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Physiological Effects of Contact with Mountain Landscape Compared with Urban Environment on Human Wellbeing

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Research into the restorative benefits of contact with different types of natural environments has amplified over the last three decades. Several studies evaluating encounters with nature has been supportive of its restorative and therapeutic effects. However, evidence remains to be seen in the area of effects of contact with mountain landscape environments on human wellbeing. This study advances empirical evidence of the physiological effects of contact with mountain landscape environment compared with urban environment. Physical experiences were explored using quantitative research approach to elicit objective physiological responses from subjects. Thirty-eight subjects comprising lecturers and students between the ages of 20 to 40 years were recruited from the urban environment of Benue State University, Makurdi, Nigeria. Pre-test and intervention measures of blood pressure and pulse rate of subjects were recorded in both environments. Findings show that contact with the mountain landscape environment influenced individual's ability to attain a relaxed state through decreased diastolic blood pressure and pulse rate. The study concludes that contact with mountain landscape environments promote recovery from stress and supports the notion that natural landscape environments improve human wellbeing. Essential physiological data is provided for use and implementation by landscape practitioners and policy makers in harnessing and managing mountain landscape environments.

Keywords: landscape; mountain; physiological response; stress; wellbeing.

Introduction

It is believed that urban residents continuously suffer from stress originating from financial security, job stress, job satisfaction, and teaching methods (Hashim & Zhiliang, 2003; Peltzer *et al*., 2009; Voight, 2009; Zurlo, Pes, & Cooper, 2007). Stress related to urban living leads to negative health challenges like hypertension, heart disease, stomach ulcer, mental distress, tobacco and alcohol misuse (Kurina, Schneider & Waite, 2004). In addition, sedentary life style, calorie and fat rich food consumption, less physical activity and the like are linked with increased level of psychosocial stress in urban residents (Sarkar & Mukhopadhyay, 2008). There is a general agreement among researchers that mental stress occur as a result of human contact with environments perceived as potentially straining, exceeding their adaptive capacities and constituting a threat to their wellbeing (Annerstedt *et al*., 2010). On the other hand, there are evidence to suggest that positive associations exist between experience of natural environments and mental health (Kaplan & Kaplan, 1989). Quite a number of studies also suggest that the detachment of most urban residents from natural environments has contributed to their stress challenges and eventual disease state (Van Os, 2004; Lederbogen *et al*., 2011). Therefore, it has become highly difficult to ignore the various dimensions on the tenets of the effects of natural environments on human wellbeing.

Stress and Human Physiological Responses

Stress Recovery Theory (SRT) is important in the exploration of why human contact with nature is likely to mitigate stress (Bratman, Hamilton, & Daily, 2012). Its focus is mainly on the physiological stress reduction benefits derivable through contact with natural environments. In proposing SRT, Ulrich *et al.* (1991) posited that landscapes possessing water, vegetation, visual depth and curvilinear forms enhanced the survival of primordial humans. Ulrich and his group suggest that given the influence such environments have on modifying human survival, the four attributes help in controlling and reducing physiological stress in present day humans. Specifically, nature scenes stimulate our parasympathetic nervous system in a manner in which stress and autonomic arousal is reduced, due to our innate link to the natural world (Bratman *et al*., 2015; Bratman *et al*., 2012). On the other hand, the pathway to stress recovery pertaining to SRT assumes that positive affect which occur during contact with nature elements regulates neurophysiologic activation including hypothalamic-pituitary adrenal axis (HPA) activity to a favourable level (Berto, 2014). Kudielka and Wüst (2009) suggest that the HPA is mainly an adaptive system characterized by clear inter and intra-individual differences. When human physiological systems are 'turned on' and 'turned off' intermittently, the stress response becomes adaptive (Brady & Matthews, 2006). Hence, SRT provides a platform for testable hypothesis pertaining to nature's influence on the autonomic nervous system. Therefore, it is important to consider physiological measures in the assessment of nature's influence on human wellbeing.

Interestingly, human response to stress is viewed as a complex process which involves physiological systems (Burchfield, 1979). Man possess a highly developed central nervous system and the evidence of the existence of a stress state is found in nervous impulses and blood carrying chemical mediators (Selye, 1976). The autonomic nervous system which helps to mediate signals between the central nervous system, organs and tissues is the major system that carries out necessary involuntary functions in the body such as blood pressure, pulse, respiration and temperature regulation (Martinez-Lavin, 2007).

