©Journal of Sports Science and Medicine (2021) **20,** 789-798
http://www.jssm.org DOI: https://doi.org/10.52082/jssm.2021.789

Research article

Sports in Natural Environment, Sports in Urban Environment: An fMRI Study about Stress and Attention/Awareness

Antonio Baena-Extremera [1], Julio F. García [2]✉, Andrés C. Martínez [3] and Cristina Martín-Pérez [4]
[1] Faculty of Education Sciences, University of Granada, Spain; [2] Department of Education, Research and Evaluation Methodology, University Pontifical Comillas, Spain; [3] Faculty of Psychology, University of Granada, Spain; [4] Faculty of Education, Universidad Internacional de la Rioja, Spain

Abstract

This study aimed to explore, on one side, the differences between a group of athletes exercising outdoor (OG) and another group exercising indoor (IG) in stress and awareness, and, on the other side, between-group differences in the fMRI activations during the visualization of natural environment images versus urban images. In addition, we aimed to analyze the associations between the resulting task-related brain activations and stress and attention-awareness in each group separately. All the participants (N = 49; OG = 21, 11 females, mean age = 40, SD = 6.49; and IG = 25, 11 females, mean age = 40; 6.19) underwent an fMRI scan and completed the Perceived Stress Scale and the Mindful Attention Awareness Scale. Besides, we collected a sample of hair cortisol. Participants viewed three types of images: water nature, green nature and urban images. Two-sample t-test with corrected p=0.001 values were carried out. Further correlational analyses were performed to estimate the associations between task-related brain activations and our pyscho-emotional measures in each group. Fisher tests were used to explore for potential between-group differences in the correlational indexes. In OG, compared to IG, we found a higher activation of the middle occipital cortex and a cluster comprising the supplementary motor area (SMA), the premotor cortex and the pre-SMA while viewing green nature images versus urban images. In OG, more than in IG, the higher activation of the left SMA cluster negatively correlated with perceived stress, while in the IG, more than in OG, the higher premotor cortex activation was positively related to the total score on MAAS. No significant association was found with the hair cortisol levels. Exercising outdoor would relate to better psycho-emotional outcomes, also for athletes. On the other side, the exposition to green nature led to higher activation of brain areas related to motor planning, but also to emotion regulation and emotional response.

Key words: Outdoor exercise, fMRI, stress, attention/awareness, hair cortisol.

Introduction

Since the appearance of the term Nature Deficit Disorder in 2005 by Richard Louv, many studies have tried to make people aware of the importance of visiting nature for their personal health (Martínez and Caballo, 2020). Scientific literature has for years shown the importance of exposure to natural environments as opposed to urban environments, being associated with better psychologycal health (De Vries et al., 2003), better psychological health (Ferguson and Evans, 2018) and even better physical-sports health (Eigenschenk et al., 2019).

Scientific evidence shows that when a person observes a scene, photo or video of a natural environment compared to an urban environment, positive psychological effects occur, such as a reduction in anxiety (Ulrich, 1981), in physiological and psychological stress (Hartig et al., 2003; Tyrväinen et al, 2014), a reduction, in work-related stress (Bjørnstad et al., 2015; Korpela et al., 2015; Sianoja et al., 2018), and even an improvement in mood (Hartig et al., 2003; Stigsdotter and Grahn, 2004). The effect on observation of these images is such that even positive effects on the satisfaction and well-being of coronary and pulmonary patients have been found simply by observing environments in nature or with houseplants from a window (Raanaas et al., 2010).

Currently, only seven studies have compared the effects of human exposure to a natural, green environment with an unnatural (urban or indoor) environment (Aspinall et al., 2013; Bailey et al., 2018; Bratman et al., 2015; Joung et al., 2015; Neale et al., 2017; Park et al, 2007; Tilley et al., 2017), with little research now using image visualisation tasks with Neuroimaging (Chang and Chen, 2005; Kim et al., 2010; Kim and Jeong, 2014; Lee, 2017; Martínez-Soto et al., 2013; Roe et al., 2013; Tang et al., 2017; Ulrich, 1981).

Regarding the brain impact of urban images compared to nature images, some EEG results (Aspinall et al., 2015; Essawy et al., 2014; Caballero et al., 2018) have shown that in a natural environment brain activity was associated with a more meditative state, represented by a greater presence of Alpha waves, while in an urban environment (Choi et al., 2015), brain activity was associated with higher levels of Beta waves and greater psychological stress. Closer to the methodology of this study, the limited work carried out with fMRI found that visualisation of images of urban environments compared to natural environments was associated with increased activity in prefrontal and occipital areas, as well as temporal areas, (Kim et al, 2010; Lee, 2017), parts of the limbic system (Kim et al., 2010; Kim and Jeong, 2014), and default mode network (DMN) areas such as the cuneus and posterior cincture (Martinez-Soto et al., 2013; Tang et al., 2017). Meanwhile, nature scenes, compared to urban images, produced greater activation in subcortical areas such as the insula, associated with higher-order emotional and cognitive processes, and the basal ganglia, involved in voluntary movements (Kim et al., 2010). Furthermore, the activation of areas of the frontal, parietal and upper temporal cortices and the occip-

Received: 21 March 2021 / Accepted: 10 September 2021 / Published (online): 01 October 2021

ital cortex were also associated with the visualisation of natural scenes (Martínez-Soto et al., 2013). Interestingly, those studies that in addition to analysing brain processing with neuroimaging used validated subjective tests showed that the visualization of urban environments was associated with responses of fear (Kim et al., 2010), stress (Choi et al., 2015) and sadness (Ulrich, 1981), in addition to being associated with over-exertion in cognitive processing tasks (Martínez-Soto et al., 2013; Tang et al., 2017). On the other hand, activation when seeing natural environments was associated with happiness (Kim et al., 2010), well-being (Chang and Chen, 2005),, cognitive restoration (Martínez-Soto et al., 2013; Tang et al., 2017) and improved attention (Ulrich, 1981), even looking for differences according to the type of landscape stimulation (with/without water, with/without trees etc.) (Tang et al., 2017).

In addition to visualizing images, Aspinall et al. (2015) and Chen et al. (2016), carried out a recording of brain activity with EEG in an outdoor activity, obtaining results that corroborated those obtained in the laboratory about stress and full attention shown by the aforementioned research. In the case of fMRI and the visualisation of nature images, work has been carried out mostly with young adults (Kim et al., 2010; Kim and Jeong, 2014; Lee et al., 2015; among others), and in primary school children (Eigenschenk et al., 2019), but never comparing adult sportsmen and women specialised in the practice of their favourite sport in a particular type of environment (outdoor or indoor). As stated by Grassini et al. (2019), few studies have yet used the fMRI technique to test the effect of natural environments and urban environments at the brain level, so this research will help to fill this theoretical gap. Therefore, the first objective of this research is to study the differences between athletes who practice outdoor sport (OG) and those who practice indoor sport (IG) in their levels of stress and awareness. On a second objective, we aimed to explore the brain reactivity, in these two groups (OG and IG), to the visualization of images of natural environments in comparison with images of urban environments, where they practice their sports. The last objective would be to study the associations between the psycho-emotional measures and the brain reactivity related to nature and urban environments in each group separately. To do so, we study the differential relationship of OG and IG in the previously mentioned brain activation with the levels of perceived stress and full attention/consciousness. As a result, two hypotheses were established. First, we expect OG to present better levels of awareness and lower levels of perceived stress (Berto, 2014). We also expect to find a differential brain activation in the OG, compared to the IG, in frontal areas when visualising images of nature compared to urban images (Elsadek et al., 2019; Yu et al., 2017), and that these resulting areas are positively related to levels of awareness and negatively related to levels of stress in the OG, more than in the GI (Berto, 2014; Brown et al., 2013).

