irrelevant stimuli, essential capacity to achieve efficient attention (Oros et al., 2014). For example, an individual walking through a lush forest should inhibit the urge to lose attention to potential distractions and thus avoid a fall. If this process is prolonged over time, AD can lose its effectiveness. This filtering of relevant information may be more costly in natural environments as perceptual demands increase (Gomez-Ramirez et al., 2016). Some studies highlighted the additional benefits of PENE on attentional functions compared to exercise in urban or enclosed conditions (Bodin & Hartig, 2003; Bowler et al., 2010; J. Pretty et al., 2007; Rogerson & Barton, 2015; Thompson Coon et al., 2011). However, a recent meta-analysis did not find significant differences between these two conditions (Lahart et al., 2019). This controversy among studies could be explained by the effect of different variables, since, as Bodin and Hartig (2003) mentioned, PENE may amplify or reduce the psychological and cognitive benefits. In addition, we found a high heterogeneity and low methodological quality among the reviewed articles, which makes it difficult to extrapolate the evidence (Lahart et al., 2019; Thompson Coon et al., 2011).

Increased DA is associated with psychological variables such as concentration and self-control (Kaplan, 1995). These variables seem to improve if students perform their tasks in a classroom that is oriented to green spaces (Li and Sullivan, 2016) or even displaying photographs of natural environments (Berman et al., 2008; Berto, 2005). Therefore a simple observation of nature seems to reduce cognitive fatigue by improving DA (Kaplan, 1995; Li & Sullivan, 2016; Raanaas et al., 2011). In relation to PENE, there were positive effects on DA after a walk-through natural environment, but not after a similar activity through built-up areas (Berman et al., 2008; Hartig et al., 2003). This could be explained by the fact that DA is a factor that can be influenced by the environment (Berman et al., 2008). In this way, the attention and cognitive processing required by the environment can modi-

fy the emotional state caused by the PE performed (Harte & Eifer, 1995). For example, a reset of depleted attentional processes can be promoted in environments with predominantly natural characteristics (Bodin & Hartig, 2003), in contrast to urban environments that require more AD processing (Kaplan & Berman, 2010). These statements agree with those from other studies that highlighted the increased demands on attentional processing required by synthetic environments (Kaplan & Berman, 2010). However, (Dietrich, 2006) found that when a PE is practiced, the DA is not affected by the environmental conditions where it is practiced. Therefore, the possible improvement in DA related to PENE compared to urban environments could be partially explained by the several stimuli present in urban environments which request greater DA in order to avoid potential dangers. Thus, a decrease in the sensation of pleasure and well-being is generated (Berman et al., 2008; Ekkekakis et al., 2000).

Differences among studies could be explained by the Attention Restoration Theory proposed by Kaplan (1993). This theory highlights that visual characteristics of natural environments lead to an increase in involuntary attention and help the recuperation of the capacity for DA (Kaplan & Berman, 2010). Therefore, DA could be affected by the attentional conditions of the natural environment or the practice of PE itself. Then, if there is a reduction in the demand for DA processes, the restoration of attention during the practice of PENE could be maximized (Kaplan & Berman, 2010). In relation to this, Marcora et al. (2009) highlighted how cognitive fatigue is affected when a higher effort is perceived and when high exercise performance is demanded. Bodin and Hartig, (2003) stress that the person-environment binomial involves incentives and processes that induce curiosity or attraction. Then, in contrast to DA, curiosity does not involve extraordinary cognitive effort. For example, in urban or synthetic environments, traffic, crowds, noise, etc., would increase cognitive demands and impair the psychological benefits associated with PE. In natural environments, factors conditioning the focus of attention differ depending on their characteristics. For instance, practicing green exercise in well-conditioned parks without many distractions does not entail the same cognitive cost as in lush forests and with more attentional demands. Therefore, synthetic environments do not require higher cognitive expenditure by itself. On the other hand, Berman et al. (2008) detected improvements in executive functions related to PENE, but there were no differences in alertness or attention orientation. Therefore, when PE leads to an overuse of involuntary attention, it implies a mental effort that decreases the use of DA, along with reducing the opportunity to restore attention resources already exhausted (Kaplan & Berman, 2010). Hence, exhaustive control

of the effort involved in exercise is essential, since urban environments can cause greater cognitive fatigue, leading to greater perceived effort (Marcora et al., 2009). In addition, Martens et al. (2011) highlighted the importance of the type of environment where PE is performed. Overly wild environments have a negative effect on the sense of well-being compared to more accessible natural environments. Therefore, future research should control those variables that may condition perceived effort in order to detect the extent to which it may be affecting cognitive fatigue.

On the other hand, the effect of the PENE on DA has been studied in populations with special needs such as children with attention deficit. Only twenty minutes walking in a park was sufficient time to raise attention performance comparing to the same practice in other urban settings (Faber Taylor & Kuo, 2009). In addition, Taylor & Kuo (2011) found that playing in PENE improves symptoms of attention deficit respect to children who plays outdoor or indoor environments. Moreover, children without baseline attentional problems who play in large, integrated outdoor areas in natural environments showed less frequent inattentional behaviors ($p < .05$) (Mårtensson et al., 2009).

From a physiological point of view, Niedermeier et al. (2017) highlights the absence of significant differences between mountain hiking and indoor treadmills in variables such as salivary cortisol, heart rate variability and blood pressure. Further, Twohig-Bennett & Jones (2018), found that outdoor walks significantly improved cardiac, anthropometric, pulmonary and psychological variables. In addition, PENE such as regular walking in forests affects cognitive variables such as natriuretic peptide levels and dopamine or sympathetic nerve activity (Li et al., 2011).