Restoration and restorative environments

Over the last three decades, researchers within the domain of environmental psychology and human geography have increased research interest in the restorative benefits of contact with different types of natural environments comparative to urban environments. The term restoration encompasses the process that facilitates people recovery from stress acquired whilst trying to meet demands of everyday life (Hartig *et al*., 2011). Modern day environments are only created to suite everyday living and working which offer no restorative health benefits (Thompson, 2011). In contrast, nature related environments like forests, wilderness and mountains are considered to possess significantly the possibility of enhancing restoration from stress through passive and active contact. For instance, studies such as those conducted by van der Ha (2011) and Tyrväinen *et al*. (2014) have shown that nature settings are more restorative as against urban settings. Also encouraged by previous studies, Song *et al*. (2013a) attempted a scientific based research in order to explain individual differences in physiological responses to forest environments based on behaviour patterns. There was significant reduction in the pulse rate of 485 male university students after viewing forest scenes compared to urban scenes relative to behaviour pattern which confirms that forest therapy induces a relaxed state. The outcome of studies by Lee *et al*. (2013) and Beil and Hanes (2013) all converge to support the notion that contact with nature and nature related environments can enhance physiological relaxation effects leading to stress mitigation. Water, vegetation, foliage, trees and forests groves are some of the natural environment attributes that aid relaxation through the stimulation of vital senses (smell, sound, touch, sight) which are likely to act as vehicle for a calming or balanced experience (Hartig *et al*., 2011).

Need for Mountain Research

Recently, researchers have started using more of real sites instead of indoor experimentation to determine the effects and benefits of interacting with these natural environments. A range of sites utilized in investigating the health effects related to contact with nature have largely focused on forests (Stigsdotter *et al*., 2011; Tsunetsugu *et al.*, 2013), wilderness (Cole & Hall, 2010; Hine, Pretty & Barton, 2009) and urban nature environments (Holbrook, 2009; Hunter, 2001; Martens, Gutscher & Bauer, 2011). Research pertaining to contact with mountain environments has however received less attention in the area of health benefits. Available documentation shows that mountain research is focused more on changes in agricultural landscapes, scenic beauty and preference (Beza, 2010; Lindemann-Matthies *et al*., 2010; Schirpke, Tasser & Tappeiner, 2013). Apart from the general bias in landscape typology research, global statistics of research on mountain and alpine environments indicates that Africa occupies a spot at the lower end of the ladder (Körner, 2009). In sum, there is a lack of research using mountain environment as setting for the study of human responses to environmental stimuli. Very few studies have merely used picture slides or video simulation of mountains to depict it (Laumann, Gärling & Stormark, 2001). Therefore, it has become imperative for substantial evidence-based studies hinged on real-life experiential contact with mountain landscape environments possessing the potential to elicit wellbeing. This will ascertain the range of benefits associated with such experiences.

The aim of this study, therefore, is to investigate and advance empirical evidence of the physiological effects of contact with mountain landscape environment comparative to urban environment by engaging real site experimental protocols.

Methods

Subjects

Forty subjects comprising lecturers and students between the ages of 20 to 40 years were recruited from the urban environment of Benue State University, Makurdi, Benue State, Nigeria through convenience sampling as volunteers in this study. A day before its commencement, two of the subjects opted out. One due to time factor and the other admitted not being psychologically stable for the experiments. Thirty-eight subjects (male = 16, female = 22; mean age ± SD, 29.1 ± 7.18 years) gave informed written consent to participate in the study at no fee. All the thirty-eight subjects formed a single within group experimental design. To ensure adequate control of the pre-test and intervention protocol, all subjects were recruited from within the same urban environment.

Study locations

The study was conducted in two comparative sites with distinct landscape character as shown in Plates 1 and 2. Plate 1 shows the urban environment of Makurdi, Benue State, Nigeria which served as the pre-test site while Plate 2 shows the natural landscape environment of the Obudu Mountain landscape environment in Cross River State, Nigeria which served as the intervention site.

Subjects lived within the urban environment of Makurdi district area. It is located around N7º43'50.00" N latitude and 8 º 32'10.00" E longitudes with a tropical savanna climate. Makurdi district with characteristic urban attributes of hardscapes, population density, commercial activities and heavy traffic lies on an altitude of about 104m above sea level. The intervention site at the Obudu mountain landscape environment lies between latitude 6°23'7.43" N and 9°23'20.47" E longitude with a semi temperate climate and an altitude of between 1700m to 1765m above sea level. This environment is rich in diverse landscape attributes such as water fall, grotto, river, forest reserve, 70m long canopy walkway, bird watching platform. In addition, the cable car ride is available for vantage point motion view of prominent surrounding mountain horizon covered by near dense but fascinating green vegetation and a water theme park.

