Disturbances of natural and cultural landscape as an element of controversies in tourism – assessment based on the analysis of stress hormones in saliva

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Abstract

Context: The ecology of the natural and cultural landscape is an important decisive factor for tourists planning trips. The emerging disturbances of a landscape may affect not only the perception of tourist values, but also the health of visitors.

Objectives: The aim of the study was to determine the relationships between identification of specific elements of a disturbed natural and cultural landscape and basic physiological reactions in study participants, namely the presence of stress hormones in saliva. The authors also intended to verify a new research method in the field of tourism and landscape assessment.

Methods: The study participants were students. Samples of saliva were collected after displaying images. Hormone levels (cortisol, DHEA, testosterone) were determined using immunoenzymatic ELISA kits.

Results: The results indicate that all respondents were in agreement as to which factors disturbed the landscapes presented. However, their subjective feelings were not reflected in a statistically significant manner in the physiological and biochemical reactions of their bodies. The authenticity of a landscape seems less important to the participants than expected. The lack of a strong reaction to a disturbed landscape is surprising, especially in the context of tourism, in which natural and cultural assets are some of the major factors affecting purchasing decisions and principal travel motives.

Conclusions: This research may be a strong prognostic in the context of sustainable tourism and environment protection. This knowledge may be used by planners and spatial development experts in designing landscapes as well as in assessing the visitors'/tourists' perception of a landscape.

Introduction

A synthetic approach that reflects the problem of defining landscape it has been formulated repeatedly over the years (Angelstam et al., 2013; Skowronek et al., 2018; Karasov et al., 2021). Many landscape architects claimed that landscape is the physiognomy of the environment (surface of the Earth), being a synthesis of natural and cultural elements.

At the same time, authors (Uuemaa et al., 2013; Vallés-Planells et al., 2014; Wood et al., 2018; Buscombe, Ritchie, 2018) proposed various landscape classification:

– primary landscape, with the ability to self-regulate, whose biological balance is not disturbed by human activity;

– natural landscape with partial ability to self-regulate, without considerable spatial elements introduced as a result of human activity;

– cultural landscape with disturbed ability to self-regulate, requiring protection and affected by intense human activity.

Natural and cultural landscapes are components of a tourism product and are some of the most important factors in consumer decision-making processes. Natural landscapes and their anthropogenic counterparts are an incentive for tourists to visit certain destinations. They provide a source satisfaction, inner experiences and reflection, as well as enable verification of one’s own needs. The importance of landscape in creating tourist potential of destinations is related to the types of tourism prevalent in these locations. While landscapes are essential in the case of sightseeing travels (cultural and nature-related), in other cases they are not a key factor for tourists. Instead, they serve as a background for other aspects of the reception areas, e.g. socio-economic or economic (which also have an impact on the attractiveness of specific destinations).

Landscape is a subject of interdisciplinary studies in the field of tourism. Its perception is a complicated issue due to the varying perception of the physical environment by individuals and the complex mechanism of processing external stimuli in the human brain. Individuals have different preferences regarding landscape depending on sex, age, education, place of origin and cultural background. Additionally, preferences of individuals change depending on their physical and psychological predispositions.

The presentation of multi-sensory aspects of tourist landscape and the determination of features that impact its attractiveness can be performed using research methods described in the literature. The selected items relate to understanding how multi-sensory spatial experience influences affective landscape image and behavioural intention (Vauhkonen, Ruotsalainen, 2017; Rahman et al., 2017; Sudakov, 2017; Ozkan et al., 2017; Simensen et al., 2018; Papathanasiou-Zuhrt, 2019; Miklós, et al., 2019; Dai, Zheng, 2021).

Publications that discuss the use of eye-tracking to study the perception of landscape are particularly interesting (Scott et al., 2016; King et al., 2019; Dupont et al., 2014; Mele et al., 2014). The advantages and disadvantages of this data collection procedure are widely discussed. Nevertheless, it is emphasised that this approach is used in research on tourism (Michael et al., 2019; Shi et al., 2021) and the hotel industry (Scott et al., 2019).

One of the most important issues that influences the selection of a methodological approach is the way of capturing the relations between the object affected by negative impacts and the categories of activity that produce the said impacts (Goodchild, 2007; Mücher et al., 2010; Cook, Van Der Zanden, 2011; Kalivoda et al., 2014; Wang, 2016; Xinxin, 2019). With ecosystem and landscape assessment performed for practical purposes, we understand landscapes not only in terms of landscape ecological patterns, but also in terms of their contribution to people's quality of life. Wartmann et al. (2021) in their study tested relationships between landscape ecology and social science indicators, by investigating how landscape patterns are linked to people’s perception of landscape quality.

The aesthetic value of landscape is the product of a specific spatial configuration of its features. Many of these features can be identified and inventoried by analysing cartographic materials (through mathematical and statistical analysis of maps). It is also worth noting the popularity of geographic information systems (GIS) in analysing landscapes (Mücher et al., 2010; Steiniger, Hay, 2009; Yu et al., 2019).

