

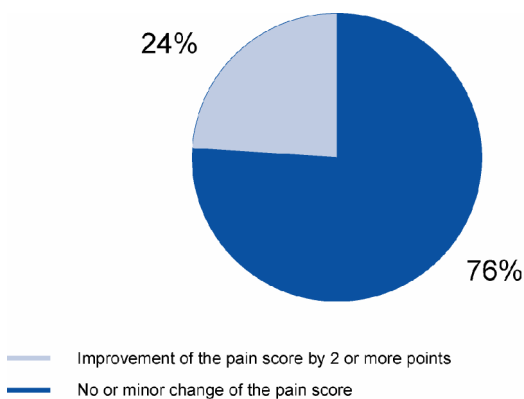
Studies on Whole-body Cryotherapy

WHOLE-BODY CRYOTHERAPY IN INFLAMMATORY AND NON-INFLAMMATORY RHEUMATIC DISEASES

D. KARGUS, K. BLUM, T. TÄUBER, J. TEUBER, BAYREUTH

Since 1999, our clinic is equipped with a whole-body cryochamber which is used to combat rheumatic disorders. The cryochamber design is a two-chamber system consisting of an antechamber with a temperature of approx. -60°C and a main chamber with a temperature of about -110°C . Patients change into bathing costume, trainers, gloves, nose mask and headband when they enter the chamber. At first, they stay in the antechamber for 1 minute, then they proceed to the main chamber with a temperature of -110°C where they keep moving for up to 3 minutes. After the first year of operation, the gathered data were critically evaluated to take stock.

PATIENT PAIN SCORE IN FIBROMYALGIA WITH CRYOTHERAPY (N=42)



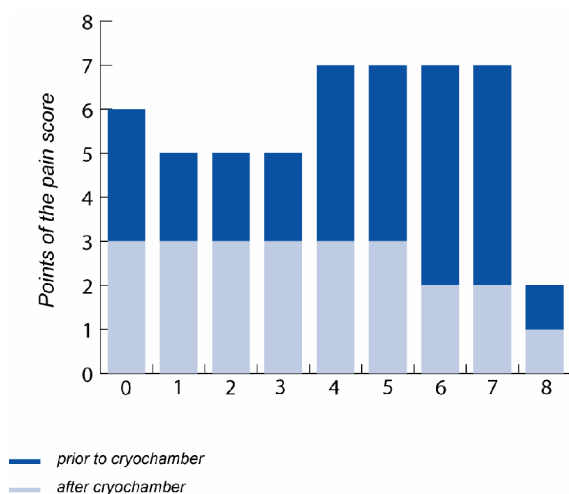
89 of our patients underwent whole-body cryotherapy for ten times. Prior to treatment and after 10 minutes of application, patients were interviewed and examined, and laboratory diagnosis was established. 42 patients suffered from fibromyalgia, 47 from an inflammatory rheumatic disorder (38 from a rheumatoid arthritis, 9 from Bechterew's disease). Patients with rheumatic arthritis and fibromyalgia met the American College of Rheumatology (ACR) criteria for the classification and diagnosis of fibromyalgia and rheumatic arthritis. Patients with Bechterew's disease were diagnosed according to the modified New York criteria.

In patients with fibromyalgia, the age span ranged from 28-73 years (with an average age of 53.05 years). The share of female patients dominated by a ratio of 35 female to 7 male patients. The mean age of patients with inflammatory rheumatic disorders was 53.37 years with ages ranging from 21 – 79 years. In this case, too, female patients were in the majority with a ratio of 24 female vs. 14 male patients. 9 patients with Bechterew's disease were examined with ages ranging from 46 – 68 years. The mean age was 54.25 years; in this case, the number of male patients dominated with a ratio of 7 male vs. 2 female patients.

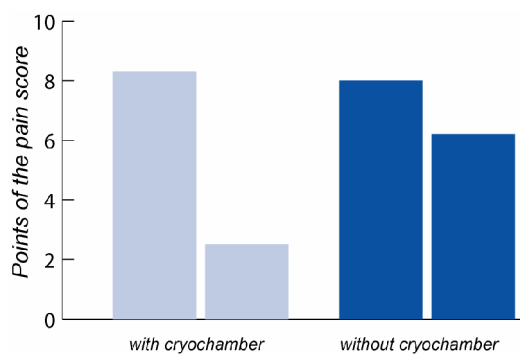
The control group was made up of patients for whom whole-body cryotherapy was contra-indicated or who rejected this therapy form from the start. Severe coronary heart disease, arterial occlusive disease, arterial hypertension, Raynaud disease symptoms, congestive heart failure or claustrophobia are considered a contra-indication. The patient pain score (PPS) was used as a control parameter for all three diseases.

Pain was rated according to a 0 – 10-point numerical scale (0= no pain, 10 = worst pain). In the case of rheumatic arthritis, the following criteria were additionally assessed: C-reactive protein (CRP), morning stiffness and number of swollen joints; additionally, blood sedimentation rate (BSR) as well as the stress hormones prolactine and cortisol were determined in the laboratory. No significant differences were found so that these parameters were no longer taken into consideration.

PATIENT PAIN SCORE FOR BECHTEREW'S DISEASE BEFORE AND AFTER CRYOTHERAPIE (N=9)



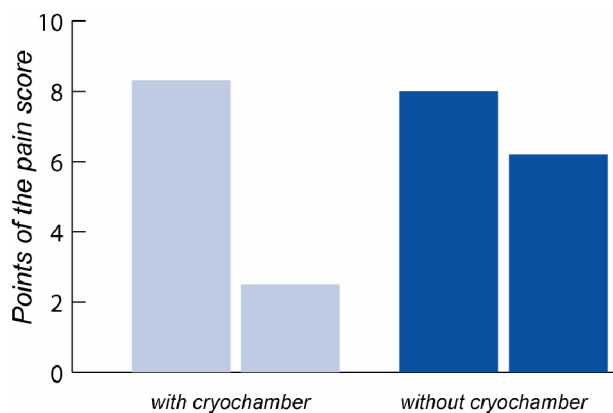
PATIENT PAIN SCORE IN PATIENTS WITH RHEUMATIC ARTHRITIS



In the case of fibromyalgia, cryochamber treatment had a positive effect on the pain score of 10 patients (7 female, 3 male). As a result, the pain score was reduced by 2 or more points thus

improving the pain intensity by reducing the pain. This is an improvement of 24% (refer to Fig. 1). In the remaining 32 cases, a relevant change of diagnosis occurred.

NUMBER OF SWOLLEN JOINTS IN PATIENTS WITH RHEUMATIC ARTHRITIS



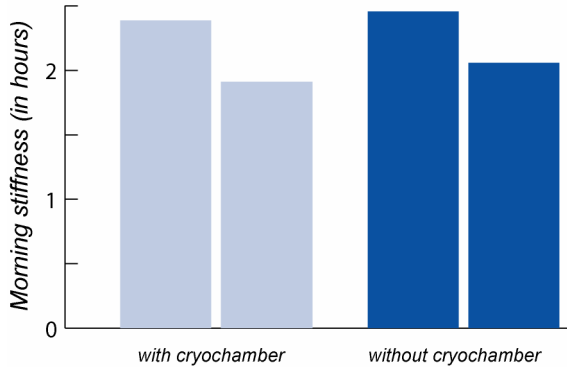
In some female patients, whole-body cryotherapy even had to be aborted due to increased pain intensity.

A diffuse increase of pain in the locomotor system which the patients were not able to localize to a specific area was reported as the main cause for therapy failure. A successful response to cryochamber treatment lead to a pain reduction of several hours. 4 of the female patients reported that they had been free of pain for several hours (up to a maximum of 5 hours) after systematic cold therapy for the first time. The need for analgesics (mainly NSAR and Tramadol) could therefore significantly be reduced by 30% as compared to the control group. When there is a positive response to whole-body cryotherapy, the number of positive tender points and also the pain produced upon pressing these points decreases. The number of positive tender points prior to treatment did not influence the result.

For Bechterew's disease, a significant improvement of the pain score occurred in 9 patients with the numerical value decreasing by 2 (or more) points (refer to Fig. 2).

The progress of the inflammation parameters (BSR and CRP) showed no significant change. In this case, too, the need for analgesics could be reduced by 30% as compared to medication prior to cold chamber treatment. Without whole-body cold therapy, no improvement of the pain intensity could be obtained.

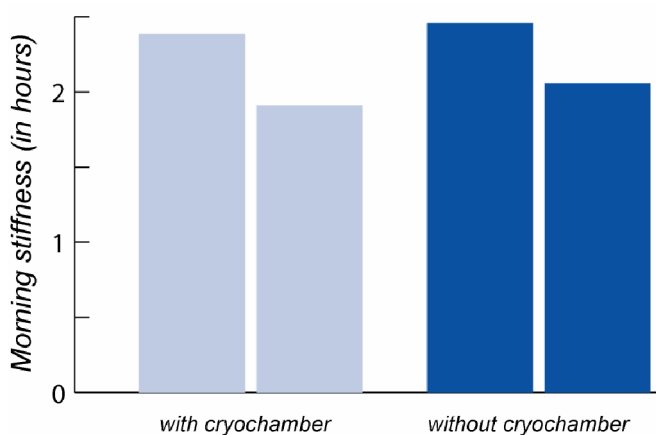
PROGRESSION OF MORNING STIFFNESS (IN HOURS) IN PATIENTS WITH RHEUMATIC ARTHRITIS



In 23 out of 32 patients with rheumatic arthritis pain was significantly relieved (visual pain score) due to systematic cryotherapy (refer to Fig. 3). As the majority of the patients was having an acute attack of disease, administration of a systemic corticoid therapy was indispensable. On average, a reduction of the cortison dose of about 10 mg Prednisolon was obtained in patients with cold therapy. In the further course of the treatment, the need for steroids could be reduced earlier than in the control group. Several patients (both with and without cold chamber treatment) were stabilized on basic therapy. As expected, the basic therapy itself had no effect on the outcome of the treatment. Concerning the number of swollen joints there was in part a significant improvement under cold therapy (refer to Fig. 4).