Methods

Participants

A convenience sample of 49 participants were recruited throughout the province of Granada (Andalucía, Spain) and divided in two groups depending on their preferred areas for physical exercise: outdoor group (OG; n = 21) and indoor group (IG; n = 25). Participants were informed about the study´s aims, signed an informed consent form and completed one session including an fMRI scan session and the assessment of several self-report questionnaires. Besides, a sample of hair was collected from the participants to measure hair cortisol accumulation (see Measures for more details). Inclusion criteria included (i) ages between 18 and 65 and (ii) being a habitual sportsperson (at least exercising 3 times a week during last five years). In this case, for the OG group, they had to exercise outdoors and conversely, the IG had to exclusively exercise indoors. In both cases, water sports were excluded to avoid confusion with natural environment (Grassini et al., 2019). On the other side, exclusion criteria were: (i) having any psychological disorder or any medical or nervous system disease diagnosed, (ii) take any medication regularly, (iii) having suffered an epileptic attack, (iv) taking any drugs and drinking regularly (3 times for week) any contraindication to undergo the fMRI session (i.e. metal prosthesis or claustrophobia). All participants had normal or corrected-to normal vision.

Procedure

The data from each participant were collected in a same-day session of approximately 1 hour and 20 minutes of total duration. In the first place, all the participants completed an fMRI task within the scanner. After that, self-report questionnaires were filled out and a sample of hair was collected in order to assess cortisol concentrations. Further neuropsychological tests beyond the study´s aims were completed by the participants.

The Human Research Ethics Committee of the University of Granada approved the study with number 621/CEIH/2018, and all the participants were informed about the aim of the study and signed an informed consent.

Measures

Imaging data acquisition

All participants performed an fMRI scan in a 3T Tim Trio Siemens equipment located at the Mind, Brain and Behavior Research Center, University of Granada, with a total duration of 7 minutes and 16 seconds equipped with a 32-channel phased-array head coil. A T2*-weighted echo-planar imaging (EPI) was obtained (TR = 2000ms, TE = 25ms, FOV = 240 x 240mm, 68x68 pixel matrix; flip angle = -0.4º, number of slices = 35, 160 whole-brain volumes). Additionally, a high resolution T1-weighted anatomical image was also acquired for each participant. This image, of 176 slices (TR = 1900ms; TE = 2.52ms; flip angle = 9°; FOV = 256 x 256 mm; slice thickness = 1 mm) was used to discard structural alterations and for the co-registration step in the preprocessing stage. In addition, 3D field maps were also collected by acquiring a gradient image with two echoes. Thus, two magnitude images were generated (TR = 468ms; TE1 = 4.92ms; TE2 = 7.38ms, FOV = 240x240mm; 68x68 pixel matrix; number of slices = 35) together with a phase map, showing the difference between the two echoes.

fMRI task design

This study shows an experimental design. An image-viewing task including images of nature and urban areas was used. All pictures were shot ad hoc for the study using standardized presentation and lighting conditions. Furthermore, all the photographs (urban and nature) were taken at the morning, namely, with the same ambient light. Three main types of images were utilized: “green nature”(defined as those images captured in field areas with vegetation where no urban area is depicted), “water nature” (defined as field areas without urban features, as previous images, but this time including water extensions and leafier fields) and urban (defined as those images depicting city center, buildings, traffic and urban-related characteristics). In each trial, each of the pictures was presented and participants had to rate these pictures. Participants were instructed to choose between two rating options (pleasant or unpleasant) according to their own preferences. Each trial began with a fixation cross, which appeared for approximately 1s. Then, images appeared until the participant chose if they seem pleasant or unpleasant. An inter-trial interval was presented after the rating to adjust each trial duration in approximately 5200ms.Then, the fixation cross was presented again. The order in which the images were presented was counterbalanced among the participants. There was a total of 80 image-viewing trials. After each trial, participants were instructed to press a button to rate the images as pleasant or unpleasant. This button pressing did not form part of the objectives of this study but, instead, allowed to assure that the participants remain alert to the images during the whole task.

Hair cortisol accumulation

We used the gold standard method to assess cortisol in hair, which has been validated and provides a test-retest reliability as a biomarker of chronic cortisol exposure in adults (Russell et al., 2012). Hair samples consisting of approximately 150 strands of hair were collected from the posterior vertex with a length no greater than 3 cm (assuming an average growth rate of 1 cm/month; Russell et al., 2012). A 3 cm segment contains the cortisol that has been deposited over approximately the last 3 months. The hair was then wrapped in a piece of aluminum foil to protect it from light and humidity, and was stored in an envelope in room temperature. Later, the hair samples were sent for analysis to the Faculty of Pharmacy of the University of Granada. The samples were weighed and ground to a fine powder to break up the hair's protein matrix and increase the surface area for extraction using a ball mill (Bullet Blender Storm, Swedesboro NJ, USA). Cortisol from the interior of the hair shaft was extracted into HPLC-grade methanol by incubation of the sample for 72 hours at room temperature in the dark with constant inversion using a rotator. After incubation, the supernatant was evaporated until completely dry using a vacuum evaporator (Centrivac, Heraeus, Hanau, Germany) and the extract was reconstituted in 150 ul of phosphate buffered saline (PBS) at pH 8.0. The reconstituted sample was immediately frozen at -20ºC for later analysis (Sauve et al., 2007). The cortisol in the hair sample was measured using the Salivary ELISA Cortisol kit© (Alpco Diagnostics®, Windham, NH) as per the manufacturer’s directions with the reagent provides. The cross-reactivity, as reported by the manufacturer, is as follows:

Prednisolone 13,6%, Corticosterone 7,6%, Deoxycorticosterone 7,2%, Progesterone 7,2%, Cortisone 6,2%, Deoxycortisol 5,6%, Prednisone 5,6%, and Dexamethasone 1,6%. No cross reaction was detected with DHEAS and Tetrahydrocortisone.

Perceived stress

The Spanish version (2.0) of the Perceived Stress Scale (PSS; Cohen et al., 1983 and adapted by Remor, 2006) was used. This scale is a self-report questionnaire assessing the level of perceives stress during the last month. It comprises 14 items with a Likert-like scale ranging from 0 (never) to 4 (very often). It is noteworthy that the total score of the PSS is obtained by reversing the scores of the following items: 4, 5, 6, 7, 9, 10 y 13 and adding the other items´ scores. Higher scores in this scale represents higher levels of perceived stress. Importantly, this scale provides an index of perceived chronic stress and has previously shown stability through repeated measures tests. The Cronbach's Alpha value was .87.

Attention-awareness

The Spanish version of the Mindful Attention Awareness Scale (MAAS; Brown and Ryan, 2003; Johnson et al., 2014; Soler et al. 2012), was used to assess the general ability to be aware and to focus the attention to what is taking place in the present moment for each situation (i.e., focus on the sensory properties of food when eating). Thus, this test reports a measure of trait mindfulness. This instrument consists of 15 items, 6-point Likert-type responses ranging from 1 (almost always) to 6 (almost never). All the items form a unique total score measuring attention-awareness with higher scores showing higher awareness. The Cronbach's Alpha value was .92.

Analyses

Preprocessing of imaging data

Functional data was preprocessed using the CONNv17 functional connectivity toolbox (Whitefield-Gabrielli and Nieto-Castañón, 2012), implemented in MatlabR2017a (The MathWorks Inc., Natick, Massachusetts, USA). The preprocessing pipeline included realignment, unwrapping and distortion correction (with fieldmaps), denoising of motion artifacts and head motion (following aCompCor; Power et al. (2012)), segmentation, co-registration to each participant´s anatomical scan, normalization, re-sliced to a 2mm isotropic resolution in MNI space and smoothing using a Gaussian kernel of FWHM 6mm. Additional steps after denoising included band-pass filtering of the BOLD timeseries (between 0.008-0.09 Hz) and linear detrending.

Functional activation analyses

The conditions of interest were modelled from the onset time at which the image was presented to the time at which participants responded. Task regressors were convolved with the hemodynamic response function. Our contrasts of interest were “green nature vs urban” “water nature vs urban” and “green nature vs water nature”, as defined in the first-level analyses (single subject) and in the second level between-group analyses.

Thresholding criteria

The minimum threshold extent for the activation analyses were estimated by 1000 Monte-Carlo simulations using the cluster-extent based AlphaSim thresholding approach, implemented in the SPM RESTplusV1.2 toolbox. For the between-group effects in the activation under the image-viewing task, the required cluster extent was calculated including as input parameters an individual voxel threshold probability of 0.001, a cluster connection radius of 5mm and the actual smoothness of imaging data after model estimation, incorporating a whole-brain image mask (184283 voxels). The minimum cluster size was 109 voxels (327 mm^3).

Behavioral analyses

To explore the relationship between brain activation during the exposure to nature/urban images and the data resulting from the questionnaires, we extracted the peak beta eigenvalues from each significant result of between-group brain differences. Using partial correlations, these brain values were correlated with physiological (cortisol) and psychological (perceived) stress and awareness in each group separately. Also, we correlated both measures of stress (perceived and physiological). Sex, age, body mass index, sport level and education were used as covariables of no interest (as in the neuroimaging analysis). Further Fisher´s tests and Zou´s intervals were carried out to explore the potential between-group differences in these correlations. Specifically, to explore whether the correlation between a resulting brain network and the psychological measures in outdoor group differed from the correlation between those two variables in the indoor group.

Results

Demographic and correlational results regarding clinical measures

No between-group differences were shown in the main demographic variables of the study. However, we found between-group differences in perceived stress and the total score of MAAS with the outdoor group (OG) showing higher MAAS scores and lower perceived stress than the indoor group (IG). These results are shown in Table 1. Besides that, physiological cortisol and perceived stress did not significantly correlate in any of the groups.

fMRI results

Between-group differences during the exposure to green nature versus urban images were shown. The OG showed higher activation in the middle occipital cortex and in a cluster comprising the supplementary motor area (SMA), the premotor cortex and the pre-SMA compared to the IG. No other result surpassed the threshold of significance. (Table 2).

Behavioral results

In OG, the higher activation of the left SMA cluster negatively correlated with perceived stress (R = -0.767; p = 0.001), while in the IG, and curiously not in the OG, the higher premotor cortex activation was positively related to the total score on MAAS (R = 0.628; p = 0.003). No significant association was found with the hair cortisol levels. Fisher´s Z and Zou´s interval (p = 0.045 and -0.8307 - 0.0062, respectively for perceived stress, and p=0.001 and 0.3715 1.3224 for the MAAS score) confirmed that these correlations showed a significant between-groups differences. (Figure 1 and Figure 2).

Table 1. Demographics and clinical characteristics of the groups.

		Outdoor Group (n=21) Mean (SD)	Indoor Group (n=25) Mean (SD)	Test statistics [a]	p value
Age		40 (6.49)	40 (6.19)	0.000	1.000
BMI		23.73 (2.65)	25.44 (3.50)	-1.883	0.066
Sex (females)		11 (52.4%)	11 (44%)	0.321	0.571
Sports level	**High**	11 (52.4%)	7 (28%)	5.151	0.076
	Medium	7 (33.3%)	7 (28%)		
	Low	3 (14.3%)	11 (44%)		
Education level	**Primary**	0	2 (8%)	1.771	0.413
	High school	3 (14.3%)	3 (12%)		
	University	18 (85.7%)	20 (80%)		
Perceived Stress		16.90 (5.66)	21.60 (7.81)	-2.357	0.023
MAAS		70.33 (8.50), n= 18	60.88 (15.11), n=21	2.666	0.011
Hair cortisol		61. 68 (27.09)	62.37 (34.45)	-0.070	0.944

[a] Independent samples t-tests and chi-square tests were used to asses for between-groups differences. Abbreviations: MAAS, Mindful Attention Awareness Scale.

Table 2. Between-group differences in the brain activations during the image-viewing task in the contrast green nature versus urban areas.

Brain region		x, y, z	t	CS	Direction
Premotor Cortex*	R	18 -4 60	5.41	679	OG>IG
Pre-SMA*	L	-10 8 58	5.15	679	OG>IG
SMA*	L	-10 6 64	4.98	679	OG>IG
Middle Occipital Cortex	L	-24 -92 -28	4.65	130	OG>IG

Coordinates (x, y, z) are given in Montreal Neurological Institute (MNI) Atlas space. *Abbreviations*: CS, cluster size; SMA, supplementary motor area; OG, outdoor group; IG, indoor group. * indicates part of the large cluster. All results herein surpassed a height threshold of P < 0.001 and a cluster of 109 voxels.

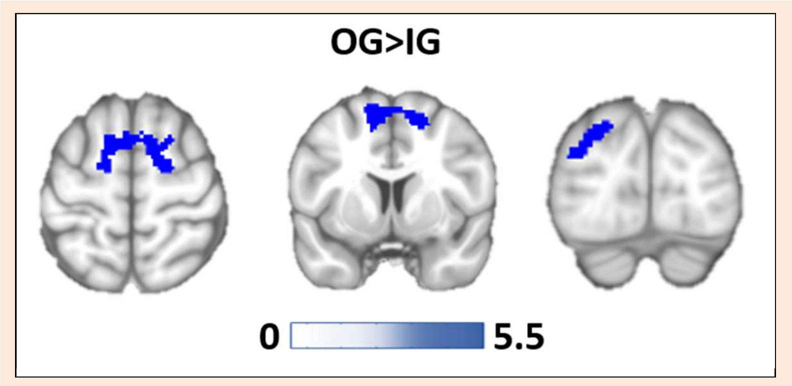

Figure 1. **Between-group differences in the areas significantly activated while participants viewed green nature images versus urban images. The regions in blue indicate higher activation in the nature areas group than in the urban areas group. The right hemisphere corresponds to the right side of axial and coronal views.**

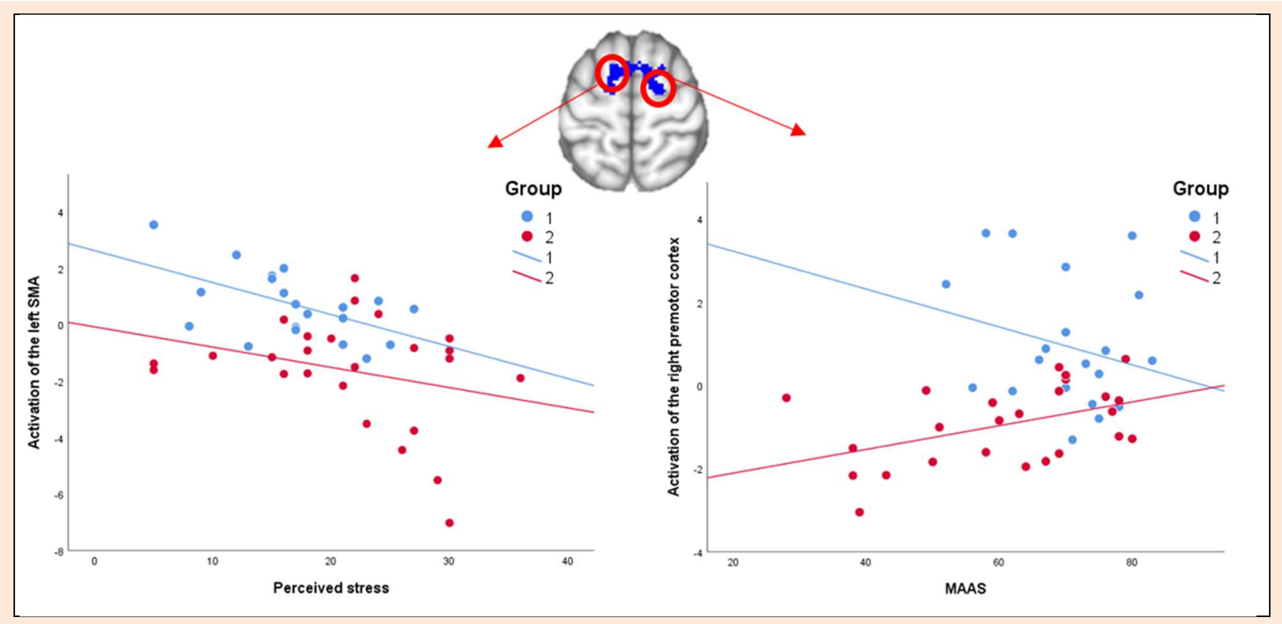

Figure 2. **Plots showing the significant correlation of the functional activity of the left SMA and the premotor cortex with the perceived stress and the MAAS total score, respectively. The right hemisphere corresponds to the right side of axial and coronal views. The blue spots represents the outdoor group, while the red spots represents the indoor group.**

Discussion

This research aimed to find out the differences in psycho-emotional processes and brain activation when faced with the task of visualising images in a group of sportsmen and women practising in a natural environment (outdoor) as opposed to urban sportsmen and women (indoor). As a third objective, this study sought to explore the relationships between this differential activation and its relationship with stress and full attention/awareness in the two groups separately.

Concerning our first objective, the results show significant differences in the perception of stress, with participants who belonged to the OG perceiving less of it. On the other hand, the OG obtained higher values in the MAAS test, which would imply greater attention and awareness. However, no differences were found in accumulated cortisol. These results would be partially in line with other research that suggests an improvement in stress levels and attention/awareness, not only when exposed to nature ((Dijkstra et al., 2008; Johnsen, 2013; Mutz and Müller, 2016)), but also when practising sports in natural environments (34-35). Therefore, this study shows that the practice of exercise, specifically in natural environments, would add more benefits to the already known advantages of practising sport on stress reduction and full attention/awareness (35), thus establishing the relevance of the type of environment in which we choose to perform physical activity to improve our processes of emotion regulation. Contrary to the results in psychological stress, we found no differences in physiological stress. This would go against other research that has measured stress using saliva (23), although we have to take into account that these studies have methodological differences from ours since previous studies have taken measures of acute stress, while our study has collected a sample of cortisol in hair, that is to say, it reports an index of accumulated stress during the last three months. Also, a recent systematic review has shown that the results of self-reported measures give the most convincing evidence of the beneficial effect of outdoor sports on stress (Kondo et al., 2018). Future studies will reveal whether sport in natural environments is useful in reducing physiological stress levels in the long term and not only in the short term, as has been studied so far.

In the case of the second objective, the OG showed greater activation in the mid-occipital cortex, premotor cortex and SMA, areas related to movement control and management, mental and motor imagery, but also to high-level cognitive processes such as decision-making, memory and attention, among others (Nachev et al., 2007; Tanaka et al., 2005). These areas found while viewing green natural environments differ from those already presented by other authors on urban environments (Kim et al., 2010; Kim and Jeong, 2014; Martínez-Soto et al., 2013; Tang et al., 2017). Furthermore, we did not find any significant difference in the "urban versus water nature" contrast, unlike other previous studies (Tang et al., 2017). These authors also found that two of the studied natural stimuli (mountain and river) produced a similar perceived restorative potential. Thus, the difference in results might be due to the characteristic of our sample. Our sample was comprised of sportsmen and sportswomen who did not perform any physical activity related to water sports (due to exclusion criteria). This particularity, although speculatively, might lead to a higher restorative perception of the green nature, mainly by the outdoor group as green nature is the environment they are used to. Despite this, our data support the results of Zhang et al., (2019), in which they find the involvement of SMA and the occipital cortex in the processing of images of green environments. The difference in areas found between the different studies and ours can be explained by one main reason and that is the sample used by our study, which for the first time used a sample with two groups of athletes who have been doing sports in nature or in an urban indoor environment at least three times a week for at least five years. Therefore, we are dealing with a population with long exposure to a particular type of environment. The most similar results were found in the study by Wood et al. (2014) in which they found brain activation in motor areas, but in this case when listening to sounds related to their favourite sport. This would suggest the involvement of these areas of "motor preparation" in the recognition of and response to known stimuli. In fact, Aspinall et al. (2013) have already proposed that the better known the sensory inputs, the greater the activation of these areas. This would also explain why the OG group shows more activation in these areas than the IG group. Another similar study is that of Davand et al. (2018) who carried out research with school children who had grown up in green areas and found that exposure to these natural areas was positively associated with more grey matter in the left premotor cortex and with a greater volume of white matter in the left premotor area cluster, among others. All these results together could suggest that people accustomed to natural environments have a better functioning of these motor areas. Furthermore, these motor areas, together with visual-occipital areas, are also involved in motor imaging (Stevens, 2005), and walking (La Fougere et al., 2010).

Taking into account all the above, we could think that prolonged exposure to green space can affect the increased reactivity of the brain to certain stimuli, presenting activations of brain areas different to those shown by subjects with prolonged exposure to another type of environment, such as the urban one. For this reason, the visualisation of natural stimuli, where the OG group carries out its physical activity, could have triggered greater imagery than in the IG group. This contribution should be contrasted with later studies.

Regarding our last objective, we found that the OG, rather than the GI, had a negative correlation between SMA cluster activation and perceived stress. Conversely, and unexpectedly, the IG, rather than OG, obtained a positive correlation between activation of the premotor cortex and MAAS, which measures awareness and full attention. Both MAAS and the premotor cortex have been related in sports subjects to motor imagery (Lorey et al., 2010; Mizuguchi et al., 2012), but also to mental imagery of various kinds (Frank et al., 2014). The negative SMA-perceived stress relationship in OG is a novel finding, as the SMA is not conceived as an area responsible for stress regulation. However, some previous studies have involved the SMA in other cognitive processes (Tanaka et al., 2005), and more importantly for our purposes, in emotional regulation processes, specifically in "up-regulation" processes (Frank et al., 2014; Kohn et al., 2014; New et al., 2009). This result would suggest that in view of the exposure to natural environments in the OG group the activation of the SMA would help to increase the positive affect of these athletes, something that is related to their predisposition to lower perceived stress.

On the other hand, we found a positive relationship between activation of the premotor cortex and greater awareness in IG than in OG. The association between the premotor cortex and awareness seems to be supported by previous studies. According to an influential meta-analysis, the premotor cortex is associated with voluntary regulation of thought and meditation (Fox et al., 2016) and processes such as mind-wandering would involve this region (Hasenkamp et al.,). Despite this, this finding is contrary to the hypothesis of this study, where we expected a greater relationship in the OG than in the GI. One possible explanation is that natural settings (like those shown in the study images) provoke higher states of meditation than any other environment in most individuals (Aspinall et al., 2013), but athletes who practice sports in natural environments have a greater amount of external stimuli during their practice that provides less opportunity to focus on their body signals, thoughts and emotions than those who exercise in indoor environments with few distracting elements (Bigliassi et al., 2020).

This study also has a number of limitations that need to be addressed. For example, one would be that the brain-emotion associations found in our results do not allow us to know if brain functioning is what predicts or is the consequence of the processing/regulation of emotions (stress and full attention), so we cannot determine cause and effect relationships between variables. Evaluation of longitudinal measures could solve this limitation in future studies because, as Norwood et al. (2019) state, there is still a need for further research to understand the effects of various environments on the brain (Coburn et al., 2017; Frumkin et al., 2017). Another limitation is the difficulty in controlling the prior exposure of each subject to their sporting environment. Besides, this paper compares subjects who, on some occasions, practice similar sports (track racing with mountain racing), but in different environments. The type of activity chosen should also be taken into account in future studies. Therefore, the outcome of this study emphasises the need to carry out more research on this subject in order to understand the effects of different environments on the brains of sportsmen and women. Finally, our study lack of qualitative data to support the individual's perception expressed in the psychological questionnaires. As regards strengths, we can highlight the novelty of using a measurement technique that is unusual in these studies, fMRI, which allows us to broaden existing theoretical knowledge and bring up the brain as a possible mediator between the type of environment chosen for physical activity and better processing/regulation of emotions. In addition, for this study we have used various assessment techniques that take into account physiological factors, such as the measurement of cortisol accumulation in the hair, cerebral, with the fMRI and psychological factors. Few if any studies so far have taken into account so many different measurement techniques in a single work. Therefore, the data obtained in this research would provide a new line of work to the already existing literature that would need further investigation.

Conclusion

Altogether, our findings show that the activation of motor brain areas while viewing images of green nature associates with a lower perceived stress in those participants who exercised outdoor, but not in those who exercised indoor. These results highlight the relevance of the type of environment chosen for exercising over psychological wellbeing, as supported by the lower perceived stress in the outdoor group. In addition, they also pinpoint a specific pattern of brain activation that could act as a mediator in the association between the aforementioned variables, which is to say, type of environment while exercising and psychological wellbeing.

Acknowledgements
The authors declare that they have no conflict of interest regarding the publication on this article. There were no funding sources for the present investigation. The experiments comply with the current laws of the country in which they were performed. The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author who was an organizer of the study.

References

Aspinall, P., Mavros, P., Coyne, R. and Roe, J. (2013) The urban brain: Analysing outdoor physical activity with mobile EEG. *British Journal of Sports Medicine* **49(4)**, 272-276. https://doi.org/10.1136/bjsports-2012-091877.

Aspinall, P., Mavros, P., Coyne, R. and Roe, J. (2015) The urban brain: Analysing outdoor physical activity with mobile EEG. *BMC Sports Medicine* **49(4)**, 272-276. https://doi.org/10.1136/bjsports-2012-091877

Asztalos, M., Wijndaele, K., Bourdeaudhuij, I.D., Philippaerts, R., Matton, L., Duvigneaud, N. and Cardon, G. (2012) Sport participation and stress among women and men. *Psychology of Sport and Exercise* **13(4)**, 466-483. https://doi.org/10.1016/j.psychsport.2012.01.003

Bailey, A.W., Allen, G., Herndon, J. and Demastus, C. (2018) Cognitive benefits of walking in natural versus built environments. *World Leisure Journal* **60(4)**, 1-13. https://doi.org/10.1080/16078055.2018.1445025

Bratman, G. N., Hamilton, J. P., Hahn, K. S., Daily, G. C. and Gross, J. J. (2015) Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proceedings of the National Academy of Sciences of the United States of America* **112(28),** 8567-8572. https://doi.org/10.1073/pnas.1510459112

Berto, R. (2014) The Role of Nature in Coping with Psycho-Phsyciological Stress: A literatura Review on Restorativeness. *Behavioral Sciences* **4**, 394-409. https://doi.org/10.3390/bs4040394.

Bigliassi, M., Galano, B.M., Lima-Silva, A.E. and Bertuzzi, R. (2020) Effects of mindfulness on psychological and psychophysiological responses during self-paced walking. *Psychophysiology* **57**, e13529. https://doi.org/10.1111/psyp.13529.

Bjørnstad, S., Patil, G.G. and Raanaas, R.K. (2015) Nature contact and organizational support during office working hours: Benefits relating to stress reduction, subjective health complaints, and sick leave. *Work* **53(1)**, 9-20. https://doi.org/10.3233/WOR-152211.

Brown, D. K., Barton, J.L. and Gladwell, V. (2013) Viewing nature scenes positively affects recovery of autonomic function following acute-mental stress. *Environmental Science & Technology* **47(11)**, 5562-5569. https://doi.org/10.1021/es305019p

Brown, K.W. and Ryan, R.M. (2003) The benefits of being present: Mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology* **84**, 822-848. https://doi.org/10.1037/0022-3514.84.4.822

Caballero, P., Hernández, E. and Reina, M. R. (2018) Analysis of the universal factors of physical activities in the natural envioronment/ physical activities of adventure in nature: preliminary study. *Spiral Teacher`s Notebooks* 11(22), 61-68. http://doi:10.25115/ecp.v11i22.1918

Caltabiano, M. L. (2006) Measuring the similarity among leisure activities based on a perceived stress-reduction benefit. *Leisure Studies* **13(1)**, 17-31. https://doi.org/10.1080/02614369400390021.

Chang, C.Y. and Chen, P.K. (2005) Human response to window view sand indoor plants in the workplace. *American Society for Horticultural Science* **40**, 1354-1359. https://doi.org/10.21273/HORTSCI.40.5.1354

Chen, Z., He, Y. and Yu, Y. (2016) Enhanced functional connectivity properties of human brains during in-situ nature experience. *PeerJ* **4**, e2210. https://doi.org/10.7717/peerj.2210

Chen, Z., Li, J., Zhang, J., Xing, X., Gao, W., Lu, Z. and Deng, H. (2013) Simultaneous determination of hair cortisol, cortisolne and DHEAS with liquid chromatography-electrospray ionization-tandem mass spectrometry in negative mode. *Journal of Chromatography B: Analytical Technologies in the Biomedical and Life Sciences* **929**,187-194. https://doi.org/10.1016/j.jchromb.2013.04.026

Choi, Y., Kim, M. and Chun, C. (2015) Measurement of occupants' stress based on electroencephalograms (EEG) in twelve combined environments. *Building and Environment* **88**, 65-72. https://doi.org/10.1016/j.buildenv.2014.10.003

Coburn, A., Vartanian, O. and Chatterjee, A. (2017) Buildings, beauty, and the brain: A neuroscience of architectural experience. *Journal of Cognitive Neuroscience* **29(9)**, 1521-1531. https://doi.org/10.1162/jocn_a_01146

Cohen, S., Kamarck, T. and Mermelstein, R. (1983) A global measure of perceived stress. *Journal of Health and Social Behavior* **24(4)**, 385-396. https://doi.org/10.2307/2136404.

Davand, P., Basagaña, X., Jerrett, M., Nieuwenhuijsen, M. J., Sunyer Deu, J., Pujol, J. and Mortamais, M. (2018) The association between lifelong greenspace exposure and 3dimensional brain magnetic resonance imaging in Barcelona schoolchildren. *Environmental Health Perspectives* **126(2)**, 027012. https://doi.org/10.1289/EHP1876

De Vries, S., Verheij, R. A., Groenewegen, P. P. and Spreeuwenberg, P. (2003) Natural environments-healthy environments? An exploratory analysis of the relationship between greenspace and health. *Environment & Planning A* **35(10)**, 1717-1731. https://doi.org/10.1068/a35111

Dijkstra, K., Pieterse, M.E. and Pruyn, A. (2008) Stress-reducing effects of indoor plants in the built healthcare environment: The mediating role of perceived attractiveness. *Preventive Medicine* **47(3)**, 279-283. https://doi.org/10.1016/j.ypmed.2008.01.013

Eigenschenk, B., Thomann, A., McClure, M., Davies, L., Gregory, M., Dettweiler, U. and Inglés, E. (2019) Benefits of Outdoor Sports for Society. A Systematic Literature Review and Reflections on Evidence. *International Journal of Environmental Research and Public Healh* **16**, 937. https://doi:10.3390/ijerph16060937.

Elsadek, M., Liu, B. and Lian, Z. (2019) Green façades: their contribution to stress recovery and well-being in high-density cities. *Urban Forestry & Urban Greening* **46***,* 126446. https://doi.org/10.1016/j.ufug.2019.126446.

Essawy, S., Kamel, B. and El-Sawy, M. S. (2014) Sacred buildings and brain performance: The effect of Sultan Hasan Mosque on brain waves of its users. *Creative Space* **1(2)**, 125-143. https://doi.org/10.15415/cs.2014.12006

Ferguson, K. T. and Evans, G. W. (2018) *The built environment and mental health reference.* Module in Earth Systems and Environmental Sciences. Elsevier.

Fox, K.C.R., Dixon M.L., Nijeboer, S., Girn, M., Floman, J.L., Lifshitz, M. and Christoff, K. (2016) Functional neuroanatomy of meditation: A review and meta-analysis of 78 functional neuroimaging investigations. *Neuroscience & Biovehavioral Reviews* **65**, 208-228. https://doi.org/10.1016/j.neubiorev.2016.03.021.

Frank, D.W., Dewitt, M., Hudgens-Haney, M., Schaeffer, D.J., Ball, B.H., Schwarz, N.F. and Sabatinelli, D. (2014) Emotion regulation: Quantitative meta-analysis of functional activation and deactivation. *Neuroscience & Biobehavioral Reviews* **45**, 202-211. https://doi.org/10.1016/j.neubiorev.2014.06.010.

Frumkin, H., Bratman, G. N., Breslow, S. J., Cochran, B., Kahn, P. H., Jr., Lawler, J. J. and Wood, S. A. (2017) Nature contact and human health: A research agenda. *Environmental Health Perspectives* **125(7)**, 075001. https://doi.org/10.1289/EHP1663

Grassini, S., Revonsuo, A., Castellotti, S., Petrizzo, I, Benedetti, V. and Koivisto, M. (2019) Processing of natural scenery is associated with lower attentional and cognitive load compared with urban ones. *Journal of Environmental Psychology* **62**, 1-11. https://doi.org/10.1016/j.jenvp.2019.01.007.

Hasenkamp, W., Wilson-Mendenhall, Ch.D., Duncan, E. and Barsalou, L.W. (2012) Mind wandering and attention during focused meditation: A fine-grained temporal analysis of fluctuating cognitive states. *NeuroImage,* **59(1)**, 750-760. https://doi.org/10.1016/j.neuroimage.2011.07.008.

Hartig, T., Evans, G., Jamner, L. D., Davis, D. S. and Gärling, T. (2003) Tracking restoration in natural and urban field settings. *Journal of Environmental. Psychology* **23**, 109-123. https://doi.org/10.1016/S0272-4944(02)00109-3

Johnsen, S.A.K. (2013) Exploring the use of nature for emotion regulation: Association with personality, perceived stress, and restorative outcomes. *Nordic Psychology* **65(4)**, 306-321. https://doi.org/10.1080/19012276.2013.851445.

Johnson, C. J., Wiebe, J. S. and Morera, O. F. (2014) The Spanish versión of the Mindful Attention Awareness Scale (MAAS): measurement invariance and psychometric properties. *Mindfulness* **5(5)**, 552-565. https://doi.org/10.1007/s12671-013-0210-1.

Joung, D., Kim, G., Choi, Y., Lim, H., Park, S., Woo, J. M. and Park B. J. (2015) The prefrontal cortex activity and psychological effects of viewing forest landscapes in autumn season. *International Journal of Environmental Research and Public Health* **12(7)**, 7235-7243. https://doi.org/10.3390/ijerph120707235.

Kim, G. and Jeong, G. (2014) Brain activation patterns associated with the human comfortability of residential environments: 3.0-T functional MRI. *NeuroReport* **25(12)**, 915-920. https://doi.org/10.1097/WNR.0000000000000205

Kim, T. H., Jeong, G. W., Baek, H. S., Kim, G. W., Sundaram, T., Kang, H. K. and Song, J. K. (2010) Human brain activation in response to visual stimulation with rural and urban scenery pictures: A functional magnetic resonance imaging study. *Science of the Total Environment* **408(12)**, 2600-2607. https://doi.org/10.1016/j.scitotenv.2010. 02.025.

Kohn, N., Eickhoff, S.B., Scheller, M., Laird, A.R., Fox, P.T. and Habel, I.J. (2014) Neural network of cognitive emotion regulation- An ALE meta-analysis and MACM analysis. *NeuroImage* **87(15)**, 345-355. https://doi.org/10.1016/j.neuroimage.2013.11.001.

Kondo, M.C., Jacoby, S.F. and South, E.C. (2018) Does spending time outdoors reduce stress? A review of real-time stress respond to outdoor environments. *Health & Place* **51**, 136-150. https://doi.org/10.1016/j.healthplace.2018.03.001.

Korpela, K., De Bloom, J. and Kinnunen, U. (2015) From restorative environments to restoration in work. *Intelligent Buildings International* **7(4)**, 215-223. https://doi.org/10.1080/17508975.2014.959461

Kubitz, K. A. and Pothakos, K. (1998) Exercise and brain activation in individuals with and without Type II diabetes (abstract). *Medicine and Science in Sports and Exercise* **30**, 128. https://doi.org/10.1097/00005768-199805001-00731

La Fougere, C., Zwergal, A., Rominger, A., Foerster, S., Fesl, G., Dieterich, M. and Jahm, K. (2010) Real versus imagined locomotion: a [18F]-FDGPET-fMRI comparison. *Neuroimage* **50**, 1589-1598. https://doi.org/10.1016/j.neuroimage.2009.12.060.

Lee, J. (2017) Experimental study on the health benefits of garden landscape. *International Journal of Environmental Research and Public Health* **14(7)**, 829. https://doi.org/10.3390/ijerph14070829.

Lee, K. E., Williams, K. J., Sargent, L. D., Williams, N. S. and Johnson, K. A. (2015) 40second green roof views sustain attention: The role of micro-breaks in attention restoration. *Journal of Environmental Psychology* **42**, 182-189. https://doi.org/10.1016/j.jenvp.2015.04.003

Longshore, K., McAlarnen, M.M., Sappington, R. and Harmon, D. (2019) Mindfulness and Green Exercise: Enhancing Our Relationship with Physical Activity and the Natural World. In: *Physical Activity in Natural Settings: Green and Blue Exercise (Cap. 17).* Eds: A.A. Donnelly & T.E. MacIntyre. Routledge. London. https://doi.org/10.4324/9781315180144-17

Lorey, B., Pilgramm, S., Walter, B., Stark, R., Munzert, J. and Zentgraf K. (2010) Your mind's hand: motor imagery of pointing movements with different accuracy. *Neuroimage* **49**, 3239-3247. https://doi.org/10.1016/j.neuroimage.2009.11.038

Martínez, R. and Caballo, B. (2020) School in the face of Nature Deficit. *Pedagogy Notebooks* **506**, 8-9.

Martínez-Soto, J., Gonzales-Santos, L., Pasaye, E. and Barrios, F. A. (2013) Exploration of neural correlates of restorative environment exposure through functional magnetic resonance. *Intelligent Buildings International* **5(Suppl. 1)**, 10-28. https://doi.org/10.1080/17508975.2013.807765.

Marselle, M.R., Irvine, K.N. and Warber, S.L. (2013) Walking for well-being: are group walks in certain types of natural environments better for wellbeing than group walks in urban environments*? International Journal of Environmental Research and Public Health* **10(11)**, 5603-5628. https://doi.org/10.3390/ijerph10115603

Meyer, J., Novak, M., Hamel, A. and Rosenberg, K. (2014) Extraction and analysis of cortisol from human and monkey hair. *Journal of Visualized Experiments* **83***,* e50882. https://doi.org/10.3791/50882

Mizuguchi, N., Nakata, H., Uchida, Y. and Kanosue, K. (2012) Motor imagery and sport performance. *Journal of Physical Fitness and Sports Medicine* **1(1)**, 103-111. https://doi.org/10.7600/jpfsm.1.103.

Mutz, M. and Müller, J. (2016) Mental health benefits of outdoor adventures: results from two pilot studies. *Journal of Adolescence* **45**, 105-114. https://doi.org/10.1016/j.adolescence.2016.03.009.

Nachev, P., Wydel, H., O´Neill, K., Husain, M. and Kennrad, Ch. (2007) The role of the pre-supplementary motor area in the control of action. *Neuroimage* **36(3-3)**, 155-163. https://doi.org/10.1016/j.neuroimage.2007.03.034.

Neale, C., Aspinall, P., Roe, J., Tilley, S., Mavros, P., Cinderby, S. and Thompson, C. W. (2017) The aging urban brain: Analyzing outdoor physical activity using the emotive affective suite in older people. *Journal of Urban Health* **94(6)**, 869-880. https://doi.org/10.1007/s11524-017-0191-9.

New, A., Fan, J., Murrough, J.W., Liu, X., Liebman, R.E., Guise, K.G. and Charney, D. S. (2009) A functional magnetic resonance Imaging study of deliberate emotion regulation in resilience and posttraumatic stress disorder. *Biological Psychiatry* **66(7)**, 656-664. https://doi.org/10.1016/j.biopsych.2009.05.020.

Norwood, M.F., Lakhani, A., Maujena, A., Zeeman, H., Creux, O. and Kendall, E. (2019) Brain activity, underlying mood and the environment: A systematic review. *Journal of Environmental Psychology* **65**, 101321. https://doi.org/10.1016/j.jenvp.2019.101321.

Park, B. J., Tsunetsugu, Y., Kasetani, T., Hirano, H., Kagawa, T., Sato, M. and Miyazaki, Y. (2007) Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest)-using salivary cortisol and cerebral activity as indicators. *Journal of Physiological Anthropology* **26(2)**, 123-128. https://doi.org/10.2114/jpa2.26.123.

Power, J.D., Barnes, K.A., Snyder, A.Z., Schlaggar, B.L. and Petersen, S.E. (2012) Spurious but systematic correlations in functional connectivity MRI networks arise from subject motion. *Neuroimage* **59(3)**, 2142-2154. https://doi.org/10.1016/j.neuroimage.2011.10.018

Raanaas, R. K., Patil, G. G. and Hartig, T. (2010) Effects of an indoor foliage plant intervention on patient well-being during a residential rehabilitation program. *American Society for Horticultural Science* **45(3)**, 387-392. https://doi.org/10.21273/HORTSCI.45.3.387

Remor, E. (2006) Psychometric Properties of a European Spanish Version of the Perceived Stress Scale (PSS). *The Spanish Journal of Psychology* **9(01)**, 86-93. https://doi.org/10.1017/s1138741600006004.

Roe, J. J., Aspinall, P. A., Mavros, P. and Coyne, R. (2013) Engaging the brain: The impact of natural versus urban scenes using novel EEG methods in an experimental setting. *Environmental Sciences* **1(2)**, 93-104. https://doi.org/10.12988/es.2013.3109

Russell, E., Koren, G., Rieder, M. and Van Uum, S. (2012) Hair cortisol as a biological marker of chronic stress: current status, future directions and unanswered questions. *Psychoneuroendocrinology* **37(5)**, 589-601. https://doi.org/10.1016/j.psyneuen.2011.09.009.

Sauve, B., Koren, G., Walsh, G., Tokmakejian, S. and Van Uum, S.H. (2007) Measurement of cortisol in human hair as a biomarker of systemic exposure. *Clinical and Investigative Medicine* **30(5)**, 183-191. https://doi.org/10.25011/cim.v30i5.2894.

Sianoja, M., Syrek, C. J., de Bloom, J., Korpela, K. and Kinnunen, U. (2018) Enhancing daily well-being at work through lunchtime park walks and relaxation exercises: Recovery experiences as mediators. *Journal of Occupational Health Psychology* **23(3)**, 428-444. https://doi.org/10.1037/ocp0000083

Soler, J., Tejedor, R., Feliu-Soler, A., Pascual, J. C., Cebolla, A., Soriano, J. and Pérez, V. (2012) Psychometric proprieties of Spanish version of Mindful Attention Awareness Scale (MAAS) *Actas Españolas De Psiquiatría* **40(1)**, 19-26.

Stevens, J.A. (2005) Interference effects demonstrate distinct roles for visual and motor imagery during the mental representation of human action. *Cognition* **95(3)**, 329-350. https://doi.org/10.1016/j.cognition.2004.02.008.

Stigsdotter, U. A. and Grahn, P. (2004) A garden at your workplace may reduce stress. In A. Dilani (Ed.) Design and health III-health Promotion through environmental design. (pp. 147-157) Research Centre for Design and Health. Stockholm

Tang, I. C., Tsai, Y. P., Lin, Y. J., Chen, J. H., Hsieh, C. H., Hung, S. H. and Chang, C. Y. (2017) Using functional Magnetic Resonance Imaging (fMRI) to analyze brain region activity when viewing landscapes. *Landscape and Urban Planning* **162**, 137-144. https://doi.org/10.1016/j.landurbplan.2017.02.007.

Tanaka, S., Honda, M. and Sadato, N. (2005) Modality-Specific cognitive function of medial and lateral human Brodmann Area 6. *The Journal of Neuroscience* **25(2)**, 496-501. https://doi.org/10.1523/JNEUROSCI.4324-04.2005.

Tilley, S., Neale, C., Patuano, A. and Cinderby, S. (2017) Older people's experiences of mobility and mood in an urban environment: A mixed methods approach using electroencephalography (EEG) and interviews. *International Journal of Environmental Research and Public Health* **14(2)**, 151. https://doi.org/10.3390/ijerph14020151.

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y. and Kagawa, T. (2014) The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology* **38**, 1-9. https://doi.org/10.1016/j.jenvp.2013.12.005

Ulrich, R. S. (1981) Natural versus urban scenes: Some psychophysiological effects. *Environment and Behavior* **13(5)**, 523-556. https://doi.org/10.1177/0013916581135001

Whitefield-Gabrielli, S. and Nieto-Castanon A. (2012) Conn: A Functional Connectivity Toolbox for Correlated and Anticorrelated Brain Networks. *Brain connectivity* **2(3)**, 125-141. https://doi.org/10.1089/brain.2012.0073

Wood, E. A., Hernandez, A. E., Wagner, V. E. and Beilock, S. L. (2014) Expert athletes activate somatosensory and motor planning regions of the brain when passively listening to familiar sports sound. *Brain and Cognition* **87**, 122-133. https://doi.org/10.1016/j.bandc.2014.03.007.

Yu, J., Ang K.K., Ho, S.H., Sia, A. and Ho, R. (2017) Prefrontal cortical activation while viewing urban and garden scenes: A pilots fNIRS study. In: *2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*, Seogwipo, 2017. pp. 2546-2549. https://doi.org/10.1109/EMBC.2017.8037376.

Zhang, W., He., X, Liu, S, Li, T., Li, J., Tang, X. and Lai, S. (2019) Neural correlates of appreciating natural landscape and landscape garden: Evidence from an fMRI study. *Brain and Behavior* **9(7)**, e01335. https://doi.org/10.1002/brb3.1335

Key points

- Perceived stress was lower in those participants who exercise outdoor than in those who exercise indoor
- Viewing images of green nature led to a higher activation of motor brain areas in the outdoor group, in comparison with the indoor group
- The higher activation of motor brain areas while viewing green nature was related to lower perceived stress only in those participants who exercise outdoor
- Exercising outdoor, especially in green spaces, might benefit psychological wellbeing

AUTHOR BIOGRAPHY

Antonio BAENA-EXTREMERA
Employment
Faculty of Education Sciences, University of Granada, Spain
Degree
PhD
Research interests
Education science, physical education, outdoor education and educational psychology.
E-mail: abaenaextrem@ugr.es

Julio Fuentesal GARCÍA
Employment
Professor in the Department of Education, Research and Evaluation Methodology, University Pontifical Comillas
Degree
PhD
Research interests
Curriculum theory, teaching methods and outdoor activity.
E-mail: jfuentesal@comillas.edu

Andrés Catena MARTÍNEZ
Employment
Professor in the Department of Experimental Psychology of the University of Granada.
Degree
PhD
Research interests
Psychopathology, neuroimaging, cognitive neuroscience and learning.
E-mail: acatena@ugr.es

Cristina MARTÍN-PÉREZ
Employment
Professor on the Master of Neuropsychology and Education at the Universidad Internacional de la Rioja.
Degree
PhD
Research interests
Neuroimaging, Neuropsychology and Health Psychology.
E-mail: cristina.martinperez@unir.net

✉ **Julio Fuentesal García**
Department of Education, Research and Evaluation Methodology, University Pontifical Comillas, Spain