Satellite images enhance map contents and increase the expressive character of the information presented. The growing availability of detailed remote sensing data allows for a gradual increase in the scope of inventoried features. Thanks to remote sensing and photogrammetric images multiple solutions were proposed for developing tourism in various areas (Colosi et al. 2009; Kamh et al., 2012; Chaplin, Brabyn, 2013, Xiao et al., 2018; Llerena-Izquierdo, Cedeño-Gonzabay, 2019). Numerous studies focus on areas degraded by human activity or on the development of mass tourism (Lai, Hitchcock, 2017).This paper proposes a different research approach, which may be considered innovative. A precise image of biochemical reactions triggered in the human body by stimuli that disturb natural and cultural landscape can be used as a basis for more in-depth analyses. The intention of the researchers is to verify a research method that is new in the field of tourism studies and may support the analysis and evaluation of reactions to disturbances in landscape perceived by viewers.

The primary goal of the study was to determine the relationships between the observation of specific elements of disturbed natural and cultural landscape and the basic physiological reactions in study participants (reflected by the levels of stress hormones in their saliva).

Two hypotheses were formulated and verified through an empirical analysis procedure:

H1: When participants see elements that disturb natural and cultural landscapes, significant quantities of specific salivary stress hormones are released.

H2: Participants react more strongly to elements that disturb natural landscape than to those that disturb cultural landscape.

Landscape as an element of controversies in tourism – literature review

The humanist approach to landscape emphasises studying the world as it is perceived by people. Practicality in the context of landscape geography is also highlighted increasingly often (Cosgrove, 2008; Ley, Samuels, 2014). It is therefore important to be aware of human experiences and the relations between people and the environment (Seamon, Lundberg, 2017). In the phenomenological approach, it is particularly important to learn how individuals experience landscapes affecting them through nature and culture. Perception is a combination of feelings and thoughts and depends on many factors, including direct information, previous experiences and spatial context. The perception of landscape, including the experience of a given location, is a component of environmental perception understood as a mechanism of processing stimuli collected from the surroundings by the individual’s mind. Studying the perception of landscape involves the assessment of feelings and emotions triggered by landscape elements and the phenomena present in it (Lengen, 2015). The relationship between perception and landscape is also highlighted by the European Landscape Convention (2000), which defines landscape as “an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors” (p. 3). Although a diverse set of geographical environment components, both natural and anthropogenic (cultural), has accompanied people for a very long time, the first studies of landscape only began in the early 19th century (Egoz, 2013).

Landscape can be viewed through its structural and functional aspects as a geocomplex, and through its physiognomic aspect as the external appearance of a specific location (Burch et al., 2015).

Landscape is experienced universally and affects the individual's quality of life wherever they are: in cities, in the countryside, in valuable natural areas as well as in degraded areas, in all the unusual and usual, “everyday”, locations. A holistic approach to landscape provides a much greater field for interpretations. Tourist landscape can also be considered through its physiognomic aspects as the appearance of the tourist space (Gkoltsiou et al., 2013). Landscape physiognomy includes shapes, colours, sizes, similarities and differences, i.e. contrasts, and mutual spatial relations, i.e. patterns or harmony. Reaching a consensus about preferences is an important issue in numerous studies of landscape perception from both a practical and a theoretical perspective (Hagerhall, 2001; Kalivoda et al., 2014; Wang et al.; 2016), which is affected by a number of factors including landscape quality and type, and the varying expectations of individuals.

Human activity results in changes to natural components of landscape, including e.g. the introduction of artificial (anthropogenic) elements. Landscape can be subject to dynamic negative changes and studies of its structure often involve the assessment of its visual attractiveness identified through aesthetic harmony or disharmony (Sowińska-Świerkosz, 2016). Additionally, landscape can be evaluated based on the source of disturbance and changes which can either be natural, e.g. the retreat of glaciers in modern times, or anthropogenic, e.g. urban sprawl (Rubiera-Morollón, Garrido-Yserte, 2020). Landscape has multiple functions in the tourist industry, including: cognitive, spatial, aesthetic, educational and ecological (van der Duim, 2007; Edensor, 2001). However, it must be noted that its assessment is subject to individual verification. What may be considered a value by some individuals, may become a source of discomfort for others.

Controversies in the tourist market can be analysed in two ways. On the one hand, this problem is considered a part of human/tourist behaviour which is not in line with social standards functioning in tourist destinations, covering the cultural, natural and economical spheres (Bhati, Pearce, 2016; Thirumaran, 2013; Uriely et al., 2011, Hughes et al., 2008; Weaver, 2006). Tourist enterprises (e.g. the hotel industry or providers of complementary tourist attractions) can also act in a dysfunctional manner and disregard acceptable local cultural standards in tourist destinations when erecting new buildings or offering forms of entertainment that are considered artificial supplements to local tourist attractions, whose authenticity affects the experience of tourists (McCannell, 1996; Urry, Larsen, 2011). On the other hand, controversies in the tourist market may apply to all forms of tourism that cause justified ethical doubts, are disputable and are not subject to clear-cut assessment (Author, 2019; Author, 2021).

The issue of controversies in tourism impacting various aspects of social, natural and cultural environment is widely discussed in the literature (Moufakkir, Burns, 2012). Some of the controversies are strongly anchored in the tourist industry, while others are novelties, created intentionally and in relation to travelling. It is important to know how to identify and assess these relations. This subject is thought provoking and strips the tourist industry of its idealised image usually associated with pleasure, rest and pristine landscapes (Betsky, 2005).

Controversial phenomena in tourism are complex processes covering its economic, cultural and environmental relation aspects (Burns, Novelli, 2008). Controversies arise within general tourist and spatial planning policies and the decisions in these areas can be affected by the diversity of natural environment used for tourist purposes (Hall, 1994), taking into account the opinions of extensive groups of stakeholders, including design and spatial planning experts (Gunn, Var, 2002).