A visible success could be observed especially in young patients with the outbreak of rheumatic arthritis having started max. 1 year ago. Only a slight effect could be observed in older patients or after a long-term chronic disease. A similar effect of whole-body cold therapy was observed for morning stiffness where a remarkable improvement was detected especially in cases with acute inflammatory attacks (see Fig. 5).

CRP MG/L PROGRESSION (MEAN VALUE)
IN RHEUMATIC ARTHRITIS





Although the blood sedimentation rate had not been significantly affected, a decrease in C-reactive protein could be observed in almost all patients (refer to Fig. 6). This success was especially obvious in patients who were having an acute attack of the disease.

In general it can be stated that in 25% of patients treated for a diffuse fibromyalgia, pain was alleviated following systemic whole-body cold therapy. If the therapy was successful, significant pain reduction or freedom from pain occasionally occurred for several hours. After termination of the treatment, patients reported that they could deal with pain better than before the therapy. Patients with Bechterew's disease who benefited from whole-body cold therapy or, besides pain relief, had observed an enhanced overall musculoskeletal movement also improved emotionally by developing the awareness that the found therapy allowed them to cope with their disease without the risk of side effects.

The positive effect of whole-body cold therapy on morning stiffness, proportion of swollen joints, C-reactive protein and visual pain score in rheumatic arthritis proved this therapy form to be a successful treatment against acute attack symptoms or at the beginning of a disease.

In summary, it can be ascertained that whole-body cold therapy is a causal and reasonable supplement of the therapy spectrum to combat fibromyalgia, Bechterew's disease and rheumatic arthritis. Due to the fast subjective and objective onset of the therapy effect especially for severe pain symptoms it is necessary to consider use of this treatment. Cold chamber therapy not only alleviates pain but also reduces medication and thus possible side effects. It has not yet been studied what exactly happens when the body is exposed to cold temperatures. There may be interferences caused by temperature-dependent biochemical reactions which occur during pain perception.

More investigations are planned to be carried out at our hospital to obtain precise information and to determine parameters which allow us to predict the success of whole-body cold therapy even before start of the therapy. In addition, we will investigate if there are further indications (such as further pain syndromes of the musculoskeletal system) which may be treated with whole-body therapy.

Contact address:

Prof. D. Kargus, MD
Herzoghoehe Clinic
Kulmbacher Str. 103
D - 95445 Bayreuth



COLD CHAMBER EXPOSURES (-67,3°C, 3 MIN) IN FIBROMYALGIA SYNDROMES CHR. GUTHENBRUNNER 1,2, G. ENGLERT 3, M. NEUES-LAHUSEN 3, A. GEHRKE 2

COLD CHAMBER EXPOSURES (- 67,3°C, 3 MIN) IN FIBROMYALGIA SYNDROMES
CHR. GUTHENBRUNNER 1,2, G. ENGLERT 3, M. NEUES-LAHUSEN 3, A. GEHRKE 2

1- INSTITUTE FOR BALNEOLOGY AND MEDICAL CLIMATOLOGY

(Head: Prof. Chr. Gutenbrunner, MD)

2- INSTITUTE FOR PHYSICAL MEDICINE AND REHABILITATION

(Director: Prof. A. Gehrke, MD) of the Medical University of Hanover, Germany

3- INSTITUTE FOR BALNEOLOGY AND REHABILITATION RESEARCH BAD NENNDORF

(Head: Prof. Chr. Gutenbrunner, MD)

ABSTRACT:

There are only a few studies looking at the analgesic effect of cold chamber exposures in patients suffering from fibromyalgia.

However, in addition to the pain symptoms, patients with this syndrome also frequently suffer from an increased sensitivity to cold. Thus, the effect of cold chamber exposures (-67°C, 1-3 min) on the sensitivity to pain, thermal comfort and actual pain intensity was examined in 17 female patients with fibromyalgia (ACR criteria) and compared with a control group without applications. The measured parameters were pressure, heat and cold pain thresholds (pressure algometry, Peltier thermode), thermal comfort (local thermal cutaneous stimulation applied by a Peltier thermode; systematically varied stimulation sequence) as well as the actual pain intensity and feeling of general well-being (visual analogue scales, VAS).

The thermal pain thresholds were determined on the inner surface of the forearm, and the sensitivity to pressure pain at the styloideus radii. The thermal comfort measurements were carried out at the forehead. After cold chamber exposures, cold and pressure pain thresholds were significantly or very significantly increased while no shifts of the threshold were evidenced for heat pain. In the range of the applied thermode temperatures of 17.5 – 27.5 °C the subjective temperature sensation curve was significantly increased after cold chamber exposure as compared to initial values and control period. The mean thermal tolerance range calculated from the intersection points of comfort curve and temperatures applied showed a statistically significant increase. Such an improvement of the thermal tolerance could not be evidenced for the control group. The mean values of the actual pain scores (VAS) were also significantly reduced after cold chamber exposures, and the overall-being improved. It is concluded that cold chamber exposures have an analgesic effect in patients suffering from fibromyalgia and that in addition the thermal tolerance is increased. Now, further studies have to be carried out to determine if repeated cold chamber applications yield in stable adaptive improvements of pain sensitivity and thermal discomfort.

INTRODUCTION:

Cold chamber therapy was introduced into rheumatology in the 1980th by Fricke (also refer to Yamauchi 1986). Startz et al. (1991a) as well as Samborski et al. were the first to report of the analgesic effect of this therapy form and who discovered an increase in the serum dopamine

concentration, a significant decrease of the β -endorphin-serotonin and cortisol concentrations (Startz et al., 1991b). As a direct effect of cold chamber therapy also the known analgesic effects of local tissue cooling including inhibition of the C-fiber system as well as muscle relaxation effects have to be taken into account (lit. transl. see Schnizer and Schöps 1995). Due to the short exposure time it is rather likely, however, that the clinically observed effects of cold chamber therapy (Birwe et al. 1989) are caused by a reflex inhibition of the pain perception by stimulation of other afferent systems.

The fibromyalgia syndrome is a chronic clinical picture which is characterized by hardly manipulable pain of the skeletal muscles and capsule-ligament apparatus as well as by frequent sleep disorders (lit. transl. see Yunus 1991). Dysfunctions of the vegetative regulatory mechanisms often cause a shift of the thermal comfort in patients with fibromyalgia syndrome, which is primarily characterized by a reduced tolerance to cold (lit. transl. see Yunus 1991); (Kosek et al. 1996). This also restricts the tolerance to the different physical therapeutic applications such as hydrotherapy, kinetherapeutic baths etc. (Piso et al. 1999).

The currently discussed pathomechanism of this disease with disturbances of the neurotransmitter metabolism (serotonin, substance P; lit. transl. see Russel 1998; also refer to Zimmermann 1991) offers a plausible explanation for the generalized shift of sensitivity thresholds. A standard treatment for this problem is not yet been known.

An essential diagnostic criterion for the fibromyalgia syndrome consists in the increased pressure sensitivity of the tendinous attachments (lit. transl. see Fischer 1991a, b; Lautenschläger 1991; Wolfe 1991). Also, the disturbances of the thermal tolerance have been objectified as compared to healthy test persons (Kosek et al. 1996). Since it is difficult to influence fibromyalgia symptoms therapeutically and no causal treatment has yet been found polypragmatic treatment approaches are currently recommended employing analgesics and antidepressants as well as physical therapy methods (Miehle 1991). Thus, the potential analgesic effect of physical therapeutic therapy forms to cure fibromyalgia is still a question of great importance. The current experimental study examines the potential effects of cold chamber exposures on thermal and pressure sensitivity as well as pain intensity and wellbeing in patients with fibromyalgia as compared to a control group without cold chamber application.

METHOD:

Based on the ACR criteria (Wolfe et al. 1990, Wolfe 1991) the inclusion criteria for participation in the study were as follows: diagnosis of existing primary fibromyalgia syndrome (syn. generalized tendomyopathy), between 30 and 70 years of age, and female sex. The latter criterion was chosen to eliminate potential sex-dependent inhomogeneities regarding pain perception and assessment (cf. Offenbaecher et al. 1998). Patients with isolated tendomyopathies, inflammable and severe degenerative spine and joint disorders, polymyositis, rheumatic polymyalgia as well as neurological and psychiatric disorders were excluded from the study. In addition, patients with severe metabolic and cardiovascular diseases were also not included in the study. The diagnosis of fibromyalgia which was made primarily by the attending rheumatologist was verified on the basis of an initial clinical examination according to the ACR criteria.