Task Performed

The analyzed studies compared the effect of walking in different environmental conditions on directed attention (DA) (Berman et al., 2008; Bratman et al., 2015; de Brito et al., 2019; Fuegen & Breitenbecher, 2018; Gatersleben & Andrews, 2013; Hartig et al., 2003; Mayer et al., 2009). The type of physical exercise may be a factor that alters the attentional results by generating different perceived effort. Exercising on a treadmill following a rhythmic pattern is different from a self-regulated exercise performed outdoors Rogerson & Barton (2015). Additionally, a similar exercise performed in different environments (indoors and outdoors) may produce different physiological reactions, such as a lower heart rate or less sympathetic activation (Kobayashi

et al., 2019; Park et al., 2010). Some of the analyzed studies have compared indoor settings (Gatersleben & Andrews, 2013; Rogerson et al., 2016), but only one reported significant differences (Gatersleben & Andrews, 2013).

Type of population

Easier access to a sample of students has involved that most of the research evaluated university students. However, we did not find any study detailing the regular place of residence of the examined subjects. This could be a key factor since certain degree of DA exhaustion must be assumed from the examined sample, and urban life can cause some exhaustion of DA(Kaplan & Berman, 2010). Additionally, estimating the previous level of physical condition and selecting those subjects with similar levels is important since both level of physical condition and its intensity produce different cognitive consequences (Labelle et al., 2013).

Exposure Time

Most of the analyzed studies used experimental designs of at least 50 minutes (Berman et al., 2008; Bodin & Hartig, 2003; Bratman et al., 2015; de Brito et al., 2019; Fuegen & Breitenbecher, 2018; Hartig et al., 2003; Mayer et al., 2009). However, only a few announced significant differences according to the PE environment (Berman et al., 2008; Hartig et al., 2003; Mayer et al., 2009). Kaplan & Berman (2010), found that using DA involves an effort as a consequence of avoiding distractions from external stimuli, so these processes associated with attention may be fatigued over time. Rogerson & Barton (2015), added that, although performing PENE is related to a longer time to exhaustion, there were no significant differences with respect to PEAE. Thus, there are clear indications that a longer time performing PENE implies a greater increase in DA than performing PEAE.

Methodological recommendations

Despite there is diverse theoretical evidence stating that AD improves through AFMN, the diversity of methodological variables influencing the restoration of AD and consequently the results observed requires further research with increased methodological quality. Therefore, based on the limitations observed in the designs of the reviewed studies, a proposal of methodological recommendations for future research is made (Table V).

TABLE V
Methodological Recommendations

Before PE	
The study sample should live in similar environments (i.e. countryside or city).	The environment characteristics may influence the level of attentional exhaustion
To consider previous physical-fitness level.	If PE involves a moderate-high physical demand, the physical-fitness level of each subject should be similar. This could be tested by a questionnaire or a test battery.
Previous questionnaires on social and physiological variables.	Variables such as wellness, stress or anxiety should be assessed.
To perform pretest and posttest at the same location	The location where the DA test takes place may influence the results, so the pretest and the posttest should be performed at the same environment.
Cognitive stress caused by the environment should be quantified	A lush forest is different than a park with green surroundings and safe paths. Designing a scale to quantify the attentional demands of a particular environment may be valuable.
During PE	
To avoid additional distraction, prohibit the use of the mobile or be accompanied.	To isolate the influence of PE and environment variables, any other variable must be controlled.
To calculate the intensity and volume of the exercise to guarantee a similar load in both environments.	Quantifying certain variables with heart rate and gps tracker would contribute to control the exercise load.
After PE	
To perform posttest and pretest at the same location.	
To control the time lasting from the completion of AP test and completion of the test	A longer rest may influence test results

Note: PENE, Physical exercise in Natural Environment PEAE, Physical exercise in Artificial Environment DA, Directed Attention

Conclusions and practical applications

PE in natural environments is a useful practice to improve cognitive performance and DA specifically. However, scientific results are inconsistent regarding the additional improvements compared to PEAE. The diversity of variables that may influence the improvement of DA during PENE has been related to methodological flaws. Among the variables to be controlled in future research, we highlight the intensity of PE, since it may carry a potential cognitive benefit. Therefore, effectively control the subjective perception of effort it is essential, as well as the mood of the subjects. Moreover, the possible factors that may lead to increased cognitive fatigue in both environments must be examined. On the other hand, it is essential to correctly standardize the time from the end of the PE to the attention test, since the recovery time of the effort can affect the result. Therefore, the level of fatigue at the time of the test should be considered in future research. Similarly, the place where the attention test is performed should be controlled, since it is not the same to perform it in a laboratory or in the natural environment itself. To mitigate this factor, it is recommended to perform the DA pretest and posttest in the same environment where the PE was performed. Thus, it could clarify whether the possible improvements in attention are due to an effect of the environment itself or to the PE itself in that environment. In addition, performing attentional tests at different times may be interesting since it would allow to correlate the elapsed time with the restoration of the prefrontal cortex. This would allow evaluation of the behaviour of transitory hypofrontality on executive functioning and cognitive performance after exercise. Finally, measuring DA in different synthetic and natural environments involves methodological difficulties, which limits consensus in the literature on the possible additional benefit of performing PENE. The methodology from the analysed studies was not strict and did not isolate DA. In conclusion, the research shows theoretical evidence that supports the improvement that PENE produces on DA, however, methodological improvements are required in future research following the mentioned recommendations as well as a meta-analysis.

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