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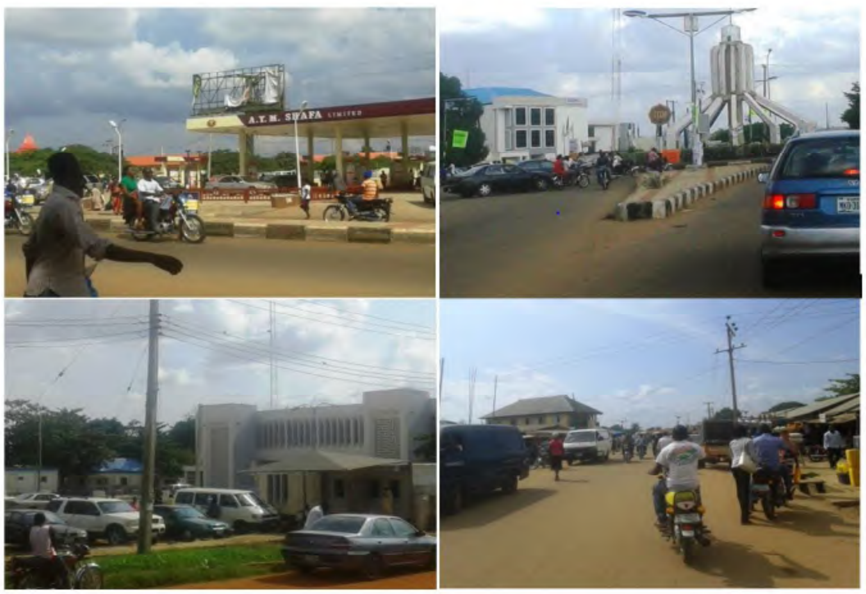

Plate 1: Makurdi urban landscape character

Plate 2: Some attributes and features of Obudu mountain landscape environment (A-river feature, B-mountain vantage point, C-canopy walkway, D-waterfall, E-built structures, F-Water theme park, G-view from the cable car, H-the cable cars)

Measures and Instruments

The study was carried out between 28th January and 3rd February 2014. The experimental protocol spanned 7 days. Three qualified medics assisted in carrying out measurements at the urban environment while two assisted at the Obudu mountain landscape environment. The subjects were verbally briefed at the beginning of the study on the measures to be taken which includes systolic/diastolic blood pressure and pulse rate measurements.

Pre-test measures were carried out at the urban environment on 28th, 29th and 30th January which represent first three days of the study. The pre-test centre for the measurements was set at the Benue State University Makurdi medical school private dining hall which was within a 10 km radius and is about ten-minute drive from the location of each subject. Daily activities engaged in by subjects in the pre-test environment included walking from one lecture venue to another as well as receiving lectures in non-air-conditioned crowded halls. Measurements were carried out between 6 pm and 8 pm during the three-day period at the urban environment. Each subject was allowed to rest in a seated position on arrival at the pre-test centre for at least ten minutes before blood pressure and pulse rate were taken.

The room temperature of about 23ºC was at a comfortable level and ambient noise was minimal. Subjects were asked to switch off their phones to avoid distraction and disturbance. Blood pressure measurement was performed using the standard mercury sphygmomanometer and the auscultatory technique with a trained observer was applied (Pickering *et al*., 2005). Systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate (PR) measurements of each subject were recorded for the three consecutive days.

Subjects were transported by road on a journey that lasted 6 hours to the Obudu mountain landscape environment on the 31st of January 2014. They were allowed to take a rest and interact freely on arrival but measurements were not taken in order to check the effect of travel fatigue. Intervention measures were carried out at the Obudu mountain landscape environment the following three days, 1st, 2nd and 3rd February. SBP, DBP and PR Measurements were also carried out every day throughout the three-day period at the mountain environment using the same equipment and process as obtained in the urban environment. Similar to the procedure in the urban environment, measures were carried out between 6 pm and 8 pm each day. This is to ensure that subjects have had enough contact with the environmental attributes of the Obudu Mountain landscape environment before measures were taken. Part of the activities' individuals engaged in during the three days period at the mountain environment were both active and passive. The active activities included but not limited to swimming in the river and forest walks while the passive activities involved silent meditative moments in the forest, mountain vantage point and river areas.

Data Analysis

The statistical package for the social sciences (SPSS version 19) software was utilized in analysing the data obtained. Physiological response of subjects was analysed using a Paired sample t-test to see whether differences exist between contact with the urban and mountain environment.

