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RESEARCH ARTICLE

Combining walking and relaxation for stress reduction—A randomized cross-over trial in healthy adults

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Abstract

Both physical activity and relaxation have stress-relieving potential. This study investigates their combined impact on the relaxation response while considering participants' initial stress level.

In a randomized cross-over trial, 81 healthy adults completed 4 types of short-term interventions for stress reduction, each lasting for 1 hr: (1) physical activity (walking) combined with resting, (2) walking combined with balneotherapy, (3) combined resting and balneotherapy, and (4) resting only. Saliva cortisol, blood pressure, state of mood, and relaxation were measured preintervention and postintervention. Stress levels were determined by validated questionnaires.

All interventions were associated with relaxation responses in the variables saliva cortisol, blood pressure, state of mood, and subjective relaxation. No significant differences were found regarding the reduction of salivary cortisol ($F = 1.30$; $p = .281$). The systolic blood pressure was reduced best when walking was combined with balneotherapy or resting ($F = 7.34$; $p < .001$). Participants with high stress levels ($n = 25$) felt more alert after interventions including balneotherapy, whereas they reported an increase of tiredness when walking was combined with resting ($F = 3.20$; $p = .044$).

Results suggest that combining physical activity and relaxation (resting or balneotherapy) is an advantageous short-term strategy for stress reduction as systolic blood pressure is reduced best while similar levels of relaxation can be obtained.

KEYWORDS

balneotherapy, relaxation, salivary cortisol, stress, walking

1 | INTRODUCTION

Chronic states of stress have the potential to negatively impact health due to constant activation of physiological systems such as the hypothalamic–pituitary–adrenal axis and the autonomic nervous system (Mauss, Li, Schmidt, Angerer, & Jarczok, 2015). Among the adverse effects of such chronic stimulation are permanently elevated cortisol levels and alterations in stress reaction patterns (Cohen et al., 2012; Eller, Netterstrom, & Hansen, 2006; Hannibal & Bishop, 2014; Inder, Demeski, & Russell, 2012; Schedlowski & Tewes, 1996). A permanent increase in blood pressure can be a further consequence of constant stress. There is growing empirical evidence that exposure to chronic psychosocial stress contributes to the development of hypertension (Brotman, Golden, & Wittstein, 2007; Spruill, 2010; Ushakov, Ivanchenko, & Gagarina, 2016). For young adults, even a dose–response relationship between specific stress factors and the incidence of hypertension has been reported (Yan et al., 2003). Apart from physiological processes, chronic states of stress influence psychological parameters such as self-reported stress levels and can lead to depressive mood (Kim, Miklowitz, Biuckians, & Mullen, 2007; Pruessner, Hellhammer, Pruessner, & Lupien, 2003).

Regular physical exercise constitutes an effective strategy in the prevention of stress-related ailments because it induces several important physical and psychological benefits (Hamer, 2012). These benefits can be partly attributed to a reduction of the stress hormone cortisol. As far as the immediate influence on cortisol is concerned, salivary cortisol is increasingly released when physical training is intense (Guezennec, Defer, Cazorla, Sabathier, & Lhoste, 1986; Kindermann et al., 1982). This effect, however, may be reduced by physical training in water (Filaire, Duche, Lac, & Robert, 1996). Physical training with

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low and moderate intensity (e.g., walking, taiji, stretching, and exercising in water), on the other hand, causes an immediate decrease of the cortisol level (Jacks, Sowash, Anning, McGloughlin, & Andres, 2002; Jin, 1992; Nieman, Henson, Austin, & Brown, 2005; Sugano & Nomura, 2000; VanBruggen, Hackney, McMurray, & Ondrak, 2011). With regard to further benefits of exercise, there is strong evidence for its positive effect on blood pressure and cardiovascular health outcomes (Hamer, 2012; Semlitsch et al., 2013). Finally, physical activity strongly enhances mental health and promotes general well-being and quality of life (Brown, Carroll, Workman, Carlson, & Brown, 2014; Mura et al., 2014; vanDyck, Teychenne, McNaughton, De Bourdeaudhuij, & Salmon, 2015). A meta-analysis and systematic review support the therapeutic effectiveness on individuals with mild and moderate depressive symptoms (Josefsson, Lindwall, & Archer, 2014). In addition, a relationship between physical activity and anxiety levels has been established (Herring, O'Connor & Dishman, 2010); Folkins and Sime (1981), for example, demonstrate that fitness training reduces anxiety levels, especially in unfit persons with high stress levels. To sum up, physical activity is an appropriate instrument in long-term stress prevention (Phelps, 1987; Santeaella et al., 2006; Trapp et al., 2009), and due to its positive effects on health that are independent from age, it is strongly recommended also by public organs (Council of the European Union, 2013).

Employing various relaxation strategies is another popular way of combating stress. These range from progressive muscle relaxation to hypnosis, and from relaxing music to compassion meditation, and have been shown to positively affect both physiological parameters such as cortisol levels or immune parameters, and psychological outcome measures such as perceived distress, self-rated relaxation, anxiety, and mood (Gruzelier, 2002; Khalfa, Bella, Roy, Peretz, & Lupien, 2003; Pace et al., 2009; Pawlow & Jones, 2005). Moreover, mindfulness meditation training has been proven to relieve stress and improve stress-related health outcomes (Creswell, Pacilio, Lindsay, & Brown, 2014); its positive effects have been demonstrated across a wide spectrum of clinical populations (Hofmann, Sawyer, Witt, & Oh, 2010; Nagele et al., 2014; Piet, Würtzen, & Zachariae, 2012). Finally, balneotherapy, immersion bathing in warm thermal mineral water especially, is associated with both physical and psychological relaxation effects in healthy adults (Matzer, Matyas, Bahadori, Dam, & Fazekas, 2014). Such effects have also been reported for spa settings (Falagas, Zarkadoulia, & Rafailidis, 2009; Mizuno et al., 2010; Toda, Morimoto, Nagasawa, & Kitamura, 2006). Concerning the effectiveness of balneotherapy in lowering blood pressure, studies among patients with cardiovascular diseases point at its potential to further enhance the positive effects of physical activity (Caminti et al., 2011; Jacob & Volger, 2009). In general, the effectiveness of relaxation strategies has been proven among a diversity of subjects including a broad range of age groups (Gruzelier, 2002).

Although both relaxation strategies and physical activity are well-established methods for stress reduction, little is known about how a combined approach affects healthy adults. A recent study in young healthy volunteers demonstrated that Osho Dynamic Meditation, a form of active meditation incorporating physical movements in the form of jumping and dancing, led to a reduction of plasma cortisol levels after 21 days (Bansal, Mittal, & Seth, 2016). In elderly hypertensive individuals, regular yoga practice—including both exercise and relaxation—performed over a 3-month period was able to reduce oxidative stress (Patil, Dhanakshirur, Aithala, Naregal, & Das, 2014). Finally, patients of a stress clinic (a section of a Clinic of Occupational Medicine) who participated in a multidisciplinary stress treatment programme, which, among other aspects, included physical exercise and relaxation, showed a significantly higher return to work rate (Netterstrom & Bech, 2010). Nevertheless, literature focusing on healthy samples is scant, and—to our knowledge—there are no studies that evaluate the immediate effects of interventions combining physical activity and relaxation. Thus, the main aim of this randomized crossover study was to investigate if a blended approach (i.e., physical activity and relaxation) was superior to a pure relaxation intervention with regard to the short-term relaxation response. We decided to set a 1-hr time limit to our interventions for three main reasons. First, on the basis of our previous research, we assumed 1 hr to be long enough to achieve short-term psychological and biological effects that would allow us to compare various combinations of stress reduction interventions. As mentioned above, long-term effects of regular stress reducing activities have been well documented, whereas little attention has been paid to possible short-term effects. Results on these could be further useful in the development and systematic exploration of long-term interventions. Second, many common interventions used for stress reduction can be applied in 1-hr sessions, and finally, this intervention time could also be integrated in everyday settings.