The examined patient collective consisted of 17 women aged between 42 and 70 years (mean age 54.2 ± 7.0 years). All patients were recruited from a local group of the rheumatology league. They were fully informed about the goal, method and possible risks of the examination and



participated voluntarily in the study. All patients took non-steroid antirheumatics on the basis of an on demand medication. 82% of the patients were additionally treated with Amitryptilin medicaments.

All patients participated in two comparative tests (control, cold chamber exposure). The order of the individual examinations was systematically varied according to a Latin square design. All examinations were carried out between 9:00 and 13:00 in the morning. The minimum interval between individual examinations was 7 days.

Cold chamber exposures were performed according to the commonly used method. The used cold chamber (*CRIO Space Cabin*) was manufactured by CRIO Medizintechnik and had an internal diameter of 2m². The chamber temperature was set to -67°C and varied between tests between -65°C and -68°C. Exposure time was 3 minutes. The patients entered the cold chamber wearing bathing costumes and nose masks, extremities were protected by gloves, shoes and head bands. Increased physical activities during cold chamber exposure were prohibited. Through a glass window and an intercom the test persons were in continuous contact with the investigator. Before and after the application, patients rested in a constant lying position covered with a wool blanket. The control examination consisted in an equally long resting phase in constant lying position during which identical measurements were performed as during therapy tests.

Determination of the pressure pain threshold was performed using a gauged pressure algometer (pd&t: Measurement range: 0.5 – 5.0 kg) using a rounded pressure tip with a diameter of 0.5 cm and a pressure speed of 1kg/sec (Fischer 1987). Evaluation of this study was limited to the pressure point values measured on both sides of the styloideus radii. Additional measurement points were the epicondylus humeri radialis, acromio and costal junction.

The same Peltier thermode was used to determine the subjective temperature sensation and thermal comfort (cf. Fruhstorfer et al. 1976; Verdugo & Ochaba 1992; Yarnitzky & Sprecher 1994; Yarnitzky et al. 1995). The measurements were carried out at the patient's forehead. The patients received applications with ten different temperatures set prior to treatment. The duration of a single stimulus was 5 seconds. Between the individual stimuli a break of at least 10 seconds was made.

Each temperature stimulus had to be rated by the patients on a scale from +10 to -10 (meaning „very comfortable“ to „very uncomfortable and „very cold“ to „very hot“ respectively) (for information on the method of thermal comfort measurement see Cabanac et al. 1976; Attia et al. 1980; Hildebrandt et al. 1981, Demuth et al. 1984). Due to the permanently stored stimulation sequence a continuous increase or decrease of the temperature stimuli could be eliminated. Hyperthermal and hypothermal stimuli were applied in an alternating order. All tests were performed at room temperature (20°C – 22°C) and in a lying position.

		Heat pain threshold	Cold pain threshold	Pressure pain threshold
Controls	Ipsilateral	99,5 ± 0,51100,1 ± 0,37	102,0 ± 1,29102,1 ± 1,11	91,8 ± 1,8490,3 ± 3,15
	Contralateral			
Cold chamber	Ipsilateral	102,4 ± 1,41 98,4 ± 1,11	53,2 ± 6,82 91,0 ± 7,70	177,8 ± 13,7011,7 ± 5,75
	Contralateral			



Tab. 1

Mean changes (in percent) of heat, cold and pressure pain thresholds at exposed and non-exposed arm after application and control test: the stated scatterings represent the ranges of mean errors of the mean values: significance specification (ipsi vs. contralateral) after variance analysis.

Before and after the therapeutic applications or control phase a 10 cm line, the visual analog scale designed by Piso, was presented to the patients. One end of the line was labeled “no pain” and the other “the worst pain ever felt”. Patients were inquired about their pain at rest, kinesiophobia and exertion pain as well as general musculoskeletal pain. The scales conformed to the accepted and evaluated method of pain progression measurement (lit. transl. see Anton 1993). Furthermore, patients were asked to rate their general physical wellbeing on a 10cm analog scale with one end marked “I feel very unwell” and the opposite end “very well”.

The statistical analysis of the results was performed using the variance analysis for repeated measurements. An error probability of under 5% was determined as significance limit.

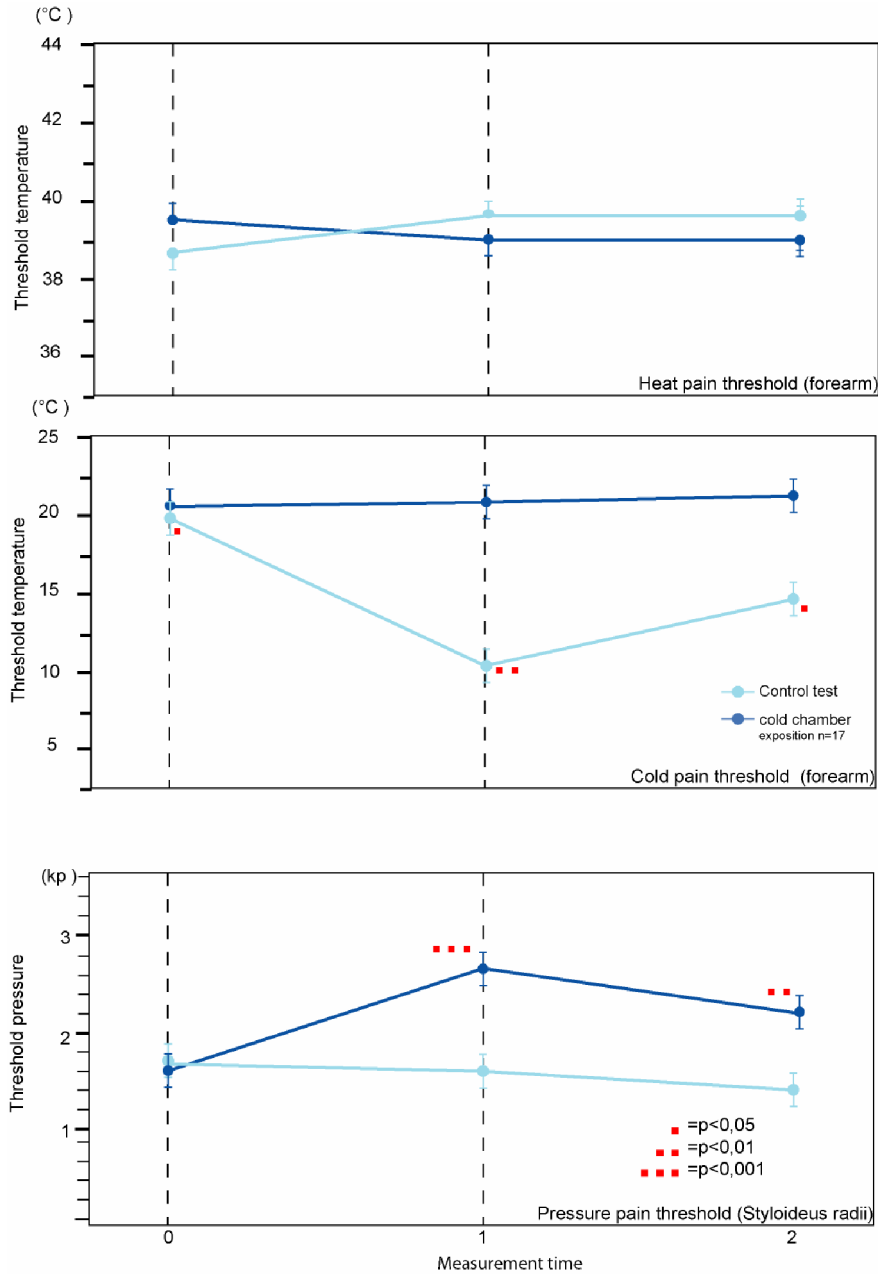


Table 1: Mean changes (in percent) of heat, cold and pressure pain threshold at exposed and non-exposed arm after application and control test. The stated scatterings represent the ranges of mean errors of the mean values: Significance specification (ipsi vs. contralateral) after variance analysis.

RESULTS:

As illustrated in Fig. 1, the mean heat pain threshold showed no noteworthy changes until the end of cold chamber application and during the resting phase after application. In contrast,

threshold temperature during cold pain provocation was decreased significantly until the end of cold chamber exposure, but slightly increased in the resting phase following application. The mean decrease was approx. 8°C, corresponding to approx. 40% (Tab. 1). Threshold temperature did not change during the control tests. A significant shift of the pressure threshold could also be observed. The mean threshold pressure increase until the end of application was 1kg, equaling approx. 60–80% ($p < 0.0001$ as compared to the control test). During the post-application resting phase this increase was also declining. It can thus be concluded that cold chamber exposures have an analgesic effect in patients with fibromyalgia. This was clearly evidenced by the chosen pain threshold determinations.

The mean data of temperature and comfort temperature sensation in dependency to the applied thermode temperatures (Fig. 2) show the typical characteristic prior to application. In contrast to the healthy test persons, patients with fibromyalgia assessed lower temperatures to be colder than they actually were (cf. Kosek et al. 1996). The resulting break in the progression between thermode temperature and sensation score was completely eliminated by cold chamber exposure thus causing a diagram that equals that of a healthy test subject.

The diagram of the mean thermal comfort sensation presented in the lower part of Fig. 2, however, showed no noticeable changes.

For statistical evaluation of the thermal sensitivity during cold chamber exposure as compared to the control group, the different temperature sensitivity values before and after application – as described above – were calculated for each thermode temperature (Fig. 3) (for information on the methodic procedure cf. Gutenbrunner et al. 1999).

