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Increase of Heart Rate Variation and Well-Being After External Cold Water Application

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Key-words: Autonomic nervous system – heart rate variation – respiratory frequency – thermoregulatory response – cold – physiotherapy.

Summary: In physiotherapy external applications of cold water are established to be effective in the prevention and treatment of many diseases. We tried to improve our understanding of this phenomenon by investigating thermoregulatory and cardiorespiratory responses after mild cold stress.
The examination was carried out in 12 healthy male caucasians (age 24 to 47 years). Heart rate fluctuations were recorded before and after application of thoracic cold wet sheet packs (randomized cross-over trial, control with thoracic dry sheet packs). The degree of sinus arrhythmia was determined by the mean successive difference of beat-to-beat intervals and the mean respiratory sinus arrhythmia double amplitude. Before and after treatment well-being was estimated on a graded eleven-point scale, ranging from completely exhausted to totally refreshed.
With thoracic cold wet sheet packs significant increases of mean successive difference and respiratory sinus arrhythmia double amplitude were found after 20 and 30 min. After 60 min both parameters showed base line values. Improvement of well being score was significantly better with cold wet sheet packs.
Our results suggest that cardiac parasympathetic activity temporarily increases after an external cold water application. This seems to be followed by enhanced regeneration, thereby enabling the described changes of well-being.

Introduction

Being involved in an effort to improve our understanding of the effectiveness of natural remedies and hydrotherapy, we report in this article on physiological changes after application of cold wet sheet packs. On the one hand, external cold water applications are certainly quite unspecific, but they are, on the other hand, very beneficial in the prevention and treatment of many diseases (1, 2, 3), and furthermore helpful in the development of physiological toughness, thereby increasing physical and mental health (4).
Heart rate, respiratory frequency and skin temperature can be regarded as standard variables of physiological research. Additional information is derived from analysis of heart rate variation. Respiratory sinus arrhythmia (RSA), its major component, represents that cyclic variation of beat-to-beat intervals, which is entrained to respiration (5, 6, 7): and currently RSA amplitude, as well as related statistical descriptives, are often used as indicators of cardiac parasympathetic activity (8, 9, 10, 11). Figure 1 gives an example of a one minute recording. Longer registrations additionally show modulations by

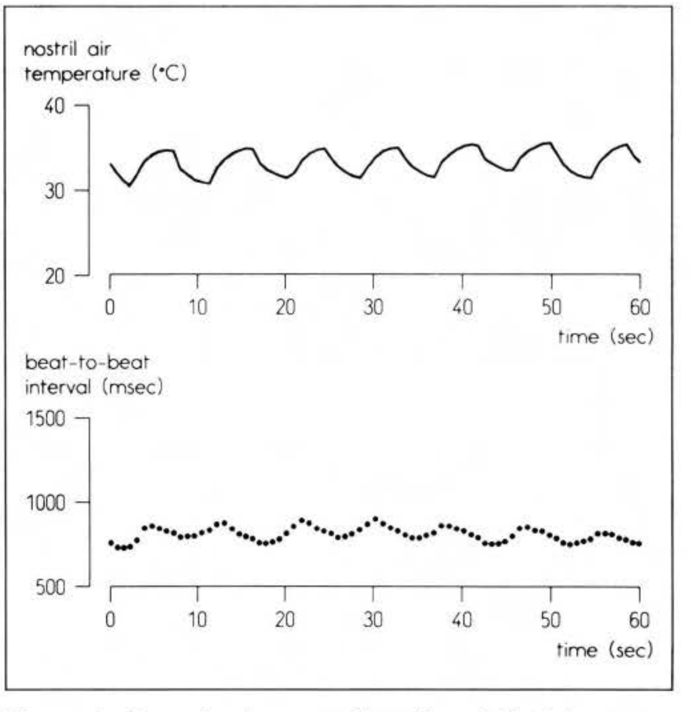

Figure 1. One minute recording of nostril air temperature (indicating the rhythm of respiration) and cardiac beat-to-beat intervals.

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slower rhythms (12, 13, 14), as well as instantaneous and delayed responses after exposure to or application of environmental factors (15, 16, 17, 18). Effects of therapeutic cold water applications on heart rate variation and respiratory sinus arrhythmia, however, have not yet been reported.

Subjects and Methods

From August 1990 to January 1991 12 healthy male volunteers were examined in a randomized crossover trial (for anthropometric data see Table 1). Night workers were excluded, and tiring activities as well as coffee, alcoholic beverages and tobacco products were forbidden for 4 hours before examination.

Data were recorded in supine position before and after application of thoracic cold wet or dry sheet packs (application according to [19], water temperature 16 to 17 °C, starting time 14.00 o'clock, after lunch). From the fifteenth minute before till the sixtieth minute after application of thoracic packs, every 4 to 10 min cardiac beat-to-beat intervals and nostril air temperatures (indicating the rhythm of respiration) were recorded simultaneously for one minute each, using a cardiotachometer (Epicon, Munich, Germany) and a thermosensor (ditto). Subclavicular skin temperatures were measured continuously with a second thermosensor (Simonsen & Weel, Albertslund, Denmark). Before and after treatment estimations of well-being were requested to be marked on a graded eleven-point scale, ranging from completely exhausted to totally refreshed.

Evaluation was done on an IBM-compatible personal computer. The degree of sinus arrhythmia was determined by the mean successive difference of beat-to-beat intervals, earlier described by *Eckoldt* et al. (20), and the mean respiratory sinus arrhythmia double amplitude, calculated automatically by a modified peak-trough method (21). Fourier transformations have not yet been done. Statistics were computed with SPSS/PC$^+$ Software (SPSS Inc., Chicago, USA).

Results

Time courses of respiratory frequency, respiratory sinus arrhythmia double amplitude, mean successive difference and subclavicular skin temperature are depicted in Figures 2 and 3. After application of

Table 1. Anthropometric data of twelve healthy male caucasians.

---	age (yrs)	weight (kg)	height (cm)
Median	29.5	74.5	182.0
Range	24 - 47	54.0 - 103.0	170.0 - 198.0

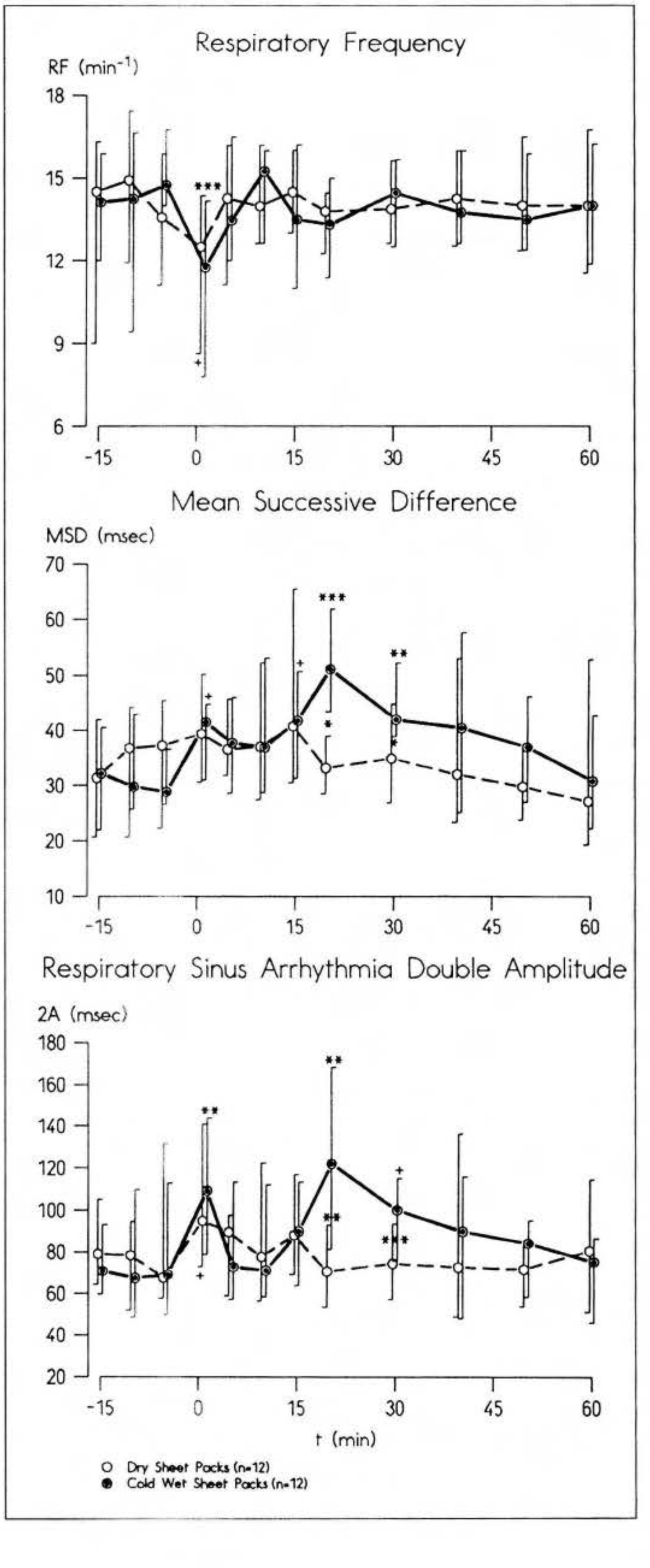
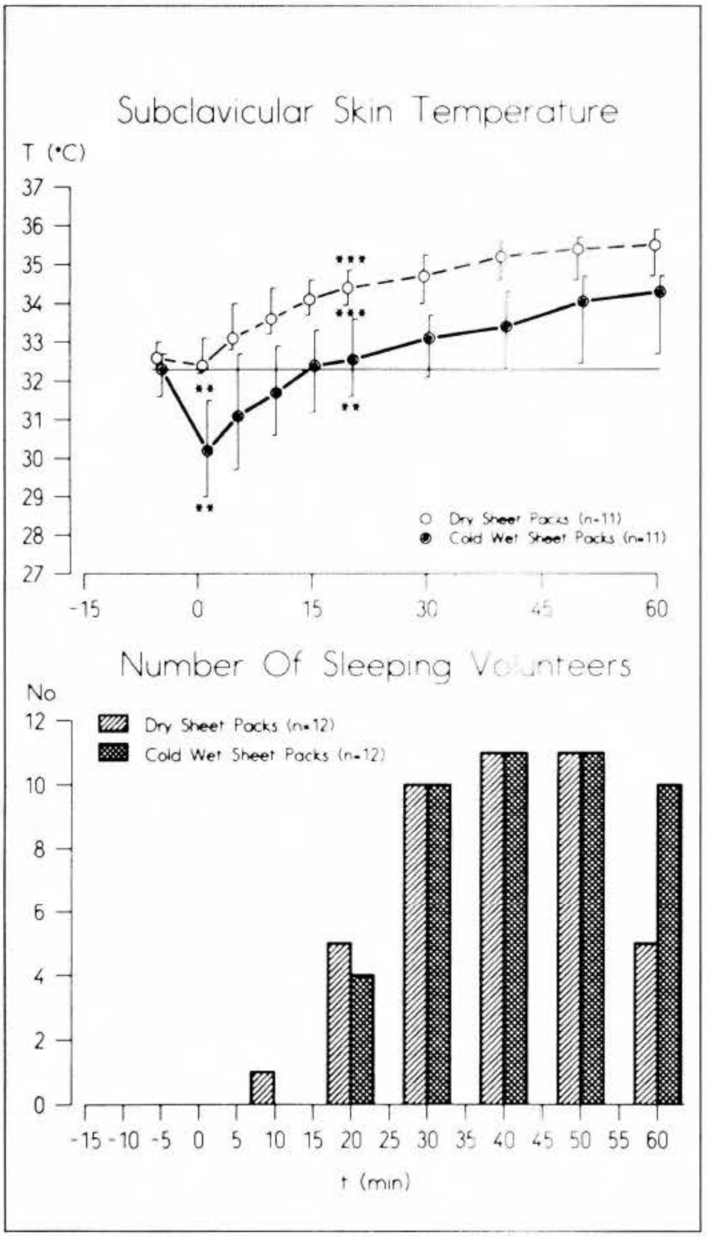


Figure 2. Time courses of respiratory frequency, mean successive difference and respiratory sinus arrhythmia double amplitude before and after application of thoracic packs. Medians, quartiles. Asterisks at the lower quartiles indicate significant differences vs. the fifth minute before dry sheet packs, at the upper quartiles vs. the fifth minute before cold wet sheet packs.

Between medians group differences are indicated (cold wet vs. dry sheet packs).

Wilcoxon's matched-pairs signed-ranks test. $^+2\ p \leq 0.1$, $*\ 2\ p \leq 0.05$, $**\ 2\ p \leq 0.025$, $***\ 2\ p \leq 0.01$.



thoracic cold wet sheet packs, initially, respiratory frequency, heart rate and subclavicular skin temperature decreased, respiratory sinus arrhythmia double amplitude and mean successive difference (the latter with 2p = 0.0844 only) increased significantly. In the following minutes respiratory frequency, respiratory sinus arrhythmia double amplitude, mean successive difference and subclavicular skin temperature returned to base line values, heart rate continued declining slightly. No significant group differences (cold wet vs. dry sheet packs) were found in respiratory frequency, heart rate, respiratory sinus arrhythmia double amplitude and mean successive difference up to the fifteenth minute. But 20 and 30 min after application of thoracic packs, respiratory sinus arrhythmia double amplitude and mean successive difference increased significantly, for a second time, with cold wet sheet packs only. At this time, respiratory frequency and heart rate remained unchanged. Table 2 summarizes the results.

Coinciding with the second increase of respiratory sinus arrhythmia double amplitude and mean successive difference, subclavicular skin temperature rose above base line values. In addition drowsiness set in at that time, and after about 30 min, most subjects slept (Fig. 3). Although, no group differences were

Figure 3. Time courses of subclavicular skin temperature and the number of sleeping volunteers before and after application of thoracic packs. Medians, quartiles. Asterisks at the upper quartiles indicate significant differences vs. the fifth minute before dry sheet packs, at the lower quartiles vs. the fifth minute before cold wet sheet packs. Between medians group differences are indicated (cold wet vs. dry sheet packs).
Wilcoxon's matched-pairs signed-ranks test. $^{+}2\ p \leq 0.1$, $*\ 2\ p \leq 0.05$, $**\ 2\ p \leq 0.025$, $***\ 2\ p \leq 0.01$.

Table 2. Respiratory frequencies (RF), heart rates (HR), mean successive differences (MSD) and double amplitudes (2A) of respiratory sinus arrhythmia 5 minutes before and 20 as well as 30 minutes after application of dry (DSP) and cold wet sheet packs (CWSP). Medians, Wilcoxon's matched-pairs signed-ranks test, within DSP and CWSP subgroups asterisks indicate significant differences vs. 5th minute before application of DSP/CWSP ($^{+}2\ p \leq 0.1$, $*\ 2\ p \leq 0.05$, $**\ 2\ p \leq 0.025$, $***\ 2\ p \leq 0.01$).

	5th minute before DSP/CWSP			20th minute after DSP/CWSP			30th minute after DSP/CWSP		
Variable	**DSP**	**CWSP**	**DSP vs. CWSP**	**DSP**	**CWSP**	**DSP vs. CWSP**	**DSP**	**CWSP**	**DSP vs. CWSP**
RF (breaths/min)	13.6	14.8	2p>0.1000	13.8	13.3	2p>0.1000	13.9	14.5	2p>0.1000
HR (beats/min)	62.5	63.1	2p>0.1000	58.6**	58.3**	2p>0.1000	59.1	60.9***	2p>0.1000
MSD (msec)	37.2	28.9	2p>0.1000	33.1	51.1***	2p=0.0342	34.8	41.9**	2p=0.0414
2A (msec)	67.8	69.2	2p>0.1000	70.8	122.1**	2p=0.0150	74.5	100.2+	2p=0.0022

found in the number of sleeping volunteers, quality of sleep was apparently different and well-being score improved significantly more after thoracic cold wet sheet packs (Median + 3.0 vs. + 1.0 [Fig. 4]).

Discussion

With acute cold stress, an initial reduction of respiratory frequency has been known for a long time (22). We also observed this phenomenon after application of cold wet sheet packs; however, similar changes were found with dry sheet packs, suggesting an additional effect of the arousal reaction (23), induced by our manipulations.

Changes of heart rate with acute cold stress primarily depend on the site of application (24, 25): Increases have been reported with the cold hand test, but decreases with the cold face test (26); 1 min head-out immersions in cold water produced increases of heart rate and decreases of mean successive difference (27). After application of thoracic cold wet sheet packs, we found an initial decrease of heart rate, but no group differences (cold wet vs. dry sheet packs), indicating absence of immediate effects of thoracic cold wet sheet packs on heart rate. Even mean successive difference and respiratory sinus arrhythmia double amplitude showed similar time courses in the first 10 min of cold wet or dry sheet packs, increasing with lower respiratory frequency and heart rate, as described by *Hirsch, Bishop* (6) and *Schlomka* (28) respectively.

In contradistinction, the second increase of mean successive difference and respiratory sinus arrhythmia double amplitude, 20 min after application of cold wet sheet packs, can neither be explained on the basis of similar changes under control conditions, nor in reference to decreases of respiratory frequency or heart rate. Instead, the time courses suggest an interaction with thermoregulation: After application of thoracic cold wet sheet packs, thoraco-cutaneous vasoconstriction diminishes at the time of subclavicular skin temperature renormalization (29). Subsequently, vasodilatation starts at the time of subclavicular skin temperature rise above base line values (29); and the switch in thermoregulation apparently triggers an increase in cardiac parasympathetic activity.

Relevance of our findings can be derived from recently published evidence, suggesting that heart rate variation at rest also reflects sufficiency or lack of regenerative capacity (30). This concept additionally provides a natural explanation for the described improvement of well-being after application of thoracic cold wet sheet packs.

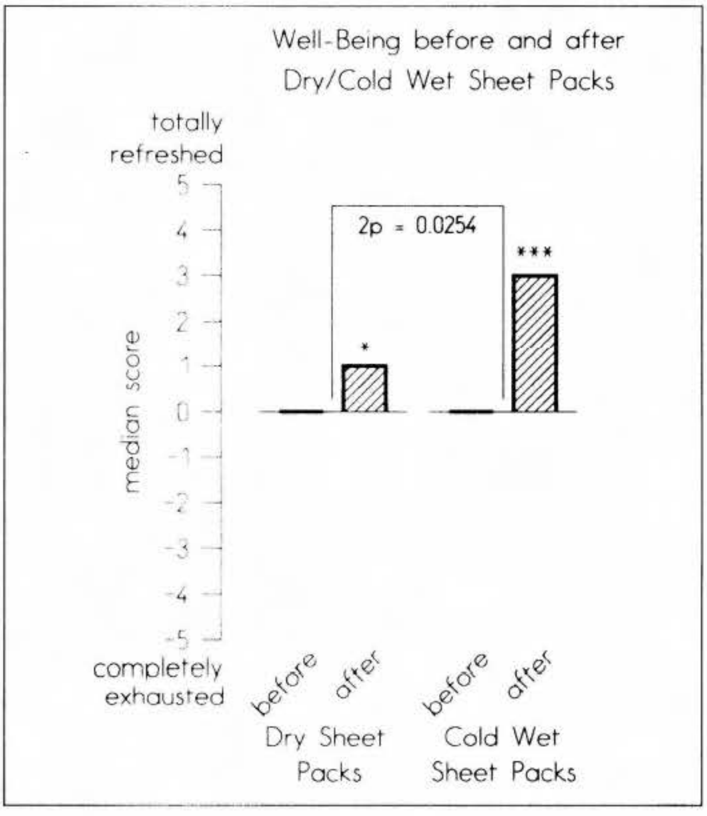


Figure 4. Well-being score at about 20 min before and 65 min after application of thoracic packs. Medians. Asterisks indicate significant differences in the time course.

Wilcoxon's matched-pairs signed-ranks test, $^{+}2\ p \le 0.1$, $*\ 2\ p \le 0.05$, $**\ 2\ p \le 0.025$, $***\ 2\ p \le 0.01$.

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Literature Review

Brief literature extracts

This section is a regular feature of our journal. Its aim is to report on studies in physical medicine and rehabilitation (PMR) which recently appeared in accepted journals which are not specialized in PMR. This is meant to be of service to those of our readers who have no regular access to medical libraries and thus might have missed what was printed in the N Engl J Med, Lancet, Ann Int Med, JAMA, Br Med J, etc.
We invite all our readers to contribute to these columns. All contributions should be short (max. 2 typed pages) and contain the main findings of the study followed by a brief comment on the importance, relevance, strength or shortcomings of the particular study.

Smoking causes disc degeneration

The objective of this study was to determine whether disc degeneration, as assessed through magnetic resonance imaging, is greater in smokers than in nonsmokers. To control for the maximum number of potentially confounding variables, pairs of identical twins discordant for cigarette smoking were selected as subjects. Data analyses revealed 18% greater mean disc degeneration scores in the lumbar spines of smokers as compared with nonsmokers. The difference was present across the entire lumbar spine, suggesting a mechanism acting systemically.

Battie MC, Videman T, Gill K, et al: Smoking and lumbar intervertebral disc degeneration, an MRI study of identical twins. Spine 1991;16:1015-1021.

Commentary: At several occasions our Journal has already emphasized the importance of risk factor research for vertebral problems. The data available so far clearly show a strong and consistent association between smoking habits and back pain. Yet the nature of this association was left open to speculation. Is it causal or is it related to other unhealthy life style variables? The present study implies the former. It is an excellent example of a well conducted study. It is exemplary in selecting a control group where all possible confounders were controlled for. Therefore only smoking can explain the relatively higher degree of disc degeneration in the smoking group. To be entirely sure, one should now investigate the mechanism by which smoking harms the disc.

E. Ernst, Vienna

Handicap after stroke

2 to 7 years after their first stroke, 328 survivors from the Oxfordshire Community Stroke Project' register were assessed for disability. Patients were classified as being either mobile or immobile. Of the 190 immobile patients, only 60 could be entered into a trial of physiotherapy. The major causes of attrition were refusal to participate and the absence of impairment causing immobility. Arthritis and dementia were common in patients with mobility disability. Immobile patients were older and had suffered a more severe stroke.

Collen FM, Wade DT: Residual mobility problems after stroke. Int Disabil Stud 1991;13:12-15.

Commentary: The literature is not entirely clear about how many survivors of a stroke will be able to walk again. Figures range from an optimistic 80% to a bleak 50%. This study shows a relatively low frequency of long-term immobility following stroke directly due to stroke impairments. Non-stroke related causes were frequent; 35% had arthritis affecting mobility. Dementia caused mobility problems in 26%. The authors of this study suggest that these 2 entities may complicate or prevent physiotherapeutic rehabilitation of stroke survivors. The study clearly emphasizes the need for more research into stroke rehabilitation.

E. Ernst, Vienna