In this study, a combined physical activity and relaxation approach was evaluated against sole relaxation interventions regarding effectiveness in reducing stress. On the basis of a previous pilot study (Matzer et al., 2014), we investigated how an inclusion of physical activity would affect the relaxation response; therefore, an examination of physical activity only was not our main objective. Our study design of 1-hr sessions ruled out balneotherapy as a "relaxation-only" intervention, because the recommended duration of balneotherapy is about 20–30 min (Harzy, Ghani, Akasbi, Bono, & Nejjari, 2009).

Furthermore, the short-term effects of stress reduction strategies may differ with regard to participants' initial stress levels. Therefore, as a second objective, we examined whether participants with a high versus low stress level would benefit from these strategies in a different manner.

2 | METHODS

2.1 | Ethics statement

The study complied with the guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of the Medical University of Graz (IRB00002556) in June 2012 (certification number 24-425 ex 11/12). All participants gave written informed consent before participation. The trial was registered at the International Standard Randomised Controlled Trial Number registry with trial number ISRCTN18122954.

2.2 | Participants

Participants were recruited between August and November 2012. Various local companies were invited to promote the study project among their employees as part of their worksite health promotion programme.

In addition, an announcement in a weekly regional newspaper facilitated the recruiting process. Eligibility criteria were as follows: men or women aged between 30 and 60 years, employed, fluent in German, and healthy. The age group of 30- to 60-year-olds was chosen to facilitate the comparability of subjects concerning their occupational life, as individuals at this age are typically well established in their professional life. Potential participants were not classified as "healthy" if their clinical diagnoses included one of the following diseases: rheumatic disease, cardiovascular disease, diabetes mellitus, Morbus Cushing, Morbus Addison, pituitary adenoma, and other serious illness; psychopharmacological medication, hypertensive medication, cortisone intake within 4 weeks prior to the study, and changes in dose rates of other medications up to 1 week before study entry. Women during pregnancy or lactation period were also excluded from the study. Applicants contacting the study personal were informed about inclusion and exclusion criteria in telephone interviews and completed a short questionnaire investigating their health status on the first study day. This way, it was ensured that persons with known diseases or medication influencing blood pressure and/or cortisol levels were excluded from the study. Out of a total of 92 persons who were interested in the study and willing to participate, 89 were selected for participation (three did not meet the inclusion criteria). Of these, eight participants discontinued the study and were not included in the analysis. The dropouts did not differ from those 81 persons who completed all interventions in any sociodemographic or health-related characteristics; nor could their initial estimate of stress level (high vs. low) be identified as a potential reason for terminating their participation. Altogether, 81 subjects could be included in the analysis (CONSORT flowchart in Figure 1).

The study was conducted at an Austrian thermal bath (Parktherme Bad Radkersburg, Thermenland Styria) within three different time slots between October 2 and November 27, 2012. Each participant was randomly assigned to one of 24 potential sequences of interventions by a random number generator (RANDOM.ORG—Randomness and Integrity Services Limited GmbH). Each participant completed all four interventions within 2 weeks, with a break of at least 2 days between each intervention. All interventions were carried out in groups of an average of seven subjects (range 3–12 persons). Group allocation for the first three interventions was concealed from participants until premeasurements had been started. Naturally, after completing three interventions, subjects

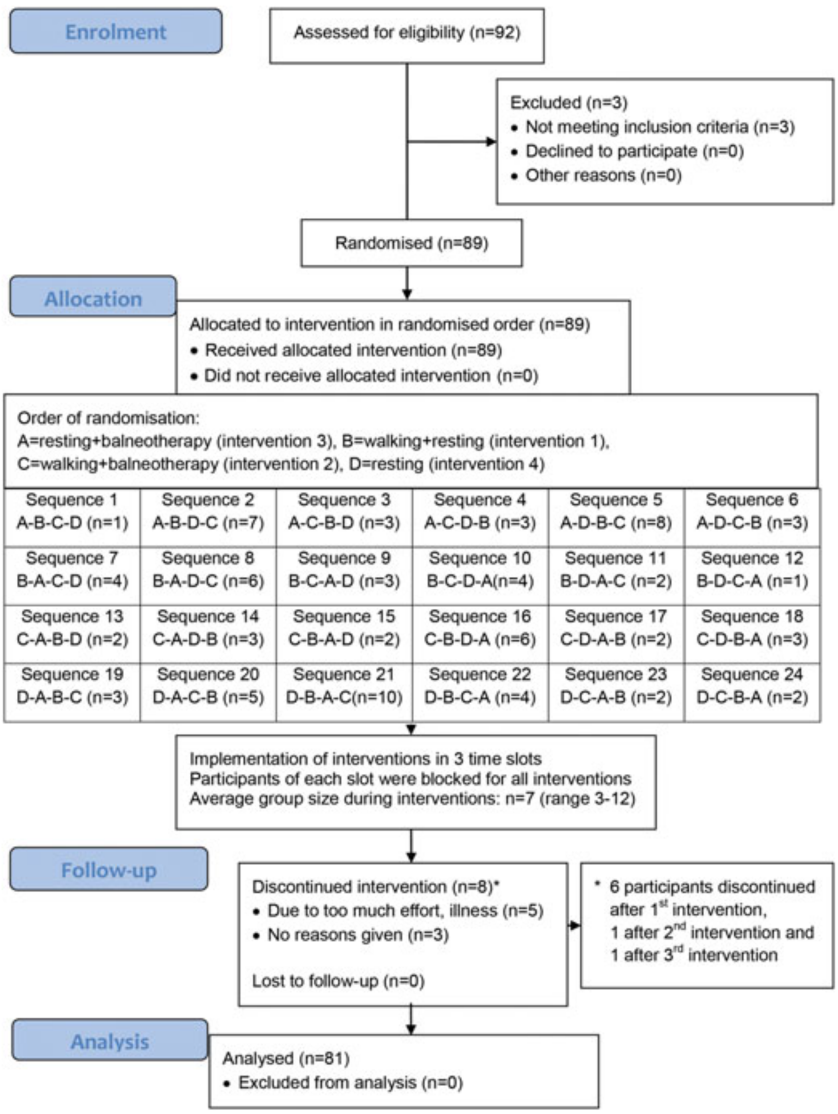

FIGURE 1 Flow of participants through the study

would be aware which type of intervention was still to be administered.

2.3 | Study design and procedure

In a randomized cross-over design, subjects underwent four different interventions for stress reduction; measurements of physiological and psychological stress markers were obtained directly before and after each intervention. We used salivary cortisol as a primary outcome measure; secondary outcome measures were blood pressure, mood, and subjective level of relaxation.

The four stress-relieving interventions included two interventions that combined physical activity and relaxation (1 and 2) and two interventions that consisted of relaxation only (3 and 4): (1) moderate physical activity (walking) combined with resting, (2) moderate physical activity (walking) combined with balneotherapy, (3) combined relaxation (resting and balneotherapy), and (4) resting only (Figure 2).

Each intervention lasted for 1 hr and started at 4:30 p.m. after premeasurements (saliva cortisol, blood pressure, state of mood, and self-reported relaxation). After the interventions at 5:30 p.m., postmeasurements for the same markers followed.

Physical activity entailed a 30-min walk across a preset flat route near the thermal spa at a speed of about 5 to 6 km/h, which was supervised by a Nordic walking instructor. For balneotherapy, an outdoor pool with a water temperature of 36°C was secluded from the normal running of the spa; the foamy, bubbly water inlet, and massage jets were disconnected. The mineral content of the water was characterized by high levels of sodium and hydrogen carbonate and its isotonic concentration. Study participants were instructed to bathe for 20 min without swimming or talking. For resting, subjects were invited to relax in deckchairs. They were instructed not to read, talk, or use any other relaxation techniques. The quiet resting area was separated from the normal running of the spa, and loudspeaker announcements were muted. Participants were instructed and supervised by the study personnel consisting of physicians and clinical psychologists.

Sociodemographic data, lifestyle and health-related factors, and stress levels and bodily complaints were assessed once at study entry. The protocol for this trial and the CONSORT checklist are available as Supporting Information; see S1 CONSORT Checklist and Protocol S1/S2.