It became apparent that particularly under low thermode temperatures, the temperature sensitivity was increased considerably by cold chamber exposure with the results from 20°C to 27.5°C being of statistical significance. In contrast, no difference was observed between application and control test in those cases where the thermode temperatures were above the thermoneural point. From this can be followed that cold chamber exposures cause a significant decrease of cold sensitivity in the hypothermal range.

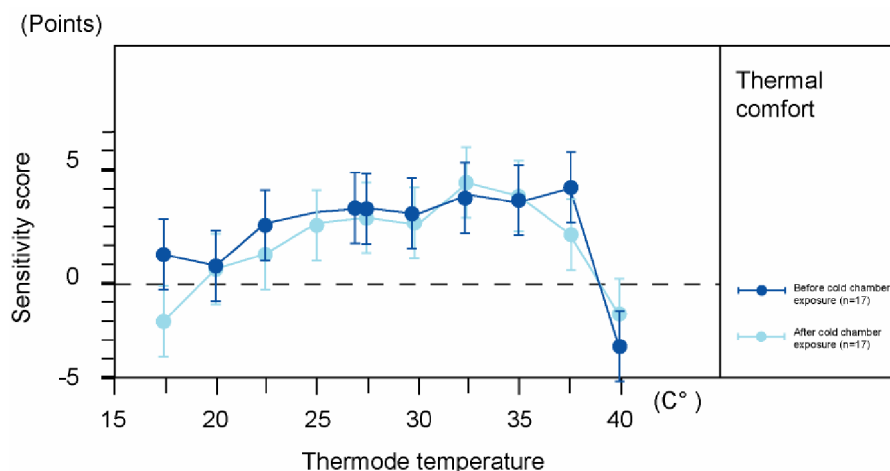


Fig. 2: Mean subjective temperature sensitivity and mean thermal comfort sensitivity during local application of different temperatures on the skin using a Peltier thermode before and after cold application in patients with fibromyalgia syndrome. Parenthesis mark the areas of mean errors and values.

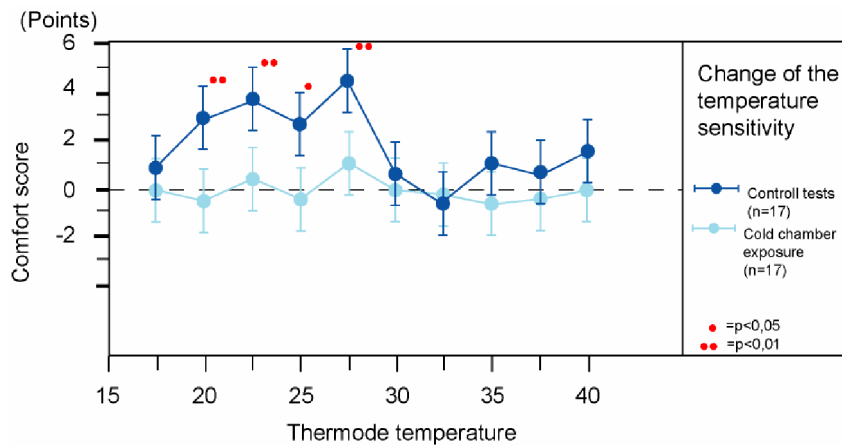


Fig. 3: Mean change of the subjective temperature sensitivity (difference of the sensitivity score) before and after and during 3-minute cold chamber exposure respectively (closed symbols) as compared to control group without therapeutic application (open symbols). Parenthesis mark the areas of mean errors of mean values. Significance information after variance analysis.

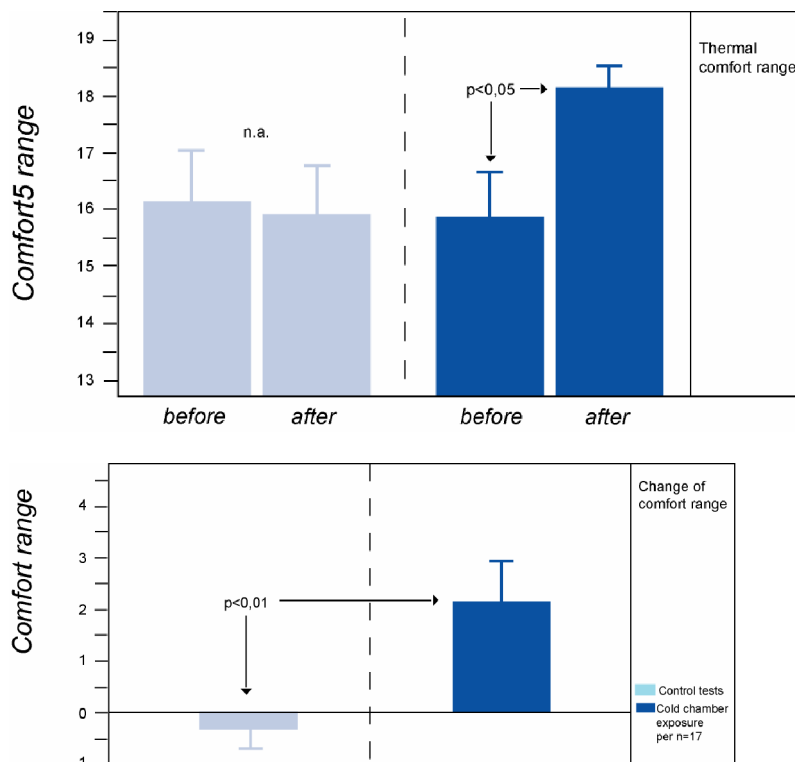


Fig. 4: Mean thermal comfort range before and after cold chamber application as well as at the beginning and end of the control phase. The mean changes of this parameter for the respective application are displayed in the lower part of the diagram. Parenthesis mark the areas of mean errors of mean values. The significance data in the upper part of the diagram refer to the difference between the values before and after application and control phase respectively; data in the lower part of the diagram represent the result of a variance analysis.

For analysis of the thermal comfort scores and their respective changes, those temperatures were determined for each individual examination at which a negative score was transformed into a positive score and vice versa. These temperatures were defined as upper or lower comfort threshold respectively (Gutenbrunner et al. 1999). The mean values and scattering ranges of these comfort thresholds before and after application or control test are shown in Tab. 2. As expected, no changes were observed in the control group while the lower comfort threshold was decreased during cold chamber application ($p < 0.01$). In contrast, the upper comfort thresholds showed no statistically relevant changes. It should be noted, though, that the tests were performed up to a thermode temperature of 40°C max. and that a significant change in an upper range could not be registered for the medium upper comfort threshold of 38.4°C.

To analyze the overall effect, the difference between upper and lower comfort threshold was defined as the thermal tolerance range. As shown in Fig. 4, no significant change was observed for this parameter during control examinations. During cold chamber exposure, however, it increased by approx. 2°C. This increase was statistically highly significant both in comparison with the values before and after application as well as when comparing the differences (tolerance range changes). The evaluations thus confirm the changes which have been observed for the temperature sensitivity, and they demonstrate that the thermal tolerance in patients with fibromyalgia can be improved by cold chamber exposure.

Parameter	Application	Point of time	Mean value ± Standard error
Lower comfort threshold	Control test	Before application	22,2 ± 1,00
		After application	22.4 ± 1.04 ns
		Change	+0.14 ± 0.34 ns
	Cold chamber exposure	Before application	22,2 ± 1,00
		After application	20,1 ± 0,95 *
		Change	-2,1 ± ,65**
Upper comfort threshold	Control tests	Before application	38,4 ± 0,42
		After application	38.2 ± 0.51 ns
		Change	-0.14 ± 0.26 ns
	Cold chamber exposure	Before application	38,1 ± 0,46
		After application	38.1 ± 0.46 ns
		Change	0.0 ± 0.30 ns

* $p < 0.01$ (t-test comparison of pre/ post application)

** $p < 0.01$ (ANOVA comparing the control group)

ns not significant: bold = significant changes or differences

Tab 2: Mean values of the lower and upper comfort threshold before and after cold chamber exposure and control test respectively as well as mean changes of the respective parameter (difference between values before and after application) in 17 patients with fibromyalgia syndrome.



Mean values and standard errors are indicated. Significance information refer to the t- test (comparison between pre/post application) or a variance analysis (comparisons of the applications).

The possible manipulation of the actual pain status is of particular clinical importance as well as the changes in well-being which may also reflect a possible positive influence on the mental strain. As shown in Fig. 5, statistically high significant reductions of the pain at rest, kinesiopia and exertion pain amounting to 12–21% were observed after cold chamber exposure as opposed to the control test. In all tested parameters, these changes were statistically significant or high significant as compared to the control examinations. This demonstrates that the analgesic effect verified by pain threshold determination is also of clinical relevance for patients with fibromyalgia.

DISCUSSION

METHOD:

Generally accepted and evaluated methods have been used for testing the pain threshold sensitivity and actual pain intensity. The used measurement methods also served for testing both the sensitivity on the skin surface (thermal pain threshold) and in the deeper layers of the tissue (pressure pain threshold). Reference values for the thermal pain threshold values can be found in studies by Fruhstorfer et al. (1996), Verdugo & Ochoa (1992), Yarnitzky & Sprecher (1994) as well as Yarnitzky et al. (1995). Determination of the pressure pain using an appropriately gauged pressure algometer represents a standard procedure in pain diagnostics of the fibromyalgia syndrome and has been used in numerous examinations for the therapy of this disease (lit. transl. cf. Fischer, 1987, 1991 a,b; Lautenschläger 1991; Wolfe 1991). Piso's (1998) modified 10-cm visual analog scale which is used for pain assessment also represents a commonly used and valid procedure applied for patients with fibromyalgia (lit. transl. cf. Anton, 1993). The modification made by Piso (1998) merely applies to the separate recording of pain at rest and exertion pain; a procedure that has proved itself in multiple cases for assessment of pain in patients with degenerative spine and joint disorders (Gutenbrunner et al. 1997, 1998).