Looking at tourism through the lens of sustainable development, C.A. Gunn and T. Var (2002) noticed a binary division between the existing concepts and the practical implementation of ideas. These are mutually contradictory and full of controversial actions, especially in cases when the protection of natural environment and its adaptation to sustainable tourist use is discussed (Higgins-Desbiolles, 2018).

Even the issue of degenerative impact of some forms of tourism on others produces serious economic and social doubts when a purported alternative appears for the existing tourism product at a given destination (Ewert, Jamieson, 2003).

Sociocultural factors form one of the categories of dysfunction occurring in the tourist consumption practice. Their scope can be very wide and include issues related to consumer behaviour, cultural differences and lack of empathy for local cultures at tourist destinations. Thus, they are the focus of numerous analyses. However, what should be the subject of scientific interpretation is the reaction of visitors to the existing factors related to natural and cultural landscape at a given destination, seen in the contest of disturbing or controversial phenomena (e.g. inappropriate spatial development, architectural elements that do not blend in with the local landscape, elements that disturb natural landscape and the visual perception of a given location). This is because the scope of these reactions changes, as does the spatial development of tourist and recreational areas. This goes beyond social feelings assessed using the typical quantitative tools (Simensen et al., 2018), and requires more in-depth interpretation based on qualitative analyses of opinions, involving the physiological reactions of study participants (Simensen et al., 2018; Guo et. al., 2021). This type of studies allows for detecting strongly personal signals that are the basis of the feedback loop between the landscape and the individuals who perceive it. Furthermore, it is very difficult to falsify such reactions because many of them are subconscious and are not subject to modelling or learning.

Methodology And Data Collection12

To assess the somatic response to disturbed landscape, changes in the level of three steroid hormones were analysed in the participants. These hormones were: testosterone (T), cortisol (C) and dehydroepiandrosterone (DHEA), also known as stress hormones. The analysis of changes in the T and K levels allows for evaluating the impact of a given stimulus on the human body (emotional situation and physical activity) (Moreira et al., 2012; Foght, 2002). Because DHEA acts antagonistically to cortisol (Morrow, 2007), it is assumed that it plays a key role in mechanisms reducing the stress response. Therefore, analysing changes in DHEA levels allows for determining how effectively the human body manages stress (Morgan et al., 2004). In general, blood is the most commonly used carrier of diagnostic information in laboratory analyses. However, taking blood samples is related to inflicting pain in participants, which in turn causes additional stress. In the present study, this would be a factor that severely disturbs the reliability of the assessment discussed. Instead, saliva was used as biological material, as it can be collected in a non-invasive and painless way. Moreover, the correlation with blood levels of the hormones in question has already been confirmed (Gonzalez-Bono et al., 1999; Maso et al., 2004).

The study was conducted in artificial conditions (in a lecture hall) in the morning hours of the day (07:00–08:15), in accordance with the procedure of collecting analytical data. Samples of saliva were collected into 2 ml Eppendorf test tubes 60 minutes and 2 minutes before commencing and 5 minutes after displaying the images (Fig. 1). The study participants were students of the Faculty of Geographical and Geological Sciences at Adam Mickiewicz University in Poznan, a total of 28 individuals (14 male, 14 female) aged 20–25 (to maintain specific hormonal parameters characteristic of this age group). A total of 168 samples collected during the first day of the study and 165 samples collected during the second day were analysed (one male participant withdrew).

During 24 hours preceding the experiment, the participants were required to avoid physical activity whose intensity exceeded that of normal everyday activity, avoid strong stressors before the experiment, refrain from consuming alcohol, drink at least 3 litres of water and have undamaged gums (traces of blood in the saliva disqualified samples from the analysis) to prepare for sample collection (Balsalobre-Fernández et al., 2014; Kivlighan et al., 2004; Valero-Politi, Fuentes-Arderiu, 1996; Andersson et al., 2017). On the day of the experiments, the participants were not allowed to eat before the commencement and the samples were collected within 2 hours of them waking up.

The analyses were performed at the Applied Biotechnology Laboratory at the Center for Advanced Technology of Adam Mickiewicz University in Poznań. The analytical procedure involved storing samples at a temperature of -20°C. Then, after thawing, each of the samples was thoroughly mixed and centrifugated (10,000 RPM x 10 min; Eppendorf 5804R centrifuge) to separate mucins. Hormone levels (cortisol, DHEA, testosterone) were determined using the following commercially available immunoenzymatic ELISA kits manufactured by Demeditec Diagnostics GmbH: *DHEA free in saliva* ELISA (DES6666), test assay range 10–2560 pg/mL; *Cortisol free in saliva* ELISA (DES6611), test assay range

0.1–30 ng/mL and *Testosterone free in saliva* ELISA (DES6622), test assay range 10–1000 pg/mL. Control, standard and participant saliva solutions were pipetted to the wells in a 96-well microplate covered with hormone-specific antibodies. Then, a solution of horseradish peroxidase conjugated with relevant antibodies was added and the microplate was incubated at room temperature and mixed continuously using an IKA MS 3 digital shaker. Next, the microplate wells were washed 4 times using a wash buffer provided with each of the kits. Then, the substrate solution for the conjugated enzyme was added producing the expected colour effect. The absorbance of samples was measured using the TECAN Infinite M200 pro spectrophotometer at a wavelength of 450 nm.