2.4 | Measures

2.4.1 | Salivary cortisol

As an objective marker of stress and the relaxation response, we evaluated salivary cortisol levels by enzyme-linked immunosorbent assay. Participants were measured for salivary cortisol levels regularly preintervention and postintervention. They had been instructed not to eat and not to take in caffeine or nicotine 60 min before giving the saliva sample. They were further advised to neither drink alcohol nor exercise heavily up to 1 hr before study participation. Saliva samples were taken using a straw and collected in signed plastic tubes (SALI-TUBES 100, SLV-4158 by DRG Instruments GmbH). Because cortisol secretion follows a circadian rhythm with a morning peak and a constant decline during the day, time and setting for cortisol measurement were kept constant for all groups and study days. Samples for the preintervention measurements of cortisol were taken between 4:10 and 4:30 p.m. and for the postintervention at 5:30 p.m. At that time of day, the usual cortisol decline is only minimal, and changes in the cortisol level can therefore be well attributed to the interventions (Kirschbaum & Hellhammer, 2000). Morning cortisol was used to validate the subdivision of our sample into two separate groups differing in stress levels (high vs. low). For the measurement of morning cortisol, the participants sampled saliva directly at awaking in the morning of the second study day. They had been advised not to brush their teeth or have breakfast before giving their samples.

2.4.2 | Blood pressure

Blood pressure measurements were conducted preintervention and postintervention on each study day. Participants were required to sit quietly for 10 min before blood pressure was taken on their left upper arms using M-400 monitors (HEM-7202-D) manufactured by OMRON Healthcare Europe B.V. Postmeasurements were performed near the pools and resting areas.

2.4.3 | State of mood

The Multidimensional Mood State Questionnaire (Steyer, Schwenkmezger, Notz, & Eid, 1997) is a validated multidimensional measurement for mood. State of mood is defined as an individual's current inner experience and inner perception and can be differentiated from attitudes, needs, and bodily sensations. We administered its short form, which contains 12 items (adjectives) that are rated on a 5-point scale (1 = *absolutely not*, 5 = *very*) and can be completed within a 3-

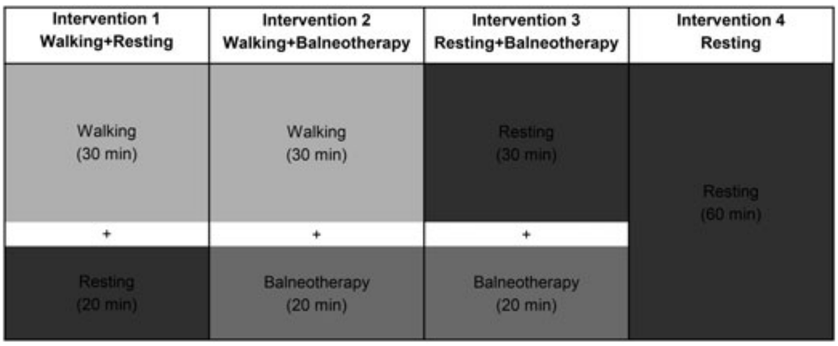

FIGURE 2 Interventions used for stress reduction

min time. Three bipolar dimensions are measured: (1) good mood–bad mood, (2) alertness–tiredness, and (3) calmness–restlessness. Cronbach's alpha for the short version ranges from α = .73 to α = .89.

2.4.4 | Subjective relaxation level

Participants' actual level of subjective relaxation was measured preintervention and postintervention using a rating scale (1–10) with 1 indicating *no relaxation* and 10 indicating *high relaxation*.

2.4.5 | Individual stress levels

These were determined by the Hamburg Burnout Inventory (HBI; Burisch, 2006, 2007) at study entry and validated by the Trier Inventory for the Assessment of Chronic Stress (TICS; Schulz & Schlotz, 1999; Schulz, Schlotz, & Becker, 2004) and the health complaints list by Zerssen (1976). The HBI measures individual risk of burnout: It lists 40 statements pertaining to emotions and situations connected with work and life. Items are rated on a 7-point scale and can be summarized into 10 scales (e.g., emotional exhaustion, helplessness, or inability to relax). The TICS is a questionnaire to evaluate different aspects of chronic stress and includes 57 items. Chronicity of stress is measured by the frequency of stress events perceived retrospectively during the last 3 months; respondents answer on a 5-point scale. The questions can be summarized in nine scales (e.g., work overload, social overload, or pressure to succeed) with an additional chronic stress screening scale. The health complaints list assesses adverse effects caused by bodily and general complaints. Its list consists of 24 items asking for currently perceived general and somatic complaints such as headaches, fatigue, or palpitations.

Two groups with a high versus low stress level were formed on the basis of the HBI results (emotional exhaustion) as suggested by Blasche, Leibetseder, and Marktl (2010): 25 participants (31%) who scored for emotional exhaustion in the quartile of more than 75% were allocated to the high-stress group. This differentiation was validated by the results of the TICS, the health complaints list, and morning saliva cortisol levels. Participants assigned to the “high-stress” group had significantly higher morning cortisol levels ($T = -2.61$; $p = .011$) and suffered from greater bodily complaints ($T = -4.15$, $p < .01$) as measured by the health complaints list. In addition, they reported more chronic stress as they scored significantly higher in 7 out of 10 subscales of the TICS. Finally, basal levels of cortisol and blood pressure before the different interventions were comparable between high- and low-stressed individuals, thus confirming the good health status of our sample. The apparent slightly higher values in the low-stress group (Table 3) did not reach statistical significance ($p > .05$).

2.5 | Statistical analyses

Sample size was calculated by means of the software PASS 2008 by applying a repeated-measures analysis of variance (ANOVA; Edwards, 1993; Mueller & Barton, 1989; Mueller, LaVange, Ramey, & Ramey, 1992) on the basis of a previous pilot study (Matzer et al., 2014). A repeated-measures ANOVA with two within factors (factor W, baseline vs. after treatment; factor V, four different treatments) resulted in a group size of 81 subjects when each subject is measured eight times. The design achieves 0.85% power to test the WV interaction with an effect size of 0.45 at a 5% significance level. As a primary outcome for sample size calculation, we used salivary cortisol with a mean cortisol reduction of 1 ng/ml ($SD = 1.5$).

Statistical analyses were conducted with the software PASW Statistics 18 for Windows. Comparisons between study groups were performed by using two-way ANOVAs for repeated measures. For post hoc comparisons, we used Bonferroni correction for significant main effects. For significant interaction effects, we calculated six singular two-way ANOVAs for repeated measures for all six possible combinations of intervention groups. These post hoc comparisons were done applying Bonferroni–Holm correction. Subgroup analyses for stress levels and their post hoc analyses were conducted the same way, but with differentiated ANOVAs for the particular subgroups. Post hoc comparisons for significant interaction effects among the high- and low-stress groups were done by applying conventional levels of significance ($p < .05$) instead of Bonferroni–Holm correction. Due to the smaller sample sizes of the subgroups, the usage of Bonferroni–Holm correction would have heightened the risk of false-negative results. The differentiation in participants with a high versus low stress level was statistically confirmed by *t* tests for independent samples.

3 | RESULTS

3.1 | Sociodemographic data

The study sample consisted of 81 healthy adults (55 women and 26 men) aged between 30 and 58 years. The mean age was 44 years ($SD = 7.9$). Participants' professions varied, with 18 persons working in the social field (teachers, hospital staff, social workers, and psychologists) and 13 holding a leading position (executive staff and managers) or being self-employed. Regarding health-related sample characteristics, the majority were non-smokers, had an average body mass index according to the World Health Organization definition (mean of 24.9 kg/m^2), and exercised regularly. All sociodemographic- and lifestyle-related variables are summarized in Table 1.

3.2 | Comparison of interventions for stress reduction

Regarding our primary outcome salivary cortisol, no significant difference was found between the different approaches ($F = 1.30$; $p = .281$). Interestingly, with regard to our secondary outcome measures, we found a significant interaction effect for the reduction of systolic blood pressure ($F = 7.34$; $p < .01$, Table 2), favouring methods including physical activity. Combined walking and balneotherapy was associated with a higher decrease of systolic blood pressure from preintervention to postintervention treatment when compared to resting and balneotherapy ($F = 10.720$; $p = .002$) or resting only ($F = 14.498$; $p < .001$). Also combined walking and resting was able to decrease systolic blood pressure better than was resting only ($F = 10.730$; $p = .002$).