In the early 1980's Hildebrand et al. (1981) already indicated that the measurement of tissue temperatures is not sufficient to prove the impact of thermally effective physical applications but that it is rather necessary to take parameters of thermoregulation into account.

Therefore, the authors suggested to use the method described by Cabanac (1969, 1973, 1979) which determines the thermal comfort sensation. Standardized measurement instruments are now available for use with this method (cf. Fruhstorfer et al. 1976; Verdugo & Ochoa 1992; Yarnitzky & Sprecher 1994; Yarnitzky et al. 1999). The method has also proved itself to determine disturbances in patients with fibromyalgia syndrome (Kosek et al. 1996).

In patients with fibromyalgia syndrome, cold chamber exposures have a clinically relevant analgesic effect, as shown by the results, and also act in favor of experimentally defined pain threshold as well as actual pain symptoms. Corresponding results have already been reported earlier; however, lower temperatures had been applied (Stratz et al. 1991 a; Samborski et al. 1992). As demonstrated by a parallel examination, the shift of pain thresholds cannot be evidenced in a thermally isolated extremity (Gutenbrunner et al.). This suggests that the analgesic effect of cold chamber therapy equals the effects of locally applied cold applications such as cold air stream or liquid nitrogen. These effects are caused by direct tissue cooling and the resulting inhibition of the conduction velocity of sensitive neurons (lit. transl. cf. Schnizer &

Schöps 1995). It is also quite conceivable that the strong stimulation of the cold afferences – in the sense of a counter irritation – causes an inhibition of the pain perception (cp. Handwerker 1995). Due to the limited local effect, a central effect has to be regarded as rather unlikely.

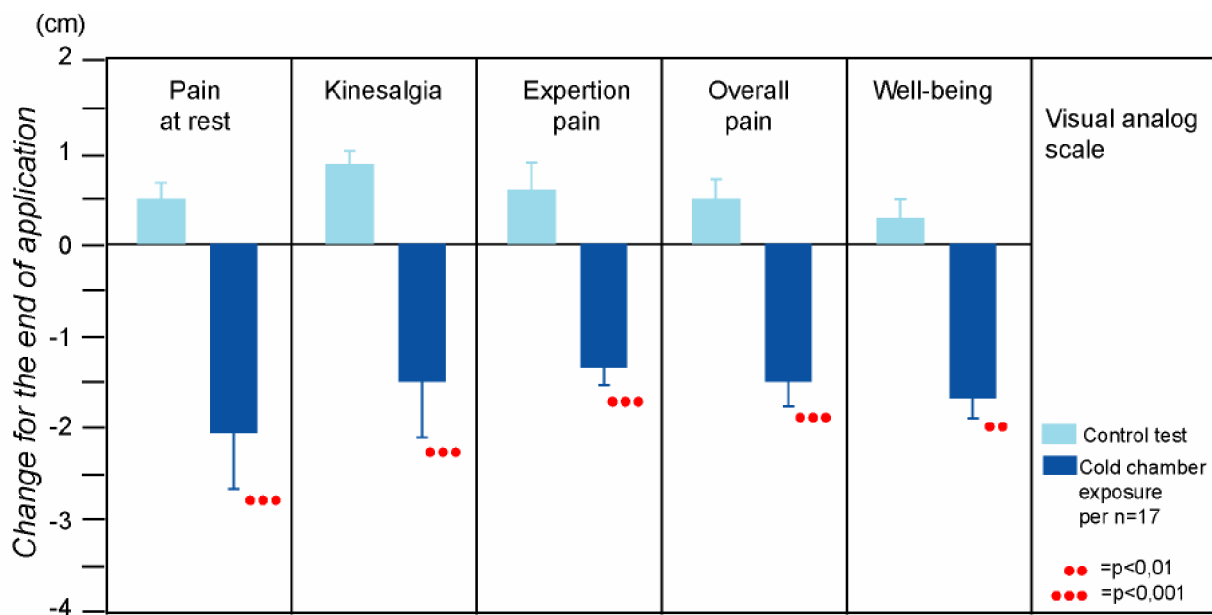


Fig. 5: Mean changes of the actual pain assessed using visual analog sales (10 cm) and general well-being shortly after application as compared to the situation before application. Absolute changes are indicated in cm. Parenthesis mark the areas of mean errors of mean values. Significance information after variance analysis.

In patients with fibromyalgia syndrome, cold chamber exposures have a clinically relevant analgesic effect, as shown by the results, and also act in favor of experimentally defined pain threshold as well as actual pain symptoms. Corresponding results have already been reported earlier; however, lower temperatures had been applied (Stratz et al. 1991 a; Samborski et al. 1992). As demonstrated by a parallel examination, the shift of pain thresholds cannot be evidenced in a thermally isolated extremity (Gutenbrunner et al.). This suggests that the analgesic effect of cold chamber therapy equals the effects of locally applied cold applications such as cold air stream or liquid nitrogen. These effects are caused by direct tissue cooling and the resulting inhibition of the conduction velocity of sensitive neurons (lit. transl. cf. Schnizer & Schöps 1995). It is also quite conceivable that the strong stimulation of the cold afferences – in the sense of a counter irritation – causes an inhibition of the pain perception (cp. Handwerker 1995). Due to the limited local effect, a central effect has to be regarded as rather unlikely.

In the literature, mainly temperatures between -110°C to -120°C are requested for cold chamber exposures (Yamauchi 1986; Fricke 1989). According to the present results, a temperature of approx. -65°C is apparently sufficient to obtain at least an analgesic effect.

The fact that cold chamber exposures are capable to improve the tolerance to thermal stimulations may be of clinical importance for a therapy of the fibromyalgia syndrome. This diagnosis is in so far of clinical relevance as these patients – as already mentioned – also suffer from thermally effective paralgnesia and have a reduced tolerance to thermally effective physical therapies. Piso et al. (1999) proved that kinetotherapeutic baths with a temperature of 29°C –

30°C are tolerated less well by patients with fibromyalgia syndrome than those with a temperature of 35°C–36°C. The disturbed tolerance to thermal stimulation has also been experimentally evidenced by Kosek et al. (1996). This also explains the recently evidenced therapeutic effect of thermal adaptations on the clinical symptoms and general condition of patients with fibromyalgia syndrome (Piso et al. 1998).

Besides the already mentioned local cold effects in the sense of local thermally related sensitivity changes of thermal receptors, adaptive level shifts in the sense of cold habituation have to be discussed as an operating principle for reducing the cold tolerance (lit. transl. cf. Hildebrandt 1998). These habituated sensitivity dampings have been described repeatedly for vegetative cold reactions (Stempel & Stroh 1982). According to Glaser (1968) they are controlled by the central nervous system on the level of the formatio reticularis (lit. transl. cf. Hildebrandt 1998).

The presented results may be of great practical importance to the treatment of the fibromyalgia syndrome because fibromyalgia, as already mentioned, not only impairs the pain symptoms but also the general well-being due to thermal paralgia. As cold chamber applications are by nature not suited for permanent therapy, the question is of particular importance as to whether a serial application over several weeks via functional adaptations may cause a longterm change of the pain sensitivity and thermoregulation as well as thermal comfort sensation.

REFERENCES

- Anton F. Schmerzmessung. In: Zenz M. Jurna I (editor). Lehrbuch der Schmerztherapie. Stuttgart/Germany: Wiss Verlagsgesellschaft, 1993: 35 – 44
- Attia M. Engel P. Hildebrandt G. Quantification of thermal comfort parameters using a behavioural indicator. *Physiol Behaviour* 1980; 24: 901 – 909
- Birwe G. Fricke R. Hartmann R. Ganzkörper-Kältetherapie (GKKT) – Beeinflussung der subjektiven Beschwerdelinderung und der Gelenkfunktion. *Z Phys Med Baln Med Klim* 1989; 18:11 – 15
- Cabanac M. Plaisir ou déplaisir de la sensation thermique et homeothermie. *Physiol Behav* 1969; 4: 359 – 364
- Cabanac M. Thermoregulatory behaviour. In: Blich J. Moore B (Eds.) *Essays in temperature*. Amsterdam/Netherlands: North Holland Publ Comp. 1973, pp 19 – 36
- Cabanac M. Sensory pleasure. *Quart Rev of Biol* 1979; 54: 1 – 19
- Cabanac M. Hildebrandt G. Massonet B. Stempel H. Behavioural study of the nycthermal cycle of temperature regulation in men. *J. Physiol* 1964; 257: 275 – 291
- Demuth F. Breithaupt H. Fuenko B. Thermischer Komfort im Verlauf einer Kneippkur. *Z Phys Med Baln Med Klim* 1984; 13: 12 – 14
- Fischer AA. Pressure algometry over normal muscles. Standard values, validity and reproductibility of pressure threshold. *Pain* 1987; 30: 115 – 126
- Fischer AA. Muscle Spasm in Fibromyalgia – Documentation in Clinical Practice. In: Müller W (Hrsg.) *Generalisierte Tendomyopathie (Fibromyalgie)*. Darmstadt: Steinkopff-Verlag, 1991: 86 – 97
- Fischer AA. Pressure Dolomrimetry for differential Diagnosis of Pain in Rheumatology Practice. In Müller W (Hrsg.) *Generalisierte Tendomyopathie (Fibromyalgie)* Darmstadt: Steinkopff-Verlag, 1991: 87 – 194
- Fricke R. Ganzkörper-Kältetherapie in einer Kältekammer mit Temperaturen um –110°C *Z Phys Med Baln Med Klim* 1989; 18: 1 – 10