In statistical analysis of the data, quantitative variables were characterised by range and numbers (N), mean, median, standard deviation (SD), interquartile range (IQR) – defined as the difference between the third and the first quartile – and range (min-max). Qualitative variables were described with numbers and percentages in groups.

Due to their non-normal distribution, the non-parametric Mann-Whitney U test was used to compare the distribution of two quantitative variables. To investigate monotonic relationships between two variables, the Spearman's rank correlation coefficient was used.

The presence of a monotonic relationship meant that the variables studied increased or decreased in the same direction, without assuming that the relationship analysed was linear as is the case with Pearson linear correlation. The Guilford's classification of correlation strength was used (1965):

- $|r|=0$ – no correlation,
- $0<|r|\leq 0.3$ – very weak correlation,
- $0.3<|r|\leq 0.5$ – weak correlation,
- $0.5<|r|\leq 0.7$ – moderate correlation,
- $0.7<|r|\leq 0.9$ – high correlation,
- $0.9<|r|<1.0$ – very high correlation,
- $|r|=1$ – perfect correlation.

A linear mixed-effects model was used to investigate the relationship between the variables. The fixed effects analysis yielded model coefficient values showing at what rate the explained variable value increases or decreases as the explanatory variable increases or decreases. The optimum model was selected using the backward stepwise method based on the Akaike Information Criterion (AIC). In cases when the results yielded by the mixed-effects model indicated overfitting, a classic linear regression model with interactions was used instead.

The level of statistical significance was set at $p = 0.05$. However, statistically significant results for $p = 0.01$ and $p = 0.001$ were also presented. P-values indicating a statistically significant result are shown in bold. In the case when $p < 0.001$, the notation $p < 0.001$ was always used.

All calculations and graph were made using R version 4.0.2.

[1] The research was approved by the Bioethics Committee for Research Involving Humans at the Karol Marcinkowski Poznan University of Medical Sciences by Resolution No 295/22.
[2] The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Results

To verify measurement errors prior to the main analysis, an analysis of the total hormone levels for all measurements was performed. The level of cortisol was established at 20.67 ± 6.06 [ng/ml]. The mean level of DHEA in the group studied was 735.85 ± 445.85 [pg/ml], the median was 628 [pg/ml], which indicates that the differences in levels of this hormone were greater than in the case of cortisol. This is further confirmed by a very broad range of measured values from 142.2 to 2349.84 [pg/ml]. Testosterone levels were not as dispersed as those of DHEA but were also characterised by considerable standard deviation relative to 138.57 ± 91.02 [pg/ml].

The analysis of hormone levels was conducted for the entire study group (male and female participants together) for different measurement times. It was found that the mean value from the first measurement was significantly different from the measurements performed immediately before and immediately after image presentation. One hour before presenting the images the mean DHEA level was 842.08 ± 495.18 [pg/ml], 2 minutes before it was 672.15 ± 294.92 [pg/ml], while afterwards it was 693.32 ± 430.14 [pg/ml]. In the case of testosterone, these values were 155.2 ± 97.95 [pg/ml], 129.39 ± 82.33 [pg/ml] and 131.13 ± 91.45 [pg/ml], respectively, and in the case of cortisol they amounted to 23.19 ± 6.23 [ng/ml], 20.3 ± 5.63 [ng/ml] and 18.52 ± 5.46 [ng/ml], respectively.

After performing the analyses discussed above, hormone levels were analysed with regard to the sex of the participants and the measurement time.

Cortisol

First, an analysis of cortisol level was performed for male and female participants together, relative to the sample collection time. No significant differences were detected between hormone levels after the presentation of cultural landscape (CL) images and natural landscape (NL) images in all samples regardless of the collection time. The biggest difference between the cortisol level response to CL and NL images was found 2 minutes before presentation. The mean cortisol level for CL images was 19.39 ± 5.05 [ng/ml], while in the case of NL images it was higher and reached 21.18 ± 6.09 [ng/ml]. It is worth noting that regardless of the sample collection time, the median range was broader before presenting NL images than before presenting CL images, e.g. 2 min before presenting: CL images – 19.95 (17.41–22.37) [ng/ml], NL images – 22.32 (17.51–24.53) [ng/ml].

Analyses were also performed taking into consideration the sex of the participants. No statistically significant differences were found in any of the cases. The total hormone level ranges were narrower in men than in women during every part of the study. Interestingly, every time cortisol level was measured, its mean value was higher in women than in men. On the other hand, the relationship between median values was inverse. The largest difference was observed for the total values: the mean cortisol level was 21.43 ± 4.97 [ng/ml] in women and 19.89 ± 6.97 [ng/ml] in men. The median value was 20.78 [ng/ml] and 21.33 [ng/ml], respectively. This means that the results obtained were more dispersed in the case of women than men. Table 1 presents changes in the cortisol level depending on sex and sample collection time.

Table 1
Cortisol level changes depending on sex and sample collection time (a – 1 h before image presentation, b – 2 minutes before image presentation, c – 5 minutes after image presentation)

		men (n = 13)		women (n = 14)		p
		cultural	**natural**	**cultural**	**natural**	
a	x ± SD [ng/ml]	23.28 ± 6.50	21.81 ± 7.94	23.37 ± 4.30	24.31 ± 6.09	0.8477
	min – max	5.72–29.88	2.62–29.92	15.42–28.82	9.23–32.46	
b	x ± SD [ng/ml]	18.34 ± 5.83	20.09 ± 7.43	20.37 ± 4.20	22.27 ± 4.40	0.5169
	min – max	6.51–26.4	4.35–28.5	11.27–26.48	16.86–32.48	
c	x ± SD [ng/ml]	17.71 ± 5.83	18.07 ± 7.24	18.09 ± 4.17	20.14 ± 4.34	0.8347
	min – max	6.66–24.09	2.95–28.44	8.64–24.21	14.55–29.77	

No statistically significant relationships were found. The total mean cortisol level in women was 20.61 ± 4.66 [ng/ml] during CL image presentation and 22.24 ± 5.18 [ng/ml] during NL image presentation. No statistically significant differences were found among men. The biggest difference was observed 2 minutes before image presentation. The mean cortisol level in men watching CL images was 18.34 ± 5.83 [ng/ml]. The level of this hormone increased in reaction to NL images, with a mean value of 20.09 ± 7.43 [ng/ml].

Based on the analysis of cortisol levels, it was determined that regardless of sex the change was close to -3 [ng/ml], which indicates a decrease. In the case of NL images, the changes varied more within a given sex. In women, the median of these differences was considerably higher than in men, although in the latter group the recorded values were more diversified. In the case of NL images, the mean decrease in the cortisol level was very similar in both sexes and amounted to 2.577 [ng/ml] in women and 2.746 [ng/ml] in men. However, when comparing the least-squares means, the analysis did not reveal statistically significant differences between the values, either in terms of the sex or the landscape type ($p > 0.05$). This leads to a conclusion that the key factor contributing to the significance of changes in the cortisol level is its baseline concentration represented by the measurement conducted 1 hour before image presentation. For example, in the case of women whose baseline cortisol was low, the level increased following disturbed CL image presentation. The higher the baseline cortisol level in this group, the less pronounced the subsequent change. In the case of participants whose baseline cortisol was close to 20 [ng/ml], no changes were observed but the trend was maintained, while the greatest decrease was observed in women with the highest baseline cortisol level.

DHEA

Similarly to the cortisol level, an analysis of DHEA level was performed for male and female participants together, taking into consideration the sample collection time. No statistically significant differences were found between any of the sample collection times studied. The greatest discrepancy between the mean DHEA levels was observed 2 minutes before image presentation: 717.02 ± 397.35 [pg/ml] for CL images and 628.89 ± 394.88 [pg/ml] for NL images.

The analysis revealed considerable differences in the DHEA value range. In women, this range was broader for all measurements as compared with men. This particularly pertains to the maximum values, which were considerably higher in women than in men. Statistically significant discrepancies were found between the levels measured in total (for both sexes) and in the samples collected 5 minutes after image presentation (Table 2). The mean DHEA level in women was significantly lower than in men (671.64 ± 497.82 [pg/ml] and 802.44 ± 376.21 [pg/ml], respectively). A similar relationship was found for samples collected 5 minutes after image presentation. Furthermore, the total DHEA level in women was visibly lower than in men (588.64 ± 427.19 [pg/ml] in women, 801.88 ± 413.19 [pg/ml] in men).

Table 2
DHEA level changes depending on sex and sample collection time (a – 1 h before image presentation, b – 2 minutes before image presentation, c – 5 minutes after image presentation)

		men (n = 13)		women (n = 14)		p
		cultural	**natural**	**cultural**	**natural**	
a	x ± SD [pg/ml]	844.40 ± 425.71	921.79 ± 358.74	852.82 ± 630.90	749.47– 555.27	0.1936
	min – max	218.40– 1581.16	346.49– 1566.88	244.02– 2349.84	196.55– 2239.97	
b	x ± SD [pg/ml]	776.90 ± 376.74	668.90 ± 256.07	661.41 ± 421.72	588.87 ± 504.81	0.0876
	min – max	212.53– 1492.57	190.41– 1082.30	190.40– 1730.10	142.10– 2107.63	
c	x ± SD [pg/ml]	838.08 ± 474.54	768.26 ± 363.03	595.78 ± 362.43	581.50 ± 497.55	**0.0339**
	min – max	158.10– 1575.09	213.57– 1472.02	205.95– 1614.02	166.89– 1811.84	

In the case of women, no difference was statistically significant. The biggest discrepancy between landscape types was found for the total results (without the division into different sample collection times). The mean DHEA level in women watching CL images was 703.34 ± 486.24 [pg/ml]. In the case of NL images, the mean level of this hormone was lower, amounting to 639.95 ± 513.04 [pg/ml]. No statistically significant differences were found in the group of men. Furthermore, the majority of p values were high, which allows for concluding that the discrepancies between image types were not clear-cut.

When analysing DHEA level changes, it was demonstrated that the median of these changes was higher in women viewing disturbed CL images and in men viewing disturbed NL images than in the case of the opposite sex for each category (CL vs. NL images). The results obtained for the two previously mentioned groups were close to -65 [pg/ml], signifying a decrease in the DHEA level. The least-squares means analysis demonstrated that in accordance with the mixed model used for this hormone, the mean change in the DHEA level in women watching the images of disturbed CL amounted to -57.7 [pg/ml], while in men watching the same images there was an increase of 62.5 [pg/ml]. In the case of NL images, the mean increase in the DHEA level amounted to 85.1 [pg/ml] in women and 52.3 [pg/ml] in men. Similarly to the cortisol level, when comparing the least-squares means of the DHEA level changes, no statistically significant differences were observed between these values, either in terms of the sex or the landscape type ($p > 0.05$). Again, this leads to a conclusion that the key factor contributing to the significance of changes in the DHEA level is its baseline level represented by the measurement conducted 1 hour before image presentation. The analysis indicated that the trends in changes occurring in men and women observing both landscape types are the inverse of the increasing baseline DHEA level. For example, in women whose baseline DHEA was low, there was an increase in this hormone level after CL image presentation.

Testosterone

Similarly to the cortisol and DHEA levels, an initial analysis of testosterone level was performed for male and female participants together, taking into consideration the sample collection time. No statistically significant differences were found between any of the sample collection times studied. Furthermore, all p values were high, which means that the differences between the groups were not statistically significant.

Statistically significant differences were found between the sexes overall (Table 3) and for each sample collection time (testosterone levels in women were considerably lower). The total mean testosterone level was 70.05 ± 33.68 [ng/ml] in women and 209.63 ± 75.92 [ng/ml] in men. The testosterone level was the highest in both sexes 1 hour before image presentation (84.11 ± 36.2 [pg/ml] in women, 228.91 ± 86.49 [pg/ml] in men). Two minutes before image presentation, the testosterone level was lower in both sexes (65.8 ± 30.84 [pg/ml] in women, 195.33 ± 64.96 [pg/ml] in men). Interestingly, 5 minutes after image presentation, the testosterone level in women decreased by ± 60.25 (30.03) [pg/ml], while in men it increased by ± 204.64 (73.56) [pg/ml] as compared to the samples collected 2 minutes before image presentation.

Table 3
Testosterone level changes depending on sex and sample collection time (a – 1 h before image presentation, b – 2 minutes before image presentation, c – 5 minutes after image presentation)

		men (n = 13)		women (n = 14)		p
		cultural	**natural**	**cultural**	**natural**	
a	x ± SD [pg/ml]	221.86 ± 84.11	235.46 ± 91.30	76.46 ± 37.64	91.76 ± 34.33	< 0.001
	min – max	119.08–383.06	116.87–412.35	37.36–155.17	20.27–143.73	
b	x ± SD [pg/ml]	195.68 ± 71.58	195.00 ± 60.91	61.37 ± 28.63	70.23 ± 33.38	< 0.001
	min – max	106.03–363.57	101.21–355.79	24.61–135.08	20.31–120.29	
c	x ± SD [pg/ml]	208.84 ± 71.98	200.74 ± 77.50	57.60 ± 31.87	62.89 ± 29.01	< 0.001
	min – max	112.30–337.41	102.12–360.29	11.97–112.98	15.06–98.54	

In the case of women, no difference was statistically significant. The biggest discrepancy between landscape types was found for the total results. The mean testosterone level in women watching CL images was 65.14 ± 33.15 [pg/ml]. During NL image presentation, the mean testosterone level was slightly higher – 74.96 ± 33.88 [pg/ml]. In the case of men, no statistically significant differences were found either. Furthermore, all p values were high, which suggests that the discrepancies between image types were not significant.

Based on the analysis of testosterone level changes, it was demonstrated that regardless of the sex, as well as in the case of women viewing CL images, the change in the hormone level was close to 0 [ng/ml]. In the case of men viewing CL images, the changes were slightly more varied (the median was nearly 15 [ng/ml]). The optimum model for changes in the testosterone level included sex, baseline hormone level and their interactions. Only one of these was statistically significant, namely sex ($p < 0.05$). The least-squares means analysis indicated that in accordance with the linear model the mean change in the testosterone level was 11.2 [pg/ml] in women and 30.3 [pg/ml] in men. However, when comparing the least-squares means, no statistically significant differences were observed for these values when taking sex into consideration ($p > 0.05$). This means that the key factor contributing to the significance of changes in the testosterone level is its baseline level represented by the measurement conducted 1 hour before image presentation.

In order to analyse the relationships between the hormones studied, Spearman's correlation analysis was conducted, which measures monotonic statistical relationships between variables. The analysis revealed a positive relationship between cortisol and DHEA levels (Fig. 2).

The relationship is more linear in women than in men. As for the relationship between cortisol and testosterone levels, the difference between women and men is more pronounced. This relationship, as well as any other relationship overall and in the group of women, does not seem to be monotonic. On the other hand, in the case of men a near-linear relationship was found. Statistically significant Spearman correlations were observed between DHEA and testosterone (Fig. 3) as well as between DHEA and cortisol. The former was weak ($0.3 < r \leq 0.5$), while the latter was very weak ($0.0 < r \leq 0.3$), and both these correlations were positive. The correlation between testosterone and cortisol was not significant.

Table 4 presents Spearman coefficients for women. Statistically significant correlations were observed between DHEA and testosterone as well as between DHEA and cortisol. Both relationships were positive and had the same value as coefficients characterising the entire group of participants, without breakdown by sex.

Table 4
Spearman’s correlation coefficients values and their significancy for hormones – females

	DHEA [pg/ml]	Testosterone [pg/ml]	Cortisol [ng/ml]
DHEA [pg/ml]	1.000 (**< 0.001**)	0.495 (**< 0.001**)	0.272 (**0.012**)
Testosterone [pg/ml]	0.495 (**< 0.001**)	1.000 (**< 0.001**)	0.201 (0.067)
Cortisol [ng/ml]	0.272 (**0.012**)	0.201 (0.067)	1.000 (**< 0.001**)

Table 5 presents Spearman coefficients characterising men. Statistically significant correlations were found between all hormones. These relationships are positive and weak ($0.3 < r \leq 0.5$ – testosterone-DHEA) or very weak ($0.0 < r \leq 0.3$ – testosterone-cortisol, cortisol-DHEA).

Table 5
Spearman’s correlation coefficients values and their significancy for hormones – males

	DHEA [pg/ml]	Testosterone [pg/ml]	Cortisol [ng/ml]
DHEA [pg/ml]	1.000 (**< 0.001**)	0.343 (**0.002**)	0.239 (**0.031**)
Testosterone [pg/ml]	0.343 (**0.002**)	1.000 (**< 0.001**)	0.288 (**0.009**)
Cortisol [ng/ml]	0.239 (**0.031**)	0.288 (**0.009**)	1.000 (**< 0.001**)

Discussion & Conclusions

Stress, defined as a threat to the homeostatic balance, triggers a complex cascade of adaptive physiological and behavioural reactions, whose purpose is to restore the disturbed homeostasis of the human body. The endocrine system is involved in the response to stress. It becomes active when stressful situations arise and releases hormones that cause changes in the functioning of the body (Kyrou, Tsigos, 2009; Russel, Lightman, 2019).

The present study involved the analysis of changes in the levels of three hormones (known as stress hormones), released in response to the images of disturbed cultural and natural landscape.

Cortisol is considered the most important among stress hormones. The body produces this hormone in crisis situations to allow for a more effective handling of problems and provide quick and effective reactions (Heimbürge et al., 2019).

The results obtained indicate that disturbances in landscape, regardless of its type, produced a stress reaction in participants, although in most cases the changes were not statistically significant. However, it is worth noting that disturbances of natural landscape produced a stronger reaction (higher levels of cortisol and testosterone). This reaction was stronger in women than in men. A statistically significant difference between the sexes in testosterone levels is not surprising, but it is interesting that in men the heightened reaction to landscape disturbances continued for a longer period of time than in women.

In addition to cortisol and testosterone, DHEA was used to assess potentially stressful disturbances of landscape. This hormone acts antagonistically to cortisol (Morrow, 2007). It is assumed that DHEA plays a key role in mitigating the stress reaction and restoring homeostasis. Therefore, analysing changes in the DHEA level in the present study allowed for determining the effectiveness of the human body in handling stress (Morgan et al., 2004).

The analysis of the DHEA change profile yielded a conclusion that, in both groups, the body fought against the stress reaction caused by viewing images of distorted landscapes. It is worth noting that in women this defensive reaction was more intense. A certain pattern, characteristic of the male and female sex, became visible in the cases analysed – men reacted by producing more testosterone to prepare for a confrontation with the problem, while women reacted by attempting to reduce stress through more pronounced changes in the DHEA level.

The empirical data analysis allowed for verifying the hypotheses formulated in the initial part of this study and motivated further research activities. All the participants were in agreement as to which factors disturbed the landscapes presented. They identified these factors without any problem and treated them as irritating. This was related to their subjective feelings, but was not reflected in the physiological and biochemical reactions of their bodies. This means that the authenticity of landscape, so crucial for tourism, seems less important to young people than assumed. Furthermore, this situation may be a strong prognostic in the context of sustainable tourism and natural and cultural environment protection.

Tourism is similar to other aspects of life in that young people are increasingly hard to surprise and astonish. Nature and the world, burdened by excessive consumerism and its consequences, elude the control of sustainable development experts. Nonetheless, these changes do not affect young people strongly enough to be reflected in the reactions of their bodies to the stimuli of this kind. This shows that the young are becoming resistant to the sight of disturbed landscapes (e.g. graffiti covering walls, illegal garbage dumps in forests) and perceive it as a normal element in their surroundings.

Modern tourists want to experience extreme stimuli that maximise their sensations and experiences. They treat the tourist offer as a spectacle that plays out before their eyes (Harris et al., 2003). In this case, however, the lack of a strong reaction to landscape-disturbing stimuli is surprising, especially in the context of tourism, in which natural and cultural assets are one of the major factors affecting purchasing decisions and principal travel motives. This is confirmed by the common desensitisation to this type of stimuli, which is even sadder given the fact that it also affects individuals who will work professionally in tourism (the majority of the participants were students majoring in tourism and recreation or geography). It is also worth remembering that we are not only purchasing items and services but also values which we assess and which can affect us very strongly. This act of purchasing is highlighted by Z. Bauman (2005) who comments on the “liquidity of life” devoted to consumption: “*It casts the world and all its animate and inanimate fragments as objects of consumption: that is, objects that lose their usefulness (...) in the course of being used*” (p. 9). McCannell (2007) suggests that being a tourist obligates individuals to look at and understand things as it should be done, by appreciating the value of nature and culture. Thus, tourist consumption (including landscape assessment) depends on the intellectual capabilities of each traveller, which affect the drive and the need to better understand the culture and nature at the destinations visited.

The results obtained in this study are an important starting point for future analyses, which can be performed among various groups of participants (considering their age, experience as tourists or jobs performed). Young people who were born to an environment featuring strongly disturbed landscapes may display considerably weaker reactions to specific stimuli as compared with older individuals who spent the majority of their lives among fairly undisturbed landscapes. The same may also apply to individuals whose careers are strongly associated with the natural environment (e.g. national park employees) or cultural environment (e.g. museum employees) in contrast to e.g. employees at corporations.

Declarations

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Competing interests

The authors have no relevant financial or non-financial interests to disclose.

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Figures

Figure 1

Analysed images containing elements that disturb (a) natural and (b) cultural landscapes Source: own elaboration based on on-line sources: (a)1 - https://www.sadyogrody.pl/prawo_i_dotacje/104/beda_wyzsze_kary_za_smiecenie_w_lesie,

22943.html; 2 - https://www.globtroter.pl/zdjecia/273512,slowacja,tatry,na,szlaku,najwyzej,polozona,toaleta, w,tatrach.html; 3 - https://www.pexels.com/pl-pl/zdjecie/trzy-szare-turbiny-wiatrowe-243138/; 4 - https://noizz.pl/spoleczenstwo/polskie-plaze-cierpia-na-parawaning-dlaczego-odgradzamy-sie-od-sasiadow/7939ld3 (photo: Wojciech Stróżyk); (b)1 - https://www.eko-gruz.plwywoz_smieci.html; 2 - https://www.bryla.pl/bryla/1,85300,11344468,Dosc_koszmarnych_bud_w_Warszawie_.html; 3 - https://tustolica.plbazgroly-na-odnowionych-fasadach-budynkow-prokuratura-to-nie-jest-czyn-zabroniony_85384; 4 - https://warszawa.naszemiasto.pl/muzeum-narodowe-kolejka-az-po-horyzont-ale-tlumy-ruszyly/ar/c1-8124827

Figure 2

Scatterplot of cortisol and DHEA values grouped by sex

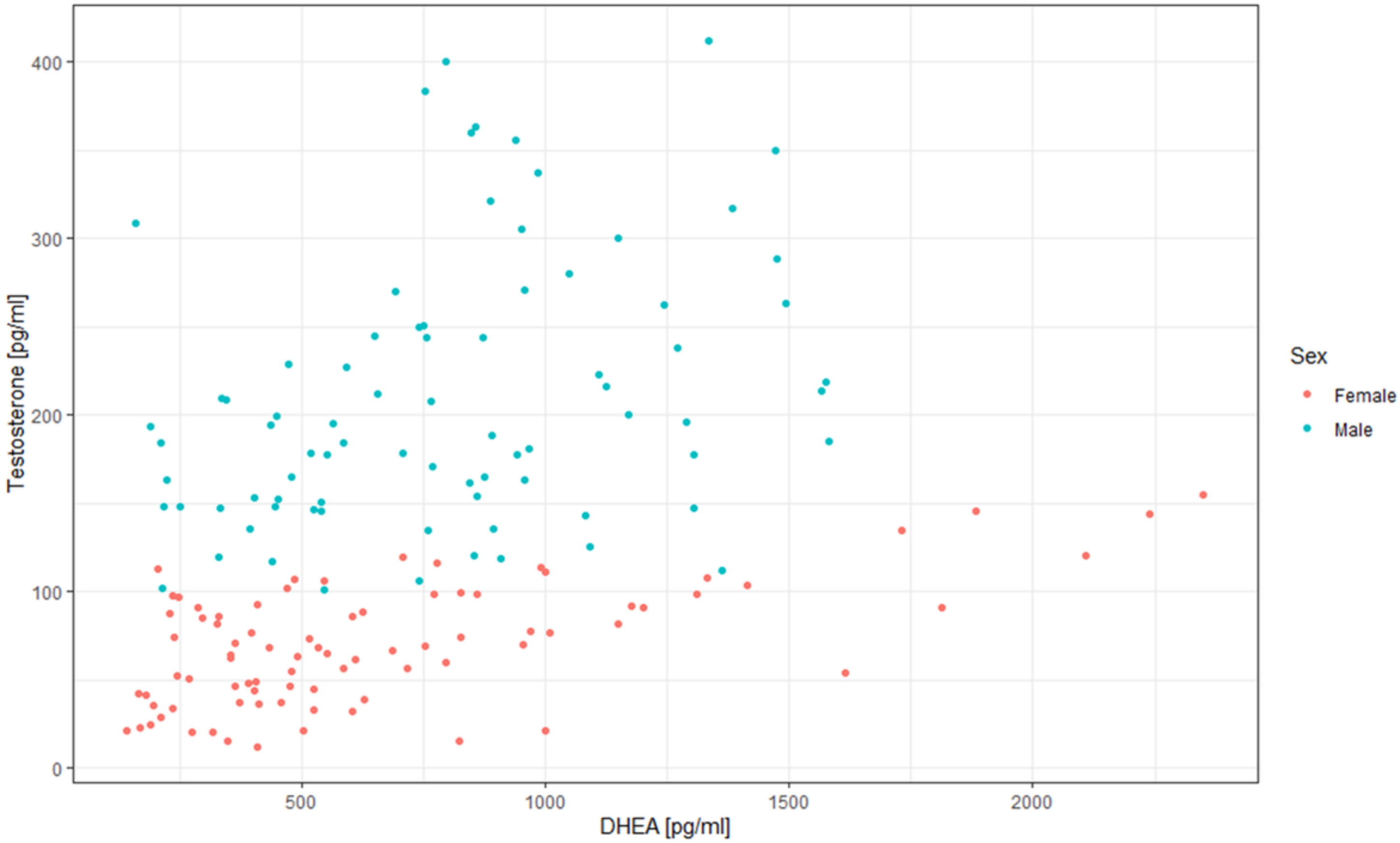

Figure 3

Scatterplot of testosterone and DHEA values grouped by sex