All four interventions for stress reduction led to increased relaxation over time, which was reflected in a reduction of salivary cortisol; a decrease of diastolic blood pressure; and an increase in good mood, alertness, calmness, and subjective relaxation.

TABLE 1 Sociodemographic and health-related characteristics of the study sample (*N* = 81)

		Total (%)
Sex	Male Female	26 (32.1) 55 (67.9)
Age	(Mean, SD)	44.4 (7.9)
Nationality	Austria Other	77 (95.1) 4 (4.9)
Life situation	With partner/family Single Single with children Other	66 (81.5) 8 (9.9) 4 (4.9) 3 (3.7)
Marital status	Married/partnership Unmarried Divorced Widowed	52 (64.2) 16 (19.8) 11 (13.6) 1 (1.2)
Level of education	Secondary 2nd stage Postsecondary Higher (university) Secondary 1st stage	37 (45.7) 21 (25.9) 21 (25.9) 2 (2.5)
Extent of work	Full time Part-time	61 (75.3) 19 (23.5)
BMI	18.5–24.99 kg/m^2 25.0–29.99 kg/m^2 ≥30 kg/m^2 <18.5 kg/m^2	48 (59.3) 25 (30.9) 6 (7.4) 1 (1.2)
Physical activity	Regularly None	69 (85.2) 12 (14.8)
Training/month	1–9 days 10–20 days ≥20 days	31 (38.3) 30 (37.0) 9 (11.1)
Training intensity	Moderate Rather exhausting Very exhausting	54 (66.7) 16 (19.8) 4 (4.9)
Smoking behaviour	None Daily Sometimes	69 (85.2) 10 (12.3) 2 (2.5)

Note. BMI = body mass index. SD = Standard Deviation.

One significant group effect was found concerning the dimension alertness/tiredness ($F = 4.70$; $p = .005$): Participants in the "resting-only" group reported more tiredness relative to participants who had combined resting and balneotherapy ($p = .034$); these participants were more tired also prior to resting.

3.3 | Subgroup analyses for participants with high versus low stress levels

In accordance with the main results, we found a significant interaction effect for the reduction of systolic blood pressure for both participants with low ($F = 3.11$; $p = .028$) and high ($F = 4.25$; $p = .008$) stress levels, again favouring interventions including physical activity (Table 3). Concerning their relaxation responses, participants with high and low stress levels differed in the subscale alertness/tiredness for state of mood. Consistent with the main results, also in the "low-stress" group, all four interventions led to increased alertness ($F = 7.25$; $p = .010$, Table 3). In persons with higher stress levels, a significant interaction effect was found for the subscale alertness/tiredness ($F = 3.20$; $p = .044$; Figures 3 and 4). Whereas walking combined with resting even led to increased tiredness, interventions including balneotherapy made highly stressed individuals feel more alert (Walking + Resting vs. Walking + Balneotherapy: $F = 9.917$; $p = .004$; Walking + Resting vs. Resting + Balneotherapy: $F = 7.254$; $p = .013$).

We also found a significant group effect for participants with high stress levels regarding diastolic blood pressure ($F = 3.31$; $p = .025$): Diastolic blood pressure was lower when walking and balneotherapy were combined as compared to resting combined with balneotherapy ($p = .031$).

Regarding all other measures, no relevant differences were found for participants with different stress levels. Summing up, participants with high stress levels had the best relaxation effects when walking was combined with balneotherapy, as after this intervention both a reduction of systolic blood pressure and an increase of alertness could be observed.

4 | DISCUSSION

Although a range of approaches to relaxation and stress reduction are well established, the short-term effects of techniques combining moderate physical activity and relaxation have not been systematically explored. Therefore, on the basis of previous work focusing on relaxation only, we investigated whether combining physical activity and relaxation would be superior to relaxation-only strategies with regard to short-term stress reduction. Our results demonstrated that all four interventions for stress reduction were associated with significant relaxation responses in both physiological and subjective variables. Moreover, in addition to all other beneficial effects found in relaxation-only techniques, undergoing 1 hr of a combined physical activity plus relaxation programme had a positive effect on blood pressure outcomes. A mere inclusion of a 20-min physical activity was sufficient to cause a higher decrease in systolic blood pressure. Such short-term effects produced by physical activity, for example, Nordic walking, have been reported by other research (Tschentscher, Niederseer, & Niebauer, 2013). However, due to our study design, we cannot say whether this additional positive effect was caused by the combination of physical activity and relaxation or if physical activity alone would have produced the same effect and would therefore constitute the determining factor.

The advantages of interventions including physical activity as concerning the lowering of systolic blood pressure were irrespective of participants' initial stress levels. Furthermore, balneotherapy seems to have a specifically activating effect on highly stressed individuals: They felt more awake and rested after 20 min of balneotherapy, irrespective of whether it was combined with walking or a resting period. This may explain why in highly stressed individuals only a combination of walking combined with balneotherapy led to both reduced systolic blood pressure and increased alertness, whereas walking combined with resting made individuals feel more tired. Numerous studies have found a positive impact of balneotherapy on quality of life, mood, physical capacity, relaxation, heart rate, blood pressure, and burnout-specific symptoms (Blasche et al., 2010; Fink, Kalpakcioglu, Bernateck, & Gutenbrunner, 2011; Jacob & Volger, 2009; Karagülle & Karagülle, 2004; Michalsen et al., 2003; Strauss-Blasche, Gnad, Ekmekcioglu, Hladschik, & Marktl, 2005). It could be assumed that a warm environmental temperature as provided by

TABLE 2 Main effects of different interventions for stress reduction ($N = 81$)

		Walking + Resting	Walking + Balneotherapy	Resting + Balneotherapy	Resting only	ANOVA Group	ANOVA Time	ANOVA Group × Time
Cortisol (ng/ml)	Pre	3.0 (2.0)	2.7 (2.3)	3.5 (3.2)	3.3 (2.9)	$F = 1.16$; $p = .331$	$F = 51.43$; $p < .01$**	$F = 1.30$; $p = .281$
	Post	2.2 (2.5)	1.9 (1.4)	2.0 (2.1)	2.2 (2.0)			
	Diff	−0.8 (2.9)	−0.9 (1.8)	−1.5 (2.5)	−1.1 (1.8)			
SBP (mmHg)	Pre	129.0 (15.5)	129.2 (14.6)	128.5 (15.2)	128.6 (15.5)	$F = 2.17$; $p = .098$	$F = 21.74$; $p < .01$**	$F = 7.34^{a}$; $p < .01$**
	Post	124.2 (15.6)	123.5 (14.1)	127.7 (15.6)	128.7 (15.3)			
	Diff	−4.8 (11.2)	−5.7 (8.7)	−0.8 (11.2)	0.1 (10.2)			
DBP (mmHg)	Pre	82.1 (8.6)	81.8 (9.7)	81.4 (10.3)	81.8 (9.4)	$F = 0.24$; $p = .870$	$F = 32.89$; $p < .01$**	$F = 1.55$; $p = .208$
	Post	78.0 (8.8)	78.9 (10.5)	79.8 (9.6)	79.5 (9.2)			
	Diff	−4.1 (6.8)	−2.8 (7.8)	−1.6 (7.5)	−2.3 (7.3)			
MDBF: Good mood/bad mood	Pre	16.8 (2.4)	16.5 (2.8)	16.3 (2.4)	16.1 (3.1)	$F = 1.34$; $p = .268$	$F = 45.61$; $p < .01$**	$F = 1.01$; $p = .392$
	Post	17.8 (1.8)	17.6 (2.1)	17.7 (2.0)	17.4 (2.1)			
	Diff	1.2 (2.8)	1.0 (2.0)	1.4 (2.3)	1.3 (2.8)			
MDBF: Alertness/tiredness	Pre	13.9 (3.7)	13.4 (3.9)	13.9 (3.2)	12.8 (3.9)	$F = 4.70^{b}$; $p = .005$**	$F = 9.88$; $p = .002$**	$F = 1.60$; $p = .197$
	Post	14.3 (3.7)	15.0 (3.1)	15.2 (3.2)	14.0 (4.8)			
	Diff	0.4 (4.0)	1.6 (4.5)	1.3 (3.6)	1.2 (5.4)			
MDBF: Calmness/restlessness	Pre	14.5 (3.2)	13.9 (3.9)	14.3 (3.0)	14.1 (3.6)	$F = 0.63$; $p = .601$	$F = 141.71$; $p < .01$**	$F = 0.64$; $p = .592$
	Post	17.1 (2.3)	17.0 (2.7)	17.2 (2.3)	17.4 (2.5)			
	Diff	2.6 (3.0)	3.0 (3.5)	2.9 (2.9)	3.3 (3.6)			
Subjective relaxation	Pre	5.9 (1.9)	5.6 (2.4)	5.6 (2.1)	5.6 (2.3)	$F = 1.16$; $p = .332$	$F = 168.40$; $p < .01$**	$F = 1.66$; $p = .183$
	Post	8.0 (1.5)	7.8 (1.8)	8.1 (1.5)	8.0 (1.7)			
	Diff	2.1 (2.0)	2.3 (2.6)	2.6 (2.1)	2.5 (2.0)			

Note. ANOVA = analysis of variance; DBP = diastolic blood pressure; MDBF = Multidimensional Mood State Questionnaire; SBP = systolic blood pressure.

[a]Results of six singular two-way ANOVAs for repeated measures using Bonferroni–Holm correction as post hoc comparisons for significant interaction effects: W + R vs. W + B, $F = 0.272$, $p = .603$; W + R vs. R + B, $F = 4.861$, $p = .030$; W + R vs. R, $F = 10.730$, $p = .002^{**}$; W + B vs. R + B, $F = 10.720$, $p = .002^{**}$; W + B vs. R, $F = 14.498$, $p < .001^{**}$; R + B vs. R, $F = 0.308$, $p = .581$.

[b]Results of post hoc comparisons of mean differences using Bonferroni adjustment: W + R vs. W + B, $p = 1.000$; W + R vs. R + B, $p = .054$: W + R vs. R, $p = 1.000$; W + B vs. R + B, $p = .795$; W + B vs. R, $p = .650$; R + B vs. R, $p = .034^{*}$.

**$p < .01$.

TABLE 3 Effects of different interventions for stress reduction for participants with low stress levels ($n = 56$) and high stress levels ($n = 25$)

							ANOVA	ANOVA	ANOVA
	Stress level		Walking + Resting	Walking + Balneotherapy	Resting + Balneotherapy	Resting only	Group	Time	Group × Time
Cortisol (ng/ml)	Low stress	Pre	3.2 (2.2)	2.9 (2.7)	3.3 (3.1)	3.3 (2.6)	$F = 0.53$; $p = .661$	$F = 47.48$; $p < .01$**	$F = 0.83$; $p = .481$
		Post	1.8 (1.1)	1.9 (1.5)	1.8 (1.8)	2.2 (2.0)			
	High stress	Pre	2.8 (1.4)	2.3 (1.2)	3.9 (3.4)	3.4 (3.4)	$F = 1.34$; $p = .269$	$F = 7.23$; $p = .013$*	$F = 2.37$; $p = .077$
		Post	3.2 (4.1)	1.8 (1.1)	2.4 (2.7)	2.2 (2.2)			
SBP (mmHg)	Low stress	Pre	129.3 (16.3)	130.6 (15.3)	129.2 (16.5)	129.0 (16.3)	$F = 0.63$; $p = .596$	$F = 11.66$; $p = .001$**	$F = 3.11^{a}$; $p = .028$*
		Post	125.3 (16.9)	125.3 (14.8)	128.1 (16.7)	129.05 (16.6)			
	High stress	Pre	128.3 (13.8)	126.0 (12.7)	127.0 (12.0)	127.9 (14.0)	$F = 2.92^{b}$; $p = .040$*	$F = 11.28$; $p = .003$**	$F = 4.25^{c}$; $p = .008$**
		Post	121.6 (12.1)	119.4 (11.9)	126.8 (13.1)	127.9 (12.2)			
DBP (mmHg)	Low stress	Pre	82.8 (9.2)	82.7 (9.4)	81.2 (10.5)	81.8 (9.3)	$F = 0.51$; $p = .678$	$F = 20.13$; $p < .01$**	$F = 0.91$; $p = .437$
		Post	79.1 (9.0)	80.2 (11.0)	79.6 (9.8)	79.6 (9.2)			
	High stress	Pre	80.7 (6.8)	79.6 (10.1)	81.8 (10.1)	81.7 (10.0)	$F = 3.31^{d}$; $p = .025$*	$F = 12.58$; $p = .002$**	$F = 1.02$; $p = .391$
		Post	75.6 (8.3)	76.1 (9.0)	80.1 (9.4)	79.2 (9.1)			
MDBF: Good mood/bad mood	Low stress	Pre	17.1 (2.4)	17.1 (2.6)	16.7 (2.3)	16.4 (3.3)	$F = 1.79$; $p = .167$	$F = 24.26$; $p < .01$**	$F = 0.93$; $p = .427$
		Post	18.1 (1.6)	17.9 (2.0)	18.0 (1.9)	17.7 (1.9)			
	High stress	Pre	16.0 (2.4)	15.2 (2.6)	15.5 (2.5)	15.5 (2.5)	$F = 0.35$; $p = .788$	$F = 24.89$; $p < .01$**	$F = 0.93$; $p = .430$
		Post	16.9 (2.0)	17.0 (2.2)	17.2 (2.3)	16.7 (2.3)			
MDBF: Alertness/tiredness	Low stress	Pre	14.0 (4.0)	14.2 (4.2)	14.3 (3.2)	13.1 (4.0)	$F = 2.96^{e}$; $p = .034$*	$F = 7.25$; $p = .010$*	$F = 0.11$; $p = .954$
		Post	14.9 (3.5)	15.4 (3.0)	15.6 (3.2)	14.4 (5.4)			
	High stress	Pre	13.1 (3.1)	11.7 (3.0)	12.9 (2.8)	12.3 (3.7)	$F = 1.21$; $p = .311$	$F = 2.53$; $p = .125$	$F = 3.20^{f}$; $p = .044$*
		Post	12.4 (3.6)	13.8 (3.1)	14.1 (2.9)	13.2 (3.5)			
MDBF: Calmness/restlessness	Low stress	Pre	15.2 (3.0)	14.5 (3.9)	14.9 (2.7)	14.4 (3.6)	$F = 0.75$; $p = .522$	$F = 74.15$; $p < .01$**	$F = 1.19$; $p = .314$
		Post	17.5 (2.3)	17.2 (2.8)	17.5 (2.1)	17.7 (2.3)			
	High stress	Pre	12.8 (3.3)	12.3 (3.5)	12.5 (3.2)	13.2 (3.4)	$F = 0.54$; $p = .658$	$F = 48.99$; $p < .01$**	$F = 0.30$; $p = .827$
		Post	16.1 (2.4)	16.2 (2.4)	16.5 (2.3)	16.5 (2.8)			
Subjective relaxation	Low stress	Pre	6.3 (2.0)	5.9 (2.4)	5.9 (2.0)	5.9 (2.3)	$F = 1.34$; $p = .245$	$F = 96.64$; $p < .01$**	$F = 0.76$; $p = .517$
		Post	8.3 (1.4)	8.0 (1.8)	8.0 (1.7)	8.5 (1.3)			
	High stress	Pre	5.1 (1.5)	4.5 (2.1)	4.8 (2.1)	4.6 (2.2)	$F = 0.88$; $p = .457$	$F = 70.72$; $p < .01$**	$F = 1.61$; $p = .195$
		Post	7.1 (1.4)	1.2 (1.8)	7.9 (1.1)	7.0 (2.0)			

Note. ANOVA = analysis of variance; DBP = diastolic blood pressure; MDBF = Multidimensional Mood State Questionnaire; SBP = systolic blood pressure.

[a]Results of six singular two-way ANOVAs for repeated measures as post hoc comparisons for significant interaction effects: W + R vs. W + B, $F = 0.396$, $p = .532$; W + R vs. R + B, $F = 1.576$, $p = .215$; W + R vs. R, $F = 4.482$, $p = .039^{*}$; W + B vs. R + B, $F = 5.545$, $p = .022^{*}$; W + B vs. R, $F = 8.096$, $p = .006^{**}$; R + B vs. R, $F = 0.366$, $p = .548$.

[b]Results of post hoc comparisons of mean differences using Bonferroni adjustment: W + R vs. W + B, $p = 1.000$; W + R vs. R + B, $p = 1.000$; W + R vs. R, $p = 1.000$; W + B vs. R + B, $p = .102$; W + B vs. R, $p = .114$; R + B vs. R, $p = 1.000$.

[c]Results of six singular two-way ANOVAs for repeated measures as post hoc comparisons for significant interaction effects: W + R vs. W + B, $F = 0.004$, $p = .951$; W + R vs. R + B, $F = 5.302$, $p = .030^{*}$; W + R vs. R, $F = 9.784$, $p = .005^{**}$; W + B vs. R + B, $F = 5.482$, $p = .028^{*}$; W + B vs. R, $F = 7.073$, $p = .014^{*}$; R + B vs. R, $F = 0.004$, $p = .953$.

[d]Results of post hoc comparisons of mean differences using Bonferroni adjustment: W + R vs. W + B, $p = 1.000$; W + R vs. R + B, $p = .074$; W + R vs. R, $p = .664$; W + B vs. R + B, $p = .031^{*}$; W + B vs. R, $p = .525$; R + B vs. R, $p = 1.000$.

[e]Results of post hoc comparisons of mean differences using Bonferroni adjustment: W + R vs. W + B, $p = 1.000$; W + R vs. R + B, $p = .442$; W + R vs. R, $p = 1.000$; W + B vs. R + B, $p = 1.000$; W + B vs. R, $p = .548$; R + B vs. R, $p = .104$.

[f]Results of six singular two-way ANOVAs for repeated measures as post hoc comparisons for significant interaction effects: W + R vs. W + B, $F = 9.917$, $p = .004^{**}$; W + R vs. R + B, $F = 7.254$, $p = .013^{*}$; W + R vs. R, $F = 1.871$, $p = .185$; W + B vs. R + B, $F = 0.938$, $p = .342$; W + B vs. R, $F = 1.123$, $p = .300$; R + B vs. R, $F = 0.095$, $p = .761$.

*$p < .05$.

**$p < .01$.

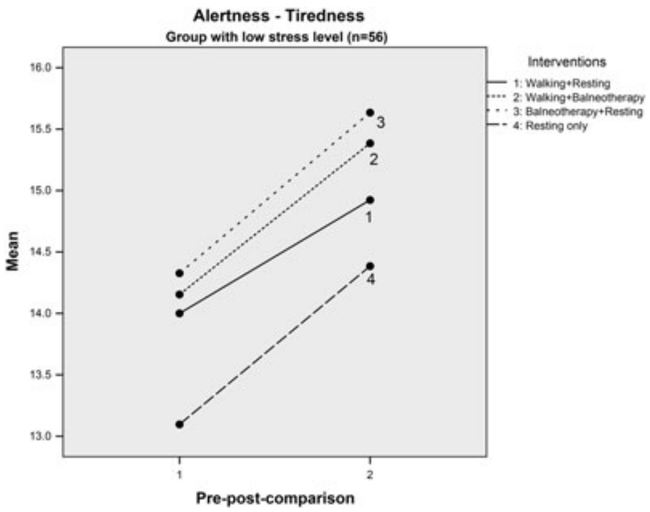

FIGURE 3 Precomparison to postcomparison of alertness in persons with lower stress levels

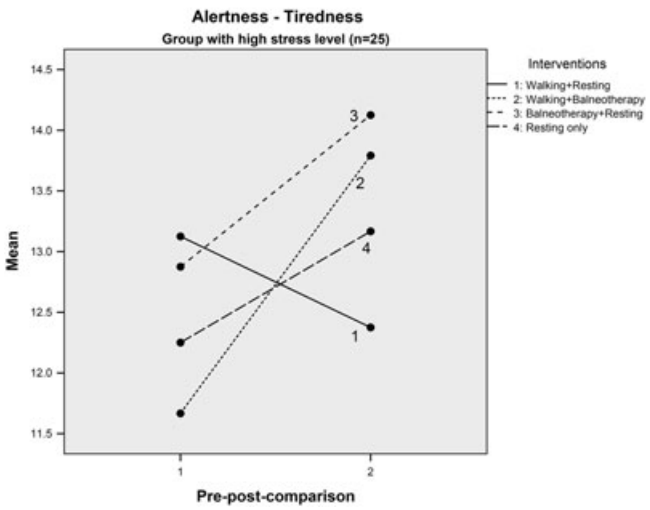

FIGURE 4 Precomparison to postcomparison of alertness in persons with higher stress levels

the balneotherapy setting may facilitate regeneration for highly stressed individuals by reducing the effort of thermoregulation, thus lowering energy expenditure. Alternatively, such immersion bathing could foster regression as a temporary and reversible state of retreat that may be associated with feelings of safety and being cared for (Balint, 1959). This may stimulate parasympathetic arousal and thus impact states of alertness and tiredness.

When physical activity was combined with resting, highly stressed participants felt more tired after treatment. A possible explanation for this outcome is that physical activity—even at this moderate intensity—may be an additional stressor for the chronically stressed organism, which cannot be fully compensated for by the following resting period. In their review, Huang, Webb, Zourdos, and Acevedo (2013) point to the fact that the combination of mental and physical stress results in an exacerbated activation of the sympathoadrenal and hypothalamic pituitary adrenal axes, which ranges above that of a single stressor.

4.1 | Strengths and limitations

To our knowledge, this is the first study to explore the effects of combined stress-reduction methods, which include physical activity and relaxation, by using a randomized cross-over design. To limit the impact of confounding variables on the stress response, we chose a cross-over design, where participants served as their own controls. We assumed that any effects caused by the interventions within this trial did not sustain long enough to influence subsequent interventions and measurements, because intervention time was kept short and participants spent at least 2 days in their everyday routine before the next treatment was implemented. Nevertheless, we randomized the order of interventions, thus controlling for potential long-term effects. The inclusion of subgroup analyses for persons with different stress levels adds relevant information regarding stress management in healthy adults and in those who may be at risk for stress-related diseases. Furthermore, our study results also reveal information on the immediate effectiveness of balneotherapy. This way, our trial expands on previous research that has mainly focused on populations with different disease patterns or on the employment of balneotherapy as a long-term treatment.

Another asset of the study is its relatively high study sample, as suggested by the power calculation. Our trial was implemented in a realistic setting with controlled conditions for the four interventions as described in Section 2. This means, however, that participants were not fully isolated from the routine operation at the thermal bath and that disturbance due to other bathers and noise could have occurred. It is possible that a more experimental setting with fewer distractions would have led to higher relaxation effects and therefore would have generated different results. On the other hand, the chosen realistic setting may contribute to the transferability of our results to everyday life.

The present study has several limitations that warrant discussion. One major limitation of the study that needs to be addressed is both the absence of a treatment entailing only physical activity and a control condition without any particular intervention. We compared the combination of physical activity plus relaxation to relaxation alone but cannot relate our results to a "physical activity alone" condition. As mentioned above, results pertaining to the combined approach are not definitely attributable to the intervention administered. It is also possible that physical activity alone would have produced the same effects. Moreover, we cannot clearly attribute relaxation effects that we observed in all four intervention groups exclusively to the interventions, because there was no control group without any intervention. It is possible that in daily life, relaxation effects can emerge without any specific intervention. Although the study would have benefited greatly from the inclusion of these additional groups, this would have made the chosen cross-over design too complicated, and we therefore decided to conduct the study as described. No doubt, including these two additional groups in a future study would be highly illuminating.

A second limitation of this study arises from the restriction of measurements to preintervention and postintervention without any additional follow-up assessment at a later point. Therefore, we cannot derive any medium- to long-term effects from our results. Nevertheless, it would be interesting to examine if regular application of these interventions over weeks would produce long-term effects on the amount of stress reduction and relaxation. As a final limitation, we have to admit that a possible selection bias of participants with a certain predilection for thermal baths cannot be ruled out.

5 | CONCLUSIONS

In this randomized cross-over trial, novel findings pertaining to stress-relief interventions that combine physical activity and relaxation in healthy adults were obtained, which should be substantiated by future studies. The combination of moderate physical activity and relaxation seems to be an advantageous strategy for short-term stress reduction relative to relaxation-alone techniques. Our data showed that such combined interventions are able to significantly reduce blood pressure while similar levels of relaxation are obtained in all other physiological and psychological measures. These results apply to large parts of the population and may impact health-related decision-making by encouraging individuals to choose such combined methods for stress reduction in their leisure time, even if only limited time for recreation is available.

These results, however, are slightly modulated in persons with high stress levels. Although the blood pressure-lowering effect of physical activity was also prevalent in this subgroup, balneotherapy had an additional positive influence on alertness. Thus, when both physiological and psychological short-term effects are considered, highly stressed individuals seem to especially benefit from physical activity combined with balneotherapy. Therefore, establishing the initial stress state can provide important information that should be considered when designing individualized strategies for stress reduction. However, potential long-term effects of these interventions still need to be explored.

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CONFLICT OF INTEREST

None of the authors declare competing financial or other interests.

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REFERENCES

Balint, M. (1959). *Thrills and regressions*. New York: International Universities Press.

Bansal, A., Mittal, A., & Seth, V. (2016). Osho Dynamic Meditation's effect on serum cortisol levels. *Journal of Clinical and Diagnostic Research*, *10*, 05–08.

Blasche, G., Leibetseder, V., & Marktl, W. (2010). Association of spa therapy with improvement of psychological symptoms of occupational burnout: A pilot study. *Forschende Komplementärmedizin*, *17*, 132–136.

Brotman, D. J., Golden, S. H., & Wittstein, I. S. (2007). The cardiovascular toll of stress. *Lancet*, *370*, 1089–1100.

Brown, D. R., Carroll, D. D., Workman, L. M., Carlson, S. A., & Brown, D. W. (2014). Physical activity and health-related quality of life: US adults with and without limitations. *Quality of Life Research*, *23*, 2673–2680.

Burisch, M. (2006). *Das Burnout-Syndrom: Theorie der inneren Erschöpfung* (3. Aufl ed.). Berlin: Springer.

Burisch, M. (2007). *The Hamburg Burnout Inventory (HBI) in two large international online samples*. Universität Hamburg: Unpublished Technical Report.

Caminti, G., Volterrani, M., Marazzi, G., Cerrito, A., Massaro, R., Sposato, B., … Rosoano, G. (2011). Hydrotherapy added to endurance training versus endurance training alone in elderly patients with chronic heart failure: A randomized pilot study. *International Journal of Cardiology*, *14*, 199–203.

Cohen, S., Janicki-Deverts, D., Doyle, W. J., Miller, G. E., Frank, E., Rabin, B. S., & Turner, R. B. (2012). Chronic stress, glucocorticoid receptor resistance, inflammation, and disease risk. *Proceedings of the National Academy of Science*, *17*, 5995–5999.

Council of the European Union (2013). Council recommendation of 26 November 2013 on promoting health-enhancing physical activity across sectors. 2013/C 354/01.

Creswell, J. D., Pacilio, L. E., Lindsay, E. K., & Brown, K. W. (2014). Brief mindfulness meditation training alters psychological and neuroendocrine responses to social evaluative stress. *Psychoneuroendocrinology*, *44*, 1–12.

vanDyck, D., Teychenne, M., McNaughton, S.A., De Bourdeaudhuij, J., & Salmon, J. (2015). Relationship of the perceived social and physical environment with mental health-related quality of life in middle-aged and older adults: Mediating effects of physical activity. *PloS One*, *10*, e0120475.

Edwards, L. K. (1993). *Applied analysis of variance in behavior sciences*. New York: Marcel Dekker.

Eller, N. H., Netterstrom, B., & Hansen, A. M. (2006). Psychological factors at home and at work and levels of salivary cortisol. *Biological Psychology*, *73*, 280–287.

Falagas, M. E., Zarkadoulia, E., & Rafailidis, P. I. (2009). The therapeutic effect of balneotherapy: Evaluation of the evidence from randomised controlled trials. *International Journal of Clinical Practice*, *63*, 1068–1084.

Filaire, E., Duche, P., Lac, G., & Robert, A. (1996). Saliva cortisol, physical exercise and training: Influences of swimming and handball on cortisol concentrations in women. *European Journal of Applied Physiology*, *74*, 274–278.

Fink, M., Kalpakcioglu, B., Bernateck, M., & Gutenbrunner, C. (2011). Is there evidence for balneotherapy in rheumatic diseases? *Aktuelle Rheumatologie*, *36*, 157–164.

Folkins, C. H., & Sime, W. E. (1981). Physical fitness training and mental health. *American Psychologist*, *36*, 373–389.

Gruzelier, J. H. (2002). A review of the impact of hypnosis, relaxation, guided imagery and individual differences on aspects of immunity and health. *Stress*, *5*, 147–163.

Guezennec, C. Y., Defer, G., Cazorla, G., Sabathier, C., & Lhoste, F. (1986). Plasma renin activity, aldosterone and catecholamine levels when swimming and running. *European Journal of Applied Physiology*, *54*, 632–637.

Hamer, M. (2012). Psychosocial stress and cardiovascular disease risk: The role of physical activity. *Psychosomatic Medicine*, *74*, 896–903.

Hannibal, K. E., & Bishop, M. D. (2014). Chronic stress, cortisol dysfunction, and pain: A psychoneuroendocrine rationale for stress management in pain rehabilitation. *Physical Therapy*, *94*, 1816–1825.

Harzy, T., Ghani, N., Akasbi, N., Bono, W., & Nejjari, C. (2009). Short- and long-term therapeutic effects of thermal mineral waters in knee osteoarthritis: A systematic review of randomized controlled trials. *Clinical Rheumatology*, *28*, 501–507.

Herring, M. P., O'Connor, P. J., & Dishman, R. K. (2010). The effect of exercise training on anxiety symptoms among patients: a systematic review. *Archives of Internal Medicine*, *22*, 321–331.

Hofmann, S. G., Sawyer, A. T., Witt, A. A., & Oh, D. (2010). The effect of mindfulness-based therapy on anxiety and depression: A meta-analytic review. *Journal of Consulting and Clinical Psychology*, *78*, 169–183.

Huang, C.-J., Webb, H. E., Zourdos, M. C., & Acevedo, E. O. (2013). Cardiovascular reactivity, stress and physical activity. *Frontiers in Physiology*, *4*, 1–13.

Inder, W. J., Demeski, G., & Russell, A. (2012). Measurement of salivary cortisol in 2012—Laboratory techniques and clinical indications. *Clinical Endocrinology (Oxford)*, *77*, 645–651.

Jacks, D. E., Sowash, J., Anning, J., McGloughlin, T., & Andres, F. (2002). Effect of exercise at three exercise intensities on salivary cortisol. *Journal of Strength and Conditioning Research*, *16*, 286–289.

Jacob, E.-M., & Volger, E. (2009). Blutdrucksenkung durch Hydrotherapie: Eine randomisierte, kontrollierte Studie bei leichter bis mittelschwerer Hypertonie. *Physikalische Medizin Rehabilitationsmedizin Kurortmedizin*, *19*, 162–168.

Jin, P. (1992). Efficacy of Tai Chi, brisk walking, meditation, and reading in reducing mental and emotional stress. *Journal of Psychosomatic Research*, *36*, 361–370.

Josefsson, T., Lindwall, M., & Archer, T. (2014). Physical exercise intervention in depressive disorders: Meta-analysis and systematic review. *Scandinavian Journal of Medicine and Science in Sports*, *24*, 259–272.

Karagülle, M. Z., & Karagülle, M. (2004). Balneotherapie und Kurorttherapie rheumatischer Erkrankungen in der Türkei: Ein systematischer Review. *Forschende Komplementärmedizin und Klassische Naturheilkunde*, *11*, 33–41.

Khalfa, S., Bella, S. D., Roy, M., Peretz, I., & Lupien, S. J. (2003). Effects of relaxing music on salivary cortisol level after psychological stress. *Annals of the New York Academy of Science*, *999*, 374–376.

Kim, E. Y., Miklowitz, D. J., Biuckians, A., & Mullen, K. (2007). Life stress and the course of early-onset bipolar disorder. *Journal of Affective Disorders*, *99*, 37–44.

Kindermann, W., Schnable, A., Schmitt, W. M., Biro, G., Cassens, J., & Weber, F. (1982). Catecholamines, growth hormone, cortisol, insulin, and sex hormones in anaerobic and aerobic exercise. *European Journal of Applied Physiology*, *49*, 389–399.

Kirschbaum, C., & Hellhammer, D. H. (2000). Salivary cortisol. In G. Fink (Ed.), *Encyclopedia of stress* (pp. 379–383). London: Academic Press.

Matzer, F., Matyas, E., Bahadori, B., Dam, K., & Fazekas, C. (2014). Stress-relieving effects of short-term balneotherapy—A randomized controlled study in healthy adults. *Research in Complementary Medicine*, *21*, 105–110.

Mauss, D., Li, J., Schmidt, B., Angerer, P., & Jarczok, M. N. (2015). Measuring allostatic load in the workforce: A systematic review. *Industrial Health*, *53*, 5–20.

Michalsen, A., Lüdtke, R., Bühring, M., Spahn, G., Langhorst, J., & Dobos, G. J. (2003). Thermal hydrotherapy improves quality of life and hemodynamic function in patients with chronic heart failure. *American Heart Journal*, *146*, 728–733.

Mizuno, K., Tanaka, M., Tajima, K., Okada, N., Rokushima, K., & Watanabe, Y. (2010). Effects of mild-stream bathing on recovery from mental fatigue. *Medical Science Monitor*, *16*, 8–14.

Mueller, K. E., & Barton, C. N. (1989). Approximate power for repeated-measures ANOVA lacking sphericity. *Journal of the American Statistical Association*, *84*, 549–555.

Mueller, K. E., LaVange, L. E., Ramey, S. L., & Ramey, C. T. (1992). Power calculations for general linear multivariate models including repeated measures applications. *Journal of the American Statistical Association*, *87*, 1209–1226.

Mura, G., Cossu, G., Migliaccio, G. M., Atzori, C., Nardi, A., Machado, S., & Carta, M. G. (2014). Quality of life, cortisol blood levels and exercise in older adults: Results of a randomized controlled trial. *Clinical Practice & Epidemiology in Mental Health*, *10*, 67–72.

Nagele, E., Jeitler, K., Horvath, K., Semlitsch, T., Posch, N., Herrmann, K. H., … Siebenhofer, A. (2014). Clinical effectiveness of stress-reduction techniques in patients with hypertension: Systematic review and meta-analysis. *Journal of Hypertension*, *32*, 1936–1944.

Netterstrom, B., & Bech, P. (2010). Effect of a multidisciplinary stress treatment programme on the return to work rate for persons with work-related stress. A non-randomized controlled study from a stress clinic. *BMC Public Health*, *10*, 658.

Nieman, D. C., Henson, D. A., Austin, M. D., & Brown, V. A. (2005). Immune response to a 30-minute walk. *Medicine & Science in Sports & Exercise*, *37*, 57–62.

Pace, T. W., Negi, L. T., Adame, D. D., Cole, S. P., Sivilli, T. I., Brown, T. D., & Raison, C. L. (2009). Effect of compassion meditation on neuroendocrine, innate immune and behavioral responses to psychosocial stress. *Psychoneuroendocrinology*, *34*, 87–98.

Patil, S. G., Dhanakshirur, G. B., Aithala, M. R., Naregal, G., & Das, K. K. (2014). Effect of yoga on oxidative stress in elderly with grade-I hypertension: A randomized controlled study. *Journal of Clinical and Diagnostic Research*, *8*, BC04–BC07.

Pawlow, L. A., & Jones, G. E. (2005). The impact of abbreviated progressive muscle relaxation on salivary cortisol and salivary immunoglobulin A (sIgA). *Applied Psychophysiology and Biofeedback*, *30*, 375–387.

Phelps, J. R. (1987). Physical activity and health maintenance—Exactly what is known? *Western Journal of Medicine*, *146*, 200–206.

Piet, J., Würtzen, H., & Zachariae, R. (2012). The effect of mindfulness-based therapy on symptoms of anxiety and depression in adult cancer patients and survivors: A systematic review and meta-analysis. *Journal of Consulting and Clinical Psychology*, *80*, 1007–1020.

Pruessner, M., Hellhammer, D. H., Pruessner, J. C., & Lupien, S. J. (2003). Self-reported depressive symptoms and stress levels in healthy young men: Associations with the cortisol response to awakening. *Psychosomatic Medicine*, *65*, 92–99.

Santeaella, D. F., Araujo, E. A., Ortega, K. C., Tinucci, T., Mion, D., Negrao, C. E., & de Moraes Forjaz, C. L. (2006). Aftereffects of exercise and relaxation on blood pressure. *Clinical Journal of Sport Medicine*, *16*, 341–347.

Schedlowski, M., & Tewes, U. (Eds) (1996). *Psychoneuroimmunologie*. Spektrum Akademischer Verlag: Heidelberg.

Schulz, P., & Schlotz, W. (1999). Trierer Inventar zur Erfassung von chronischem Streß (TICS): Skalenkonstruktion, teststatistische Überprüfung und Validierung der Skala Arbeitsüberlastung. *Diagnostica*, *45*, 8–19.

Schulz, P., Schlotz, W., & Becker, P. (2004). *Trierer Inventar zum chronischen Stress (TICS)*. Göttingen: Hogrefe.

Semlitsch, T., Jeitler, K., Hemkens, L. G., Horvath, K., Nagele, E., Schuermann, C., … Siebenhofer, A. (2013). Increasing physical activity for the treatment of hypertension: A systematic review and meta-analysis. *Sports Medicine*, *43*, 1009–1023.

Spruill, T. M. (2010). Chronic psychosocial stress and hypertension. *Current Hypertension Reports*, *12*, 10–16.

Steyer, R., Schwenkmezger, P., Notz, P., & Eid, M. (1997). *Der Mehrdimensionale Befindlichkeitsfragebogen (MDBF). Handanweisung*. Göttingen: Hogrefe.

Strauss-Blasche, G., Gnad, E., Ekmekcioglu, C., Hladschik, B., & Marktl, W. (2005). Combined inpatient rehabilitation and spa therapy for breast cancer patients: Effects on quality of life and CA 15-3. *Cancer Nursing*, *28*, 390–398.

Sugano, A., & Nomura, T. (2000). Influence of water exercise and land stretching on salivary cortisol concentrations and anxiety in chronic low back pain patients. *Journal of Physiological Anthropology and Applied Human Science*, *19*, 175–180.

Toda, M., Morimoto, K., Nagasawa, S., & Kitamura, K. (2006). Change in salivary physiological stress markers by spa bathing. *Biomedical Research-Tokyo*, *27*, 11–14.

Trapp, M., Miggitsch, E. M., Egger, J. W., Richtig, E., Wurst, L., Magometschnigg, D., & Schwaberger, G. (2009). Körperliche Aktivität als Resilienzfaktor. *Psychologische Medizin*, *20*, 9–16.

Tschentscher, M., Niederseer, D., & Niebauer, J. (2013). Health benefits of Nordic walking: A systematic review. *American Journal of Preventive Medicine*, *44*, 76–84.

Ushakov, A. V., Ivanchenko, V. S., & Gagarina, A. A. (2016). Psychological stress in the pathogenesis of essential hypertension. *Current Hypertension Reviews*, *30*. [Epub ahead of print]

VanBruggen, M. D., Hackney, A. C., McMurray, R. G., & Ondrak, K. S. (2011). The relationship between serum and salivary cortisol levels in response to different intensities of exercise. *International Journal of Sports Physiology and Performance*, *6*, 396–407.

Yan, L. L., Liu, K., Matthews, K. A., Daviglus, M. L., Ferguson, T. F., & Kiefe, C. I. (2003). Psychosocial factors and risk of hypertension: The Coronary Artery Risk Development in Young Adults (CARDIA) study. *JAMA*, *290*, 2138–2148.

Zerssen, D. v. (1976). *Die Beschwerden-Liste - Manual*. Beltz Test GmbH: Weinheim.

SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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