- Fruhstorfer H, Lindblom U, Schmidt WC. Method for quantitative estimation of thermal thresholds in patients. *J Neurol Neurosurg Psychiatry* 1976; 39: 1071 – 1075
- Glaser EM. Die physiologischen Grundlagen der Gewöhnung. Stuttgart/Germany: Thieme Verlag. 1968
- Gutenbrunner Chr, Hildebrandt HD, Schaff P, Gehrke A. Untersuchungen über Wirkung und Wirksamkeit funktioneller Kniebandagen bei Chondropathia patellae und Conarthrosen. *Orthop Prax* 1997; 33: 53 – 58
- Gutenbrunner Chr, Kopetzki K, Neues-Lahusen M. Vergleichende Untersuchungen der analgetischen Wirkung natürlicher Schwefelbäder. *Phys Rehab Kur Med* 1998a; 8: 149
- Gutenbrunner Chr., Hildebrandt HD, Gehrke A. Katamnestische Untersuchungen über Wirkung und Wirksamkeit der Verordnung einer dynamischen Kreuzstützbandage bei Patienten mit chronischen Lumbalsyndromen. *Orthop Prax* 1998 b; 34: 383 – 390
- Gutenbrunner Chr., Englert G, Neues-Lahusen M., Gehrke A., Analgetische Wirkungen von natürlichen Schwefelbädern und Kältekammerexpositionen bei Fibromyalgie. *Phys Rehab Kur Med* 1999; 9: 56 – 62
- Handwerker HO. Nozizeption und Schmerz. In: Schmidt PF (Hrsg.). *Neuro- und Sinnesphysiologie*. Berlin, Heidelberg, New York, Barcelona, Budapest, Hongkong, London, Mailand, Paris, Tokyo: Springer-Verlag, 1995: 249 – 261
- Hildebrandt G., Therapeutische Physiologie. In: Gutenbrunner Chr, Hildebrandt G. (Hrsg.) *Handbuch der Balneologie und medizinischen Klimatologie*. Berlin, Heidelberg, New York, Barcelona, Budapest, Hongkong, London, Mailand, Paris, Santa Clara, Singapur, Tokyo: Springer- Verlag, 1998: 5 – 8
- Hildebrandt G., Engel P, Attia M. Temperaturregulation und thermischer Komfort. *Z Phys Med* 1981; 10: 49 – 61
- Kosek E., Ekholm J, Hansson P. Sensory dysfunction in fibromyalgia patients with implication for pathogenic mechanisms. *Pain* 1986; 68: 375 – 383
- Lautenschläger J. Die Erfassung der Druckpunkte bei generalisierter Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag. 1991: 95 – 104
- Miehlke K., Systemische und lokale Pharmakotherapie bei der generalisierten Fibromyalgie. In: Müller W (Hrsg.). *Generalisierte Tendomyopathie (Fibromyalgie)*. Darmstadt: Steinkopff-Verlag, 1991: 267 – 269
- Offenbächer M., Glatzeder K., Ackenheil M. Psychische Belastung und Depressivität: geschlechtsspezifische Unterschiede bei Fibromyalgie. *Phys Rehab Kur Med* 1998; 8: 155
- Piso u. persönliche Mitteilung, 1998
- Piso u. Gutenbrunner Chr., Gehrke A. Effekte einer sechswöchigen Saunatherapie und die Schmerzschwelle an den ACR-Tenderpoints bei der generalisierten Tendomyopathie. *Phys Rehab. Kur Med* 1998; 8: 156
- Piso u. Schwone A, Küther G, Gutenbrunner Chr, Gehrke A. Fibromyalgia: Effects on an aquatic exercise program. 11th European Congress of Physical Medicine and Rehabilitation. Göteborg Sweden, May, 26 – 28, 1999
- Russell IJ. Advances in Fibromyalgia: Possible Role for Central Neurochemicals: *Am J. Med Sci* 1998; 315: 377 – 384
- Samborski W, Stratz T, Sobieska M, Mennet P, Müller W, Intraindividuellem Vergleich einer Ganzkörper-Kältetherapie und einer Wärmebehandlung mit Fangopackungen bei der generalisierten Tendomyopathie. *Z. Rheumatol* 1993; 51: 25 – 30
- Schnizer W, Schöps P. Thermo-, Hydro- und Kryotherapie. In: Schmidt, KL, Drexel H, Jochheim KA (Hrsg.) *Lehrbuch der Physikalischen Medizin und Rehabilitation*. Stuttgart, Jena, New York; G. Fischer-Verlag. 1195: 106 – 135
- Stratz T, Menner P, Knarr D, Müller W. Ganzkörper-Kältetherapie – eine neue Möglichkeit



- im Therapiekonzept der generalisierten Tendomyopathie (CTM). In: Müller W (Hrsg.). Generalisierte Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag. 1991a: 317 – 323
- Stratz T, Schlegel P, Mennet P, Müller W. Biochemische und hormonelle Reaktionen unter der Ganzkörper-Kältetherapie. In: Müller W. (Hrsg.) Generalisierte Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag. 1991b; 299 – 306
- Stempel H, Stroh H. On adaptation to cold pain: In: Hildebrandt G. Hensel H (Eds.). Biological Adaptation. Stuttgart: Thieme-Verlag, 1982: pp 296 – 304
- Verdugo R, Ochoa JL. Quantitative somatosensory thermotest. A key method for functional evaluation of small calibre afferent channels. Brain 1992; 115: 893 – 913
- Wolfe F. Criteria for Fibromyalgia: The American College of Rheumatology 1990 – Criteria for the Classification of Fibromyalgia. In: Müller W (Hrsg.) Generalisierte Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag, 1991: 13 – 22
- Wolfe F, Smythe HA, Yunus MB, The American College of Rheumatology 1990 – Criteria for Classification of Fibromyalgia: Report of the Multicenter Criteria Committee. Arthritis Rheum 1990; 33: 160 – 172
- Yamauchi T. Whole Body Cryotherapy is Method of extreme Cold – 175°C Treatment Initially used for Rheumatoid Arthritis. Z Phys Med Baln Med Klim 1986; 15: 311
- Yarnitzky D, Sprecher E. Thermal testing. Normative data and reliability for various test algorithms. J Neurol Sci 1994; 125: 39 – 45
- Yarnitzky D, Sprecher E, Zaslansky R, Hemli JA. Heat pain thresholds: normative data and reliability. Pain 1995; 60: 329 – 332
- Yunus MB. Clinical Features of Fibromyalgia Syndrome. In: Müller W (Hrsg.) Generalisierte Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag, 1991: 3 – 12
- Zimmermann M. Neurological Mechanisms of Fibromyalgia. In: Müller W (Hrsg.). Generalisierte Tendomyopathie (Fibromyalgie). Darmstadt: Steinkopff-Verlag, 1991: 163 – 174

Prof. Chr. Gutenbrunner, MD
Institute for Balneology and Medical Climatology
Medical University of Hanover, Germany
Carl-Neuberg-Straße 1
D – 30625 Hanover



EFFECTS OF WHOLE-BODY CRYOTHERAPY ON THE CYTOKINE SERUM LEVEL IN CHRONIC POLYARTHRITIS C. RICHTER, R. FRICKE

On the basis of an initial study it was demonstrated that T-helper lymphocytes in the peripheral blood of patients with chronic polyarthritis were reduced significantly under whole-body cryotherapy (WBCT) for up to 3 hours.

To obtain further evidence for the immunomodulatory effect of WBCT on chronically inflamed system disorders, the serum level of interleukin-1- β , IL-6 and the tumor necrosis factor (TNF) α were analyzed in 20 patients with established chronic polyarthritis (CP) (ARA criteria, no immunosuppressive therapy) and 10 control subjects, before and directly after 30, 60, 120 and 180 min following a minimum 1.5-minute whole-body cryotherapy at -100°C .

The following results were obtained:

1. Significant decrease of the IL-6 serum levels in patients with CP directly after WBCT followed by a slow increase after 1 hour, but without having reached the initial value after 3 hours. No noticeable changes of the altogether low IL-6 serum level in the control group.
2. Significant increase of the IL-2 concentration in the blood after WBCT and slowly decrease to the initial value in the patient group after 3 hours. In the control group, a reverse behavior of the serum level was observed with a decrease directly after WBCT. After 180 min the initial values had partially still not been reached.
3. A slight, in some patients a distinctive decrease of the IL-1- β and TNF-1097 values after WBCT was observed but without any statistic relevance due to the small patient collective.

The control group showed hardly any fluctuation of the IL-1 values and again a reverse behavior with an increase of the TNF serum level within the first hour. The examinations showed that IL-6, which increases during inflammations and in CP, is decreased significantly thus resulting in an antiphlogistic effect.