Results and Discussion

A paired sample t-test was carried out to ascertain whether contact with the urban and mountain environments differ in outcome based on the pre-test and intervention physiological responses of the individuals. It can be seen from Table 1 that there was no significant difference between the urban and mountain environment in the SBP ($t = -1.47$, $P>0.05$) and DBP ($t = 1.41$, $P>0.05$) response of the individuals during the seven days experimental period. However, pulse rate ($t = 3.12$, $P < 0.05$) of the individuals indicated a significant difference between the two environments (urban and mountain). Interestingly, the mean scores on SBP, DBP and PR of individuals between the urban and mountain environment all showed substantial difference.

This pattern is similar to the study by Tsunetsugu *et al.* (2013) that revealed that differences exists between the forest and urban environment in their impacts on most of the physiological indices measured. The differences exhibited in this study shows an increase in the SBP of participants at the mountain environment (urban 120.0 ± 11.9 mmHg, mountain 122.6 ± 15.8 mmHg), whereas, it was found that DBP (urban 78.3 ± 11.4 mmHg, mountain 76.4 ±10.8 mmHg) and PR (urban 78.5 ± 7.3 bpm, mountain 74.7 ± 4.7 bpm) decreased at the mountain environment. The results connote that despite the absence of significant difference in the SBP and DBP the tangible differences in mean of the SBP, DBP and PR demonstrates that their physiological wellbeing was comparatively altered.

Table 1: Physiological response of participants between urban and mountain environment

Physiological indices	Environment	Mean	Std. Deviation	t	Significance
SBP (mmHg)	Urban	120.0211	11.93100	-1.478	.148
	Mountain	122.6263	15.83410		
DBP (mmHg)	Urban	78.3895	11.40701	1.413	.166
	Mountain	76.4368	10.88556		
PR bpm	Urban	78.5316	7.39101	3.122	.003
	Mountain	74.7000	4.75258		

The increase in the mean SBP of individuals in the mountain environment was not anticipated but portends interesting implications. The reason for increased SBP at the mountain landscape environment is perhaps due to individual's failure to adapt to sudden changes in the environmental configuration. These adaptive traits have been found to be influenced by the manipulation and reactions of the human physiognomy. The reactions are influenced by the sympathetic nervous system (SNS) activation and release of hormones (e.g. adrenaline, testosterone and cortisol) consequent upon the activation of the hypothalamic-pituitary adrenal axis (HPA) and the neuroendocrine system that regulates reactions to stress and body processes such as mood and emotions (Hey & Sghir, 2011). The HPA axis is a predominantly adaptive system typified by distinct inter and intra-individual variability (Kudielka & Wüst, 2009). According to Brady and Matthews (2006), when systems are intermittently 'turned on' and 'turned off' the stress response is believed to be adaptive.

The Obudu mountain landscape environment is characterized by features such as undulating topography, densely forested areas and cascading waterfalls which profoundly are in contrast with the features of Makurdi urban environment. The sudden change in environmental features exerted a demand on the sympathetically-mediated cardiovascular system which initiates the release of catecholamine from the nerves and adrenal medulla leading to increase in blood pressure (Brady & Matthews, 2006). These factors conceivably exerted consistent effect on the entire group of individuals leading to the mean increase in their SBP. This finding is inconsistent with that of Tsunetsugu *et al*. (2013) which observed no main effect on SBP whilst comparing forested areas with urban areas. It is also not in agreement with the findings of Lee *et al.* (2012) which showed that individuals exhibited significant lower SBP in the forest environment compared to urban environment. However, within the context of environmental influence on blood pressure, SBP responses cannot be discussed in isolation of DBP.

The result obtained indicates that the DBP of individuals decreased at the mountain environment by 1.9 mmHg. The increase in SBP and decrease in DBP at the mountain environment is consistent with previous findings of studies that investigated human response to natural environments using forests as stimuli (Lee *et al*., 2009; Tsunetsugu *et al*., 2007). Parallel to the physiological reactions acting upon SBP, DBP is also an outcome of the activities of HPA and the sympathetic adrenomedullary (SAM) system which are regarded as the main physiological stress response system in the body structure (Dinan, 2004; Koolhaas *et al*., 2011). Studies have shown that heightening or lowering of the stress response system activities such as SBP and DBP is in reaction to stressors (Hartig *et al.*, 2003; Song, Ikei, & Miyazaki, 2015) or 'wellbeing enhancing' environmental stimuli. Chrousos (2009) regards a stressor as a stimulus that endangers homeostasis while the stress response involves the effort made by the organism aimed at retrieving homeostasis. Hence, it appears the individual hitherto exposed to urban stressors had their DBP decreased at the mountain environment through the sustained effort to combat a skewed homeostasis.

Also, the decrease in DBP of Individuals at the mountain environment shows that their response system was able to activate the process of adjustment and subsequent adaptation to inherent cues. These cues generated the kind of positive feelings which manifested in the physiological responses of individuals. Calmness and excitement are positive feelings fostered by observation and exploration of the inherent features of Obudu mountain landscape environment such as views of the horizon from vantage points, sounds of cascading water fall, river pool, forest groves, and sublime vegetation. This finding is in accord with the study by Takayama et al. (2014) which demonstrated that interaction with forest compared with urban environment enhance positive feelings and attenuate sources of stress (e.g. anxiety, depression, tension and confusion) leading to enhanced human wellbeing. The pulse rate (PR) result obtained shows a pattern similar to the DBP result. Following the principle of the law of initial value (Wilder, 2014), PR was observed to have a significant difference between the urban and mountain environment ($t = 3.12, P < 0.05$) with a mean difference of 3.8 bpm which indicates a decrease at the mountain environment. This mean difference is significantly higher than the findings of Song *et al.* (2013b) which demonstrated a reduction in PR of individuals by 2.5 bpm after contact with a forest environment.

Interestingly, SBP increased at the mountain environment while DBP and PR reduced. There is however, an established relationship between the operations of SBP, DBP and PR. According to Lee *et al*. (2012), SBP, DBP and PR are indices of the autonomic nervous system (ANS) which is divided into two aspects; the parasympathetic and sympathetic nervous systems. The parasympathetic nervous system commonly referred to as "relax and renew" is the aspect of ANS which controls recovery and return to homeostasis (balanced state) through heart rate reduction, dilation of blood vessels, enhancement of digestion and energy storage after a stressful experience (Berto, 2014; Sluiter *et al.*, 2000). Hence, the findings of this study point out that experiential contact with the mountain environment enhanced the individual's physiological ability to attain a relaxed state via decreased diastolic BP and pulse rate.

Furthermore, the evidence of recovery from stress through contact with the mountain environment is hinged on the contrast drawn by this study to that of Benetos *et al*. (2000) which clinically revealed that increase in SBP and decrease in DBP instigates increase in PR. In this case, despite increase in SBP and decrease in DBP, PR of individuals decreased moderately at the mountain environment. Also, the attainment of a relaxed state indicates the absence of stress stimulating features in the mountain environment. This is in accord with the assertions of De Vente *et al*. (2003) and Sluiter *et al*. (2000) that blood pressure and pulse rate of human beings generally increases in response to a stressor. This suggests that the mountain environment features greatly enhanced homeostatic state of the individual due to the absence of stressors (e.g. unpleasant noise, overcrowding and excessive built structures) usually present in the urban environment. The findings of this study are similar to those of Park *et al*. (2009) and Song *et al.* (2013b) which revealed significantly lower DBP and PR of individuals in the forest environment after viewing than in the urban environment.

Conclusion

The history of research in the area of restorative environment is long running and this study builds on it. Overall, the findings pertaining to systolic blood pressure, diastolic blood pressure and pulse rate demonstrated that the mountain environment affects the stress response mechanism of the individual. These findings are broadly consistent with one aspect of the stress reduction theory (SRT) which posits that contact with specific natural environments stimulates our parasympathetic nervous system thereby leading to stress reduction and autonomic arousal (Bratman *et al.*, 2015). Therefore, experiential contact with the mountain landscape environment has led to mitigation of stress through reduced diastolic blood pressure and pulse rate. This study provides essential physiological data for use and implementation by landscape practitioners and policy makers in harnessing and managing mountain landscape environments. This is achievable through a systematic approach to the development of mountain landscape environments with the view of according urban dwellers the opportunity of restoration. Hence, individuals confronted with many sources of stress from daily engagements in urban environments can obtain short term relieve measures in the mountain landscape environment. However, certain limitations were observed in this study leading to suggestions for further studies. The convenience sampling method used and the characteristics of the sample employed require attention. Perhaps, a balanced sample will produce a different outcome in terms of physiological outcomes as it relates to mountain landscape environment studies. Also, pertaining to the characteristics of the sample, the subjects where healthy male and female volunteers. Thus, it is necessary to ascertain through further studies if the outcomes could be generalized when applied to other groups such as patients with historical stress challenges, the elderly and children.

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