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RESTORATIVE EFFECT OF DIRECT AND INDIRECT NATURE EXPOSURE – A SYSTEMATIC REVIEW

Psychology

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ABSTRACT

In today's world, exposure to nature has been greatly limited due to human's sedentary lifestyle combined with urbanization. However, the surge in technological advancements has led researchers to explore and replicate the restorative effects of nature via images, slideshows and virtual reality. But the question remains the same, whether being exposed to nature in an indirect way has the same effect as being exposed to nature in a direct way. Aim: The aim of the systematic review is to compare the restorative effect of direct and indirect nature exposure of the past 11 years of research. Methodology: A systematic search was conducted in 3 databases (Google Scholar, SCOPUS and EBSCO), providing, 3847 articles. Initial screening gave 55 articles. After reading full texts, 24 studies were excluded, and 31 studies were included. Results: The results indicate that direct nature exposure has better effect on mood states than indirect exposure. Similarly, direct nature exposure has better effect on cardiovascular markers (PR, BP, HRV and HR). Due to lack of studies for pulse rate in indirect exposure, the results cannot be concluded with respect to PR. Limitation: The major limitation of the review is the timeframe (11 years) and language bias - limiting the studies to only English language. Implications: Further research has to be done in comparing direct and indirect exposure with a broader time frame and inclusive of other physiological and psychological measures.

KEYWORDS

direct nature exposure; indirect nature exposure; restorative effect; heart rate variability; mood states; cardiovascular outcomes; POMS; virtual reality

1. Introduction

Estimates and forecasts of the current and future global disease burden greatly emphasize the epidemics of non-communicable diseases (NCD), such as cardiovascular and mental disorders (Alleyne et al., 2013). According to the World Health Organization (2021), NCD's account for 71% of death every year and cardiovascular disease holds the highest mortality rate among the others (17.9 million deaths annually). The rapid urbanization and industrialization along with the advancements in artificial environments have caused the current population to live in a constant state of stress. It is believed that humans have spent more than 99.99% of their time in natural environment and only 0.01% in urbanized surroundings (Song et al., 2015).

Exposing humans to natural settings helps their physiological responses to return to their natural states and induce feelings of comfort and relaxation (Song et al., 2019) because our physiological functions have evolved in and have adapted to this environment. Wilson (1984) in his groundbreaking theory the Biophilia Hypothesis stated that humans have an innate affiliation to nature and other forms of life. This inclination towards nature implies that contact with nature can be an important component of well-being in humans (Frumkin, 2001)

The increased attention to environmental stress has led to the accumulation of evidence that the urban environment can elicit substantial stress in people whereas the natural environment can enhance human health (Park et al., 2009). Furthermore, several studies support the restorative effect of nature on physiological and psychological well-being (Liu et al., 2021). Restorative effect refers to the restoration of people's physical, psychological and social resources and abilities that have been depleted due to stress conditions. This effect is characterized by reduction in stress, decrease of negative emotions and promotion of psychological and physical health (Ulrich et al., 1991; Kaplan, 1995) and evidence show improved cardiovascular functions (Tamosiunas et al., 2014; Kabisch et al., 2020) and mood (Park et al., 2011; Tsunetsugu et al., 2013), reduced stress levels (Fan et al., 2011) as well as the restoration and sustainment of vitality (Pasanen et al., 2018; Tyrväinen et al., 2014; White et al., 2013) due to natural environments.

The experimental studies concerned with the effect of natural environment on physiological and psychological health are built on the framework provided by two major theories, Attention Restoration Theory (ART) and Stress Reduction Theory (SRT). According to ART, immersion and interaction with natural environments capture attention in an involuntary fashion. This involuntary attention can then be shifted from one stimulus to another without much effort while this happens the internal mechanism responsible for directed attention is allowed to recover, thus resulting in improved cognitive function (Kaplan, 1995; Kaplan, 2001). The second theory SRT proposes that immersion experience in nature positively influences the affect by promoting recovery from excessive arousal states, and reduce negative thoughts through psycho-physiological pathways (Ulrich et al., 1991). The two theories can be differentiated based on their emphasis-ART focuses on cognition, while SRT focuses on affective responses. Evidence to date suggests that activities that are immersive and involve focused attention have restorative effects at both physical and mental level (Pretty et al., 2017) and shinrin-yoku or forest bathing is considered to be the most widespread activity associated with nature and human health. Forest bathing can be defined as making contact with and taking in the atmosphere of the forest through all 5 senses- a process that induces physical and mental relaxation (Park, Tsunetsugu, Kasetani, Kagawa, et al., 2009). Studies have found that forest bathing enhances human natural killer (NK) activity by increasing the number of NK cells and anticancer proteins such as perforin, granulysin, and granzymes in both male and female subjects (Li et al., 2007).

Moreover, forest bathing reduces sympathetic nervous activity and negative emotions, increases parasympathetic nervous activity, and has a relaxing effect on humans (Li et al., 2007). In some Asian countries such as China, Japan, Korea and Taiwan, forest bathing (taking in the forest atmosphere) is already popular and is considered a type of alternative therapy (Lee et al., 2011). Bowler et al. (2010) in his review reported that even simple visits to green environments such as urban parks and urban woodlands can improve mood and attention, and enhance psychological stress recovery.

The present day life appears to be lived on simmer and the red alert mode is regularly activated, producing non-stop SNS-HPA activation. Overtime, repeated SNS-HPA stimulation takes a toll on the body causing negative impacts on the gastrointestinal system, immune system, cardiovascular system, and on the endocrine system and the stress hormones continues to be high without any recovery period (Pretty et al., 2017). Contemporary living condition provides less opportunity to experience nature and its benefits, and not everyone has access to natural environments. Therefore, researchers are trying to replicate the restorative effect of nature by using indirect nature experience. Earlier researches on indirect nature experiences placed a greater emphasis on static modes of simulation (photographs, sketches, or slides) (Annerstedt et al., 2013). With the emergence of new technologies such as VR and 3-D videos, researches are now investigating new ways to improve the quality of life both within the home and clinical settings (Villani & Riva, 2008; Valtchanov et al., 2010). Now, researchers are extensively studying the restorative effects of virtual natural environment. Research done by Villani and Riva (2008) found that immersive 3-D video can aid recovery in a stress management protocol and concluded that the more intense the virtual reality, the more effective is the restoration.

As several studies have supported the restorative effect of indirect nature experience, especially through simulation, there arose another question as to whether or not the effect of indirect nature exposure/simulated environment has the same effect as a real natural environment. Hence, the present review is aimed at answering the question by comparing the restorative effect of direct vs. indirect nature exposure through a systematic review of past 10 years of research.

2. Method

The methodology of the systematic review followed the guidelines set forth in the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P). The PICO (Population/ Problem, Intervention, Comparison, and Outcome) framework (Table 1) was used to clarify the objectives of the review and facilitate the search strategy.

2.1. Eligibility Criteria

For this systematic review we included randomized controlled-trials, non-randomized controlled trials and pretest-posttest study design for both direct and indirect exposure studies. Since the field chiefly consists of non-randomized trials excluding non-RCT studies due to its less rigorous study design could lead to an inconclusive result. Therefore, one should be aware of the greater risk of bias in the non-RCT studies.

The time period was restricted to 11 years i.e., from 2011 to 2022 and the language was limited to English. Limitations concerning language are common in reviews, but they subject the results to potential biases (Higgins et al., 2022), which will be discussed in the limitations section. The eligibility criteria include adult informants without mental disabilities or serious physical or mental illnesses. In case of direct exposure studies the exposure should take place outdoors in natural environments, whether in urban gardens and parks or in more remote and unspoiled areas such as forests, mountains, grasslands, and beaches. In case of indirect exposure studies the exposure should take place in a controlled laboratory setting that made use of virtual reality or videos or images/slideshows of natural/ urban environment. Only studies with sedentary and light physical activity were included, as vigorous physical exercises, such as running or mountain biking, have been found to have psychological and physiological effects in themselves (Penedo, 2005)

To be eligible, the studies needed to entail psychological effect measures in terms of measuring changes in mood states using Profile of Mood States questionnaire and/or physiological effect measures in terms of measuring changes in cardiovascular functioning, in accordance with stress recovery theory. We included only those studies which made use of POMS to measure mood states as it is a widely used questionnaire in the clinical field when examining psychotherapeutic, psychological and somatic questions to record the state of mind.

2.2. Information Source and Search Strategy

A systematic search was done in the following databases: Google Scholar, SCOPUS and EBSCO. The search took place in December 2021. The search terms used for physiological outcomes were: restorative OR cardiovascular OR physiological OR heart rate OR pulse rate OR blood pressure OR restorative effect. For psychological measure the following search terms were used: psychological OR mood OR emotion OR fatigue. For direct exposure: nature OR forest OR environment OR green OR natural. Finally for indirect exposure the search terms used were: virtual reality OR videos OR nature OR virtual nature.

3. Results

3.1. Article Selection Process

The search in the databases returned 3847 articles. Initial screening gave 55 articles. After reading full texts, 24 studies were excluded, and 31 studies were included.

Table 2.1- Indirect nature exposure (compiled by the author)

S.no	Author/year	Country	Study design	Sample size	Characteristics	Age	Gender	Intervention	Control	Duration
1.	Li/2016	Japan	Pre/post Cross over	19 (19)	Middle-aged	40-69 years	Male	Guided walks in Forest park	Urban guided walks	1 day
2.	Lee/ 2011	Japan	CCT	12 (12)	University Students	21.2 years	Male	Forest bathing	Urban walking	15 min
3.	Chen/2018	Taiwan	Pre/post	16	Middle aged	46.88 years	Female	Forest therapy program	-	2.5 h
4.	Song/2019	Japan	RCT crossover	65	Young women	21.0 years	Women	Forest viewing	City viewing	15 min
5.	Gidlow/2016	UK	CCT crossover	38 (38)	Unstressed adults	40.9 years	Mixed	Green walk/ blue walk	Urban walk	30 min
6.	Horiuchi/2014	Japan	CCT crossover	15 (15)	Healthy volunteers	36 years	Mixed	Forest view	Enclosed view	15 min
7.	Song/2015	Japan	CCT crossover	23 (23)	University students	22.3 years	Male	Park walk	City walk	15 min
8.	Ochiai/2015 (b)	Japan	Pre/post	17	Middle-aged	62.2 years	Female	Forest therapy program	-	2 days
9.	Ochiai/2015 (a)	Japan	Pre post	9	Normal-to-high BP	56 years	Male	Relax & walk in forest	-	1 day
10	Bang/2017	South Korea	Pre/post cross over	51 (48)	University students	24.3 years	Mixed	Forest walk in Lunch break	Passive control	6 weeks
11.	Yu/2017	Taiwan	Pre/post	128	Middle-aged & elderly	60.0 years	Mixed	Forest bathing program	-	2 h
12.	Tsunetsugu/ 2013	Japan	RCT crossover	48(48)	University students	21.1 years	Male	Viewing forest Area	Viewing urban Area	15 min
13.	Ohe/ 2017	Japan	Pre/post	43	Office workers	20-70 years	Mixed	Forest therapy program	-	2 days
14.	Gladwell/ 2016	UK	CCT crossover	13 (13)	Healthy individuals	39 years	Mixed	Nature walk	Campus walk	30 min
15.	Lanki/ 2017	Finland	RCT crossover	36 (36)	Adult volunteers	46 years	Female	Forest- viewing + walking Park-viewing+ walking	City centre-Viewing + walking	15+30 min

16.	Triguero-Mas /2017	Catalonia	RCT crossover	26	Healthy volunteers	M: 44.32 years	Mixed	Blue environment	Urban area	30+180 min
17.	Stiggsdotter/2017	Denmark	CCT crossover	51 (51)	University students	20-36 years	Female	View and walk in arboretum	View and walk in city	50 min
18.	Xiang/2012	China	Pre/Post	20	Healthy university students	20+0.54 years	Male	Broad leaved green area	City area	2 days

Table – 2 – Direct exposure (compiled by the author)

S.no	Author/year	Country	Study design	Sample size	Characteristics	Mean age	Gender	Intervention	Control	Duration
1.	Jeon/2018	South Korea	RCT	30 (30)	University students	21.2	Mixed	Laboratory	Direct exposure	NA
2.	Yu/2018	Taiwan	Crossover & Pre/post test	30(30)	Sound well-being	20-29	Mixed	Forest view VR	Urban VR	9min 30s
3.	Brown/2013	NA	RCT crossover	23(23)	NA	36.91	Mixed	Nature scene slides	Built scene slide	10 min
4.	Gladwell /2012	NA	RCT crossover	29(29)	Free from disease	39.7	Female	Nature scene slides	Built scene slide	5 min
5.	Wang/2019	China	Pre/post test	96	Students and social workers	24.03	Mixed	Forest view VR	-	5 min
6.	Alyan/2021	NA	Pre/post test	20	Healthy individuals	21.8	Mixed	Dream like & Realistic forest View- VR	-	5 min
7.	Takayama/ 2022	Japan	Pre/post test	25	Busy working individuals	36.1	Mixed	Digital forest bathing	-	20 min
8.	Chan/ 2021	Singapore	Crossover	30	UG Students	20.5	Mixed	Walking in Virtual nature	Walking in Urban environ	5 min
9.	Nukarenin/ 2020	Finland	RCT	24	Volunteers	26	Mixed	VR forest (sound & no sound)	Real forest viewing	10 min
10.	Song/ 2018	Japan	CCT crossover	17	University Students	21.1	Female	Forest images	City images	90s
11.	Yu/ 2020	Taiwan	Crossover & Pre/post test	34	Middle aged	-	Mixed	VR natural setting	VR urban setting	10 min
12.	Gao/2019	China	Pre/post test	120	Chinese college students	20.7	Mixed	VR Green Space	VR Grey space and VR Blue Space	5 min
14.	Mostajeran/2021	Hamburg	Within-subject	35 (34)	NA	21-34 years	Mixed	Forest Virtual Environment	Urban Virtual Environment	6 min

3.2. Characteristics of Included Studies

Table 2 (direct exposure) and 2.1 (indirect exposure) summarizes the characteristics of the included studies: country of origin, study design, sample size and characteristics, type of intervention and control, and time duration.

3.2.1. Location

Most of the direct exposure studies were conducted in Asia (13). Japan was represented with 9 studies making it by far the single most-represented country in the review. Two studies were from Taiwan and UK. South Korea, Catalonia, Denmark, China and Finland were each represented with one study.Majority of the indirect exposure studies were also conducted in Asia (8). Two studies were from China, Japan and Taiwan. South Korea and Singapore were each represented with one study. Finland and Hamburg represented with one study each and the location of 3 other studies is unknown.

3.2.2. Sample Characteristics

The sample sizes for direct exposure varied widely, ranging from 36 to 65 subjects in the RCTs, 12 to 51 subjects in the CCTs, and 9 to 128 subjects in the pre-post studies. Great variation was also found in sample populations, which included office workers, middle aged and elderly and subjects with good health. The most common sample consisted of middle-aged adults followed by university students. Most studies included both the sexes as subjects.

The sample sizes for indirect exposure differed widely, ranging from 24 to 30 subjects in the RCTs, 17 subjects in the CCT (1), and 25 to 120 subjects in the pre-post studies. The sample population has a mixed representation of university students, middle aged adults and healthy individuals with no hearing impairment. Most studies included both the sexes as subjects.

3.2.4. Environments and Activities

The most common research setup for direct exposure studies entailed comparing an intervention in a natural environment, forest, or park to an intervention in an urban environment, mainly in city centers. The most common activity was walking and/or sitting and viewing and few studies involved other activities such as relaxation exercises in nature. The durations of the interventions differed substantially and were spread between 15 and 55 min, one to several hours, one to several days, and one to several weeks.

The common research setup for indirect exposure studies involved comparison between viewing natural environment and viewing built/urban scenes through VR or slideshows or images. Majority of the studies did not include any type of activity and few studies included activities like walking and incorporated nature sounds during the viewing period. The durations of the interventions were spread between one to several minutes only.

Direct Exposure- Pulse Rate

S.no	Author/year	Measure	Intervention	p-value
1.	li/2016	PR	SD	* < 0.05
2.	J. lee/2011	PR	SD	** < 0.01
3.	Chen/2018	PR	NA	0.782
4.	Song/2019	PR	SD	* < 0.05
5.	Ochiai/2015 (b)	PR	SD	** < 0.01
6.	Yu/ 2017	PR	SD	** < 0.01
7.	Ohe/ 2017	PR	NS	

Indirect Exposure- Pulse Rate

S.no	Author/ year	Measure	Intervention	p-value
1.	Takayama/2022	PR	NA	

Direct Exposure- Blood Pressure

S.no	Author/year	Measure	Intervention	p-value
1.	li/2016	BP	NA	
2.	lee/2011	BP	NA	
3.	Chen/2018	BP	Decreased SBP & DBP	0.023 0.153
4.	Song/2019	BP	SI (DBP&SBP)	□ < 0.05
5.	Horiuchi/ 2014	BP	Decreased	□ < 0.05
6.	Ochiai/2015 (a)	BP	Decreased SBP & DBP	p < 0.01
7.	Yu/ 2017	BP	Decreased SBP & DBP	p < 0.01
8.	Tsunetsugu/ 2013	BP	Decreased- DBP SBP- NS	□ < 0.05
9.	Ohe/ 2017	BP	Decreased DBP & SBP	□ < 0.05
10.	Lanki/ 2017	BP	Decreased SBP and not DBP	

Indirect Exposure- Blood Pressure

S.no	Author/ year	Measure	Intervention	p-value
1.	Yu/2018	BP	NS	
2.	Brown/2013	BP	NA	
3.	Gladwell/ 2012	BP	NA	
4.	Takayama/2022	BP	NA	
5.	Yu/2020	BP	NA	

Direct Exposure- Heart Rate Variability

S.no	Author/year	Measure	Intervention	p-value
1.	lee/2011	HRV	HF- SI LF/HF-SD	* < 0.05 ** < 0.01
2.	Song/2019	HRV	HF-SI LF/HF-SD HR-SD	** < 0.01
3.	Gidlow/2016	HRV	ND	
4.	Horiuchi/2014	HRV	HF-SI LF/HF- NS HR-SD	p=0.009 - *p<0.05
5.	Song/2015	HRV	HF-SI LF/HF-SD HR-SD	
6.	Bang/2017	HRV	HF-SI	
7.	Yu/2017	HRV	HF-NS LF/HF-NS	p=0.345 p=0.199
8.	Tsunetsugu/ 2013	HRV	HF-SI LF/HF- SD HR- SD	** < 0.01 - ** < 0.01
9.	Gladwell/ 2016	HRV	rMSSD, SDNN - SI HR-NS	
10	Lanki/ 2017	HRV	HF-SI HR- SD	** < 0.01 * < 0.05
11.	Jeon/ 2018	HRV	NA	

Indirect Exposure- Heart Rate Variability

S.no	Author/ year	Measure	Intervention	p-value
1.	Jeon/2018	HRV	NS	0.336
2.	Yu/2018	HRV HR	NS	-
3.	Brown/2013	HRV	SI HR-NA	p < 0.05 -
4.	Gladwell/ 2012	HRV	SI HR-NS	-
5.	Takayama/ 2022	HRV	HF-SI HR-SD	P<0.05 P<0.001
6.	Chan/2021	HRV	rMSSD- NS HR-NS IBI-SI	-

7.	Nukarinen/ 2020	HRV	RMSSD-SD HR-NS (VR)	-
8.	Song/2018	HRV	HF-NA LF/HF-NA HR-NA	-
9.	Yu/2020	HRV	HF-NA LF/HF-NA HR-NA	-
10.	Valtchanov	HR	Decreased	-
11.	Annerstedt/ 2013	HRV	HF-SI (F+) HR-Dec	-

Direct exposure – Psychological effect

S.No	Main Author	Measure	Intervention	p value
1	Horiuchi/2014	POMS	Improvement in subscales	p<0.05-0.01
2	Song/2015	POMS	Improvement in subscales	p<0.01
3	Stigsdotter/2017	POMS	Improvement	p<0.05
4	Li/2016	POMS	Improvement in subscales	p<0.05-0.01
5	Pin Yu/2017	POMS	Improvement	p<0.01
6	Xiang/2011	POMS	Difference in subscales	p<0.05
7	Tsunetsugu/2013	POMS	Improvement in subscales	p<0.01
8	Mas/2017	POMS	Improvement	p<0.01
9	Chen/2018	POMS	Improvement in subscales	p<0.05-0.01
10	Ochiai/2015	POMS	Improvement in subscales	p<0.01

Indirect exposure: Psychological effect:

S.No.	Main Author/Year	Measure	Intervention	p-value
1	Jeon/2017	POMS	Improvement in subscales	p<0.01
2	Pin Yu/2020	POMS	Improvement	p<0.001
3	Takayama/2021	POMS	Improvement in subscales	p<0.01-0.1
4	Wang/2019	POMS	Improvement in subscales	p<0.05-0.01
5	Gao/2019	POMS - SF	Improvement in negative mood	p=0.03
6	Pin Yu/2018	POMS	Significant changes in all except self-esteem	p<0.01
7	Alyan/2021	POMS	Decrease in RE than DE in all subscales	p<0.05
8	Mostajeran/2021	POMS	Effect only in fatigue subscale	p=0.03

3.3. Direct Exposure - Cardiovascular Outcomes

To measure the relaxation effect of real natural environments on individuals, eleven studies analyzed the heart rate variability to assess autonomic activity. All the eleven studies used HF data as an index for parasympathetic activity and LF/HF ratio for sympathetic activity. Nine studies showed a significant increase in HF value indicating an improved parasympathetic activity and four of these studies showed a significant decrease in LF/HF ratio indicating a reduced sympathetic activity. Two studies found no significant changes in both HF and LF/HF ratio. HR was measured in six studies, and five studies found a significant decrease. The significant effect was found to be low in all studies ($p< 0.05$-0.01).

Of the fifteen studies, seven studies had measured pulse rate out of which two studies showed no significant differences between before and after stimuli period, whereas five studies showed a significant reduction in PR in either during or after stimuli period. The significant effect was found to be low in all the five studies ($p< 0.05$-0.01).

Four studies found no significant differences between conditions (urban and forest) for BP (SBP & DBP) however, one of these studies showed significant increase between before and after viewing period (forest environments) and since the participants' mean BP was low the increase helped to achieve the appropriate BP level. Two studies showed a significant decrease in SBP but found no difference in DBP, while one study showed a significant decrease in DBP but no difference in SBP. Three studies found a significant decrease in both SBP and DBP. The significant effect was low for all the studies ($p < 0.05$-0.01).

3.3.1. Indirect exposure - Cardiovascular Outcome

Of the eleven studies only one study had measured pulse rate and the results showed no significant changes in the pulse rate for indirect nature exposure. Similar results were found for BP, five studies which measured BP reported no changes in both SBP and DBP. Four studies that measured HRV using time-domain measurements (RMSSD & SDRR) found a significant increase in RMSSD and SDRR indicating an increased parasympathetic activity. In terms of frequency domain measurements only one study reported increased HF value and four studies found no differences in both HF value and LF/HF ratio. Eight studies found no significant differences in heart rate while three studies showed a significant decrease in heart rate.

3.4 Psychological Outcomes

3.4.1 Direct exposure

Of the ten studies in direct exposure, one study found significant decrease in the anxiety, fatigue, depression and confusion with no differences in anger and vigor. In another study, significant changes were noted in anxiety, fatigue, confusion and anger, increase in vigor, depression marginally significant lower. Tension, fatigue and confusion were significantly lowered in another study. In three pre-post studies it was found that there was significant decrease in all of the five negative subscales anxiety, fatigue, depression and significant increase in vigor ($p<0.01$, $p<0.05$). However, in one study it was proven that there were significant changes in all scales (except depression) ($p<0.01$). In another pre-post study, a short form POMS was used which found significant difference in anxiety and vigor ($p<0.01$). In a RCT they found that there was significant lowered Total Mood Disturbance. In another pre-post crossover study Japanese version of POMS revealed that there was decrease in negative subscales (confusion, depression, anxiety and fatigue) and increase in vigor.

3.4.2 Indirect exposure

In indirect exposure, three studies found overall significant changes in all the 6 scales. In one pre-post study they found that there was significant change in vigor (positive) and no effect in the negative subscales ($p=0.03$). However, in contrast in another pre-post study they found significant effects in the negative subscale and no significant effect in vigor. One of the studies reported a significant effect in all subscales except anger and vigor and in one study where a different version of POMS was used which included self-esteem found changes in all subscales except self-esteem. In a recent study, they found that there was only effect in fatigue but no effect in other subscales.

4.DISCUSSION

The results from the review indicate that simulated natural environments do not have the same effect as real natural environments on cardiovascular markers and mood states. The evidences of direct nature exposure show a significant improvement on all cardiovascular parameters i.e. PR, BP (SBP & DBP), HRV and HR whereas the results of indirect nature exposure show a relatively lesser or no improvement. Comparison between exposures cannot be made for PR because only one indirect nature exposure study had measured PR, hence the results are inconclusive. With regard to BP, direct nature exposure had a substantial improvement on both SBP and DBP, whereas indirect nature exposure showed no effect. Direct nature exposure is more effective in increasing parasympathetic activity and decreasing sympathetic activity than indirect nature exposure. Though indirect exposure showed improvement in PNS and SNS activity, a significant difference in results can be seen between the two types of exposures. In terms of heart rate, again, direct exposure showed better results than indirect exposure.

In direct exposure, the majority of the studies found significant changes in all of the 6 subscales tension, anger, confusion, fatigue, depression and vigor. There were also several studies where depression was found to be marginally lower. And in some studies, there were no changes found in vigor. For indirect exposure, the findings are mixed. Most of the studies included have adopted pre-post study design. Only in three studies there were significant changes in all subscales. In few studies no significant change was found in vigor, the positive subscale. On comparing the results of direct and indirect exposure in this review, direct exposure to nature seems to be effective in bringing significant differences in mood than indirect exposure. Even the results are more consistent in direct exposure and much varied in indirect exposure.

The findings of this study are in accordance with Ulrich's argument that interaction with nature provides positive physiological and psychological responses. Furthermore, the results indicate that indirect nature exposure also can produce significant improvements, especially concerning mood states. Two recent systematic reviews have concluded that exposure to nature is associated with improved mental well-being compared to indoor and synthetic or built environments (Coon et al., 2011; Brown et al., 2010). Similar finding has also been observed using simulated environments in controlled laboratory conditions (Pretty et al., 2005). However, the results cannot be generalized due to smaller sample sizes and with majority of the direct nature exposure studies being represented by Japan it is disproportionate to generalize that direct exposure would be more effective in bringing about significant changes in cardiovascular markers and mood states than indirect exposure. In addition, the majority of the studies did not report effect sizes and the findings were evaluated based on p values only. Since the p-values can only provide information about the statistical significance of the effect found in relation to the null hypotheses and not about the importance (how strong the effect is), they cannot be used to determine the therapeutic relevance of the given intervention (Baker, 2016). Therefore, future researches should be directed towards reducing these limitations in order to provide a conclusive result.

4.1. Limitations

1. One major limitation is the inclusion of both peer-reviewed and non-peer reviewed researches. Each has their own disadvantages like, peer-reviewed researches may be subjected to publication bias and non-peer-reviewed paper may lack scientific quality.

2. Another limitation concerns with the inclusion of both randomized and non-randomized controlled studies. There are several problems in RCT and non RCT that cause bias in findings. For example, numbers of exclusions are frequently unclear, intervention and outcome assessment are often not conducted according to standardized protocols. In addition, non-RCTs are more susceptible to selection bias and confounding bias.

3. There is a potential language bias because the studies included in the review were limited to only English language. Hence, there is a possibility of missing out on important findings/ studies published in other languages.

4. Another major limitation is the timeframe of the review. Since the time span was restricted to past 11 years (2010 to 2022) of research the review could not obtain a broader perspective on the subject.

5. Quality assessment was not carried out for the included studies. Therefore, the strength of the studies (strong, moderate, or weak) based on methodological ratings is not determined.

5. Conclusions

The past eleven years' of research into psycho-physiological stress recovery in nature based interventions support the evidence of psychological and physiological effects for direct nature exposure. The evidence base for the psychological and physiological effects of indirect nature exposure seems to be weak. From the results of the review, it can be inferred that direct nature exposure has better effects on psycho-physiological stress recovery than indirect exposure. However, a complete conclusion cannot be drawn due to various limitations, especially limitations concerning the timeframe of the review.

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