The unexpected increase of IL-2 may denote a stimulation for differentiation of T-suppressor lymphocytes.

Although a tendency for the increase of IL-1- β and TNF- α can be observed and therefore for the inactivation of T-cell line and tissue destruction, further studies are necessary to obtain insight into manipulation of the cytokines.

Prof. Dr. Reinhard Fricke (MD), head physician at the rheumatology clinic,
St. Josef-Stift Sendenhorst, D-48324 Sendenhorst



WHOLE-BODY CRYOTHERAPY AT -110°C IN ANKYLOSING SPONDYLITIS J. WICHMANN, R. FRICKE

Twenty patients with ankylosing spondylitis received in-patient treatment over 28 days with daily physiotherapy and additional daily whole-body cryotherapy.

The control group comprised ten patients with ankylosing spondylitis who received in-patient treatment over 28 days with daily physiotherapy and additional daily thermotherapy.

Furthermore, 10 additional out-patients showing symptoms of ankylosing spondylitis were examined before and after an average of 36 days regarding their activity indexes (objective and subjective parameter, see below). After 28 days of therapy, the two in-patient groups showed a statistically significant decrease of the disease activity ($p=0.0001$, $p=0.0050$). In contrast, the out-patient group showed statistically significant changes of the activity index ($p=1.0000$) over an average period of 36 days.

After 28 days of whole-body therapy in hospital, the decrease of the overall disease activity was significantly higher as compared to a 4-week hospital treatment with thermotherapy. After therapy, the objective disease activity criteria (general limited range of motion, moveability of the individual vertebral regions, erythrocyte sedimentation rate, haemoglobin value, general medical diagnosis) showed significant improvements ($p=0.0009$, $p=0.0196$) in the in-patient groups.

After WBCT, significant functional improvements ($p=0.003$, $p=0.0019$, $p=0.0124$) were observed in all three vertebral regions.

In contrast, significant functional improvements after thermotherapy were only observed with respect to the thoracic spine function ($p=0.0235$).

Functional improvements in the region of the cervical spine were significant larger after WBCT as compared to the functional diagnosis of the cervical spine after thermotherapy.

After 28 days of treatment, the in-patient group with daily whole-body cryotherapy showed a statistically significant improvement ($p=0.0002$) of subjective complaints (morning stiffness, abnormal fatigue, joint pain as well as subjective discomfort). In contrast, no statistically significant improvement of subjective complaints was observed either in the in-patient group with additional daily thermotherapy nor in the out-patient group ($p=0.1025$, $p=0.0588$).

The results of the present study suggest an independent effect of daily long-term cold chamber therapy.

According to our findings, whole-body cryotherapy is of particular therapeutic importance to the required combination therapy of ankylosing spondylitis.

J. Wichmann

Rheumatology clinic, St.-Josef-Stift, Sendenhorst,

Dept. of rheumatology, Weserland clinic, Vlotho, Bad Seebruch,

D-32602 Vlotho



REINHARD FRICKE

LOCAL CRYOTHERAPY AND WHOLE-BODY CRYOTHERAPY AT -110°C

Cryotherapy with ice, cold gas or cold packs reduces or even eliminates pain, acts anti-inflammatory, decongesting and improves the function of the affected joints. Muscular hypertonicities will be reduced. Under cryotherapy, blood circulation will be maintained in the inflammatory region. Thus, the following indications result: inflammation, pain, swelling, impairment of function, muscular hypertonicity. Whole-body cryotherapy at -110°C results in a significant functional improvement. Oxygen concentration in the blood increases.

Since time immemorial, cold therapy in its various forms has been used for suppressing inflammations. The cold back of a knife to cure stye (hordeolum), aluminium acetate compresses against sprain, cold compresses against fever and local application of ice were elements of the general medical knowledge and were used to suppress inflammations.

However, as also local pain of the shoulder-hand syndrome, tennis elbow, sciatica, and pain in a tendon had been lumped together under the term "rheumatism", heat therapy, which may be used to cure these non-inflammatory pain syndromes, had become of great importance to the treatment of rheumatic disorders over the millenniums. The „few“ inflammatory rheumatic illnesses, amounting to about three million in Germany alone, were thus included into heat therapy. If the inflammation had been fuelled by the heat and the symptoms worsened, this was credited to the so-called 'cure reaction'. But in fact, it was a grave error in treatment.

More than 100 years ago, the ice bag had been described in Germany for treatment of inflammations. In the early 1960's only a few studies about the therapeutic effect of intense local cold against inflammations were available. For more than 25 years, we have successfully been using cold therapy in the form of ice to cure inflammatory rheumatic disorders. After it had become evident that the therapeutic effect lasted only approx. three hours, we started to apply local ice treatment three to four times per day at intervals of three hours.

Today, several methods for use in local cryotherapy are available.

LOCAL CRYOTHERAPY

ICE TREATMENT

Ice in a closed plastic bag may be applied to hand and finger joints for 5 to 10 min, to shoulder and knee joints for 5 to 20 min.

COLD PACKS

In addition to the ice therapy, cold packs are used today which are supplemented with a cold storing agent, e.g. glycerol, and applied to the skin after being cooled down to -12°C to -14°C in the freezer.

COLD GAS

In 1979, Yamauchi introduced the nitrogen cold gas therapy with -180°C on the rheumatology congress in Wiesbaden/Germany. The intense local, dry cold is perceived as comfortable by most people. The -180°C cold air stream is blown onto the relevant body part by means of



compressed air and has to be moved over the skin. Joints or extremities are moved simultaneously. The application time is 0.5 to 1.5 minute.

In 1982, the first local cold gas instrument in Europe, which we developed in cooperation with the company Westfalen AG, was put into operation. Using a dry air pressure of two atmospheres above atmospheric pressure, the liquid nitrogen is transformed into nitrogen gas and blown onto the skin.

In recent years cold air instruments have been developed using a local cold air stream of -30°C (refrigerator principle) which is blown onto the skin. Due to the higher temperature, the application time is 2 to 3 minutes. The application period is determined by the initial temperatures of the different local cryotherapeutic methods. The application time, however, also depends on the patient's individual tolerance range.

1.1. Physiological Effect

Reduction of tissue temperature

According to Blair, the local tissue temperature is decreased 3.2 cm deep to a temperature of 22°C during ice application. The skin temperature is decreased to approx. 8°C and lower. The cryotherapeutic effect continues for about three hours [3].

As long as the ice melts, a temperature from 0°C to $+2^{\circ}\text{C}$ can be maintained for more than one hour.

Without lying on a hot joint, the cold pack becomes increasingly warmer and exceeds the 0°C limit after 30 minutes at the latest.

By means of ice bags and locally applied cold air stream applied by various methods, a large area of the joint and its narrow environment will be cooled. This therapeutic effect is desired as nociceptors (pain receptors) in the skin are linked to the connective tissue around the joints as Scheible and Mensing demonstrated in their studies around 1985. [16,18]. A therapeutic, analgesic effect is thus realized by cryotherapy also near the joints.

Tissue blood perfusion

Highly dosed cold causes vasoconstriction of the skin. In the muscle tissue underneath the skin, however, a reactive dilatation occurs.

In the case of chronic polyarthritis (rheumatoid arthritis) it was proved that the arterial blood flow in the knee joint can be maintained for more than 15 to 20 min after ice application [15]. This may be ascribed to the fact that in chronic polyarthritis no physiological vasoconstriction occurs due to a vasculitis and a strong formation of new capillaries in the granulation tissue as it is observed in healthy persons. Arteries and arterioles affected by vasculitis are no longer able to receive any physiological stimulation.

Lewis has observed that periodic vasodilatations occur during cooling of the skin. The constant succession of vasoconstriction and vasodilatation ensures a sufficient oxygen supply to the cells. In addition, excessive cooling of the body is prevented.

1.2 Therapeutic effect

Pain relieving effect

Cold has a pain relieving, analgesic effect. After decrease of the skin temperature, nociceptors are blocked thus creating a connection to the sensitive periarticular nerves. On the soccer field,



the therapeutic effect of extremely low temperatures is used by means of the cold air spray. This effect is verified by a diminishment of the pain area in shoulder pains (pain under the arch of the shoulder blade) upon ice or cold air therapy [7].

Pain induced by electrical stimulation is clearly blocked under the influence of ice, cold gas or cold air stream. The pain threshold is raised to a higher level for more than three hours after occurrence of a maximum pain relieving effect directly after therapy [14].



Functional improvement

As we have proved after local ice treatment and local nitrogen cold gas therapy, a limited range of motion is significantly improved in inflamed joint diseases.

Decongesting effect

Analog to bodies contracting under the influence of cold, a decongesting effect may be obtained simply by cooling in tissues which are swollen due to water retention (edema). At the same time, the edema which was caused by an inflammation is dissipated via the lymphatic system. In addition, it reduces edemas caused by traumatic lesions.

Increase in strength

In chronically inflamed joint diseases, the analgesic effect, decongesting effect, and the related functional improvements result in an increase of strength. In patients with polyarthritis significant increases in function, e.g. grasping, were observed [7].

Anti-inflammatory effect

Cooling of the tissue results in a significant reduction of temperature in deeper tissue regions [3]. As a result, the enzyme collagenase, which causes a degradation of tendinous tissue (collagen), is inactivated by a temperature decrease of only 6 K. [12]. This may be realized since a temperature reduction of 14 K already occurs in a depth of 3.2 cm after prolonged cooling with cold packs. A further evidence of the anti-inflammatory effect of cryotherapy was found in the observation that in crystal-induced arthritis created in the joints of dogs only a tenth of the usually observed 20,000 leuko/ml³ of white blood cells appear in the effusion after local cryotherapy. In contrast, leukocytes increased to 40,000 under heat application (thermotherapy).

.....

LOCALLY APPLIED CRYOTHERAPY – THERAPEUTIC EFFECT		
Decrease of the tissue temperature		
Pain reduction	Anti-inflammatory effect	Tissue regeneration
Slow-down of reflexes	Metabolic slow-down	Functional improvement
Vasoconstriction	Increase in tonicity (short application)	
Periodic vasodilatation		
Reactive hyperemia	Decrease in tonicity (long application)	
FROM THE THERAPEUTIC EFFECTS THE FOLLOWING INDICATIONS FOR LOCALLY APPLIED CRYOTHERAPY RESULT:		
Inflammation	Functional limitations	
Pain	Muscle tension	
Tissue swellings	Muscle weakness (edema)	

.....

Heat aggravates inflammations [4].



A third example of an anti-inflammatory effect of locally applied cryotherapy is the induced regeneration of inflamed tissue underneath the skin in hedgehogs after silicon implantation. While under normal ambient conditions a solid granuloma with dense macrophage accumulation develops, no cellular reaction is observed during winter sleep [13].

1.3 Change of the muscle condition

Relieving muscle spasms

Intense local cryotherapy may relieve excessive tonicity, i.e. muscle tensions. In the case of lumbago, i.e. pain in the lower region of the back, this is possible simply by local application of ice bags. An even faster effect can be obtained by a cold air stream applied locally for half a minute.

Muscle activation

In case of lack of muscle tone cooling may have a stimulating and activating effect. A temporary short-term cooling may result in a higher initial muscle tone which allows subsequent physiotherapeutic treatment thus strengthening the musculature with a greater stimulating effect.

As a result, the following therapeutic effects can be achieved:

1.4 Therapeutic procedure

The fact that cryotherapy lasts for about three hours until the tissue has re-warmed calls for a sensible strategy: To achieve a long-term treatment success, local cold treatments applied in intervals of three hours are required. A long-term treatment success can be achieved by application of four daily therapy sessions over a period of approx. 12 hours. As a result, this may lead to drug savings. In addition to its therapeutic effect, locally applied cryotherapy using ice or cold air stream in its various forms is also a reasonable preparation for subsequent physiotherapeutic treatments. Multiple daily cryotherapy and physiotherapy, when used in conjunction with medicamentous therapy, are important adjuvant therapy forms leading to a significant functional improvement within three to four weeks [8].

Whole-body Cryotherapy

The therapeutic effect of cryotherapy will even be considerably improved by whole-body cryotherapy. Since 1984, the first cold chamber outside Japan, built by the company Westfalen AG, has been in use in Germany after introduction of whole-body cryotherapy by Yamauchi in 1980 [21]. Each day, up to 40 to 60 patients are treated with a temperature of -110°C [9,10].

Using liquid nitrogen dry air is cooled down via heat exchanger in the cold chamber to a desired temperature of -110°C and -160°C . Yet another procedure of whole-body cold treatment is represented by the cold cabin where cold air is blown onto the body.

The latest development of a three-phase refrigerating system delivers a constant temperature of -110°C (Seus, Wilhelmshaven/Germany). This system runs at considerably lower operating costs as compared to cold chambers operated with nitrogen or cold air.

The patients enter the cold chamber wearing nose mask, head band and gloves as well as closed shoes. After the blood pressure has been checked and upon approval of the physician who stands at the control panel to supervise the application, patients enter the antechamber accompanied by a therapeutic assistant in winter clothes. After closing the door, the inner door is opened. Patients now enter the main chamber which has a temperature of -140°C to -110°C and walk around for 0.5 to 3 minutes in the chamber. Breathing out the inhaled air takes twice as



long because the cold air expands while being warmed in the patients' lungs. Due to the mist which forms in all cold chambers as a result of the warm, humid air flowing in patients walk along handrails for better orientation in the chamber. Patients may leave the chamber at any time. A member of the therapeutic team who is watching the patients from the antechamber may also assist them.

Within 0.25 to 1 minute after leaving the cold chamber, the blood flow in pale skin is strongly stimulated by vasoconstriction causing a pleasant, comforting sensation.

2.1 Physiological effects

Whole-body cryotherapy does not cause any stress to the organism. ACTH increases, cortisol is decreased. No change of the blood glucose occurs. Furthermore, no increases in adenohipophysial hormone, prolactin and STH were observed. Nor was an increase in adrenalin observed [5].

In comparison, a significant increase in noradrenalin was verified. This indicates an activation of synapses and nerve endings in the skin. This increase induces a kind of supply reaction. Minor increases in blood pressure are observed in patients with normal blood pressure. Hypertensive persons have to be treated with drugs.

An increase of the oxygen content was observed both in the blood of the sick and the control persons [19]. This increase can be traced back to a deeper respiration and inhalation of a larger number of oxygen molecules per liter air at -110°C . The increased oxygen content in the blood [19] produces an improved coronary blood flow. No angina pectoris has been observed although patients with coronary heart diseases entered the cold chamber. Moreover, extrasystolies were considerably reduced. These two observations indicate an improved oxygen supply in the coronary system.

2.2 Therapeutic effects

Analgesic effect

After approx. 30 seconds, children and adults (1/2 to 83 years of age) experience a pain blocking effect. It becomes easier to move the joints. The therapeutic effect lasts a minimum of three hours.

Functional improvement

Directly after treatment in the cold chamber a significant functional improvement in all joints affected by chronic polyarthritis or ankylosing spondylitis is evidenced. A significant functional improvement in some parameters [1] has also been observed following the three hours after cryotherapy in which physiotherapy had been performed.

Influencing immunocytes

Studies showed that in chronic polyarthrits, the number of lymphocytes is decreased for a minimum of three hours [2]. Further differentiation of lymphocyte population proved that T-helper lymphocytes decrease in chronic polyarthritis (rheumatoid arthritis) and ankylosing spondylitis (Morbus Bechterew) [17,11]. This results in an increase of the T-suppressor cells which control T-helper lymphocytes by inhibiting their tissue-destroying activity. The control mechanism probably works by means of Langhans' giant cells which express antigenes after cryotherapy in patients with chronic polyarthritis.

In further studies we observed a decrease of interleukine 1, 2 and 4. [22]. The results suggest an immunomodulating effect of whole-body cryotherapy.

Furthermore, we observed a bronchospasmolytic effect in emphysematous bronchitis and bronchial asthma.

2.3 Indications

Based on the current research results, whole-body cryotherapy may successfully be employed as part of a combination therapy in the following diseases:

Inflammatory joint diseases

Degenerative diseases with secondary inflamed components

Spine disorders – inflamed and degenerative

Soft-tissue rheumatic disorders

Collagenoses

REFERENCES:

- [1] Birwe G., Fricke R., Hartmann, R.
Ganzkörper-Kältetherapie – Beeinflussung der subjektiven Beschwerdelinderung und der Gelenkfunktion: Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 18 (1989), p. 11
- [2] Birwe, G. Taghawinejad M. Fricke, R. Hartmann, R.: Beeinflussung hämatologischer und entzündlicher Laborparameter. Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 18 (1989), p. 16
- [3] Blair, E. : Clynical Hypothermia. Mc-Graw-Hill. N.Y. (1964).
- [4] Dowart, B. B. et a1.: Arthritis and Rheumatism 16 (1973) 540.
- [5]Fricke, L., Fricke, R. Wiegelmann, W.: Beeinflussung hormoneller Reaktionen durch Ganzkörper-Kältetherapie. Z. phys. Med. Balneol. Med. Klimatol, Gräfelting 17 (1988), p. 363
- [6] Fricke, R. : Lokale Kryotherapie bei chronisch entzündlichen Gelenkerkrankung drei- bis viermal täglich. Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 17 (1988), p. 196.
- [7] Fricke, R: Lokale Kaltlufttherapie - eine weitere kryotherapeutische Behandlungsmethode. Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 13 (1984), p. 260.
- [8] Fricke, R.: Ganzkörper-Kältetherapie bei -110°C bis -120°C . Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 14 (1985), p. 291
- [9] Ganzkörper-Kältetherapie bei -110°C bis -120°C . Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 14 (1985), p. 291
- [10] Fricke, R.: Ganzkörper-Kältetherapie in einer Kältekammer mit Temperaturen um -110°C . Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 18 (1989), pp. 1 – 10.
- [11] Frye, K.: Promotionsarbeit Univ. Münster /1994).
- [12] Harris, E. D. et al.: New England J. Med. 290 (1974), pp. 1 – 16.
- [13] Janssen, C. E., Waaler, E.: Acta path. et. microbiol scandinav. 69 (1967), p. 577
- [14] Kröling, P., Mühlbauer: Einfluß von Eisbeutel, Kaltluft und N.-Kaltgas auf die gelenknahe elektrische Gelenkschwelle. Phys. Rehab. Kur. Med. 2 (1992), pp. 1 – 6.
- [15] Liman, W., Fricke, R.: Arterielle Durchblutung unter Kryotherapie, bei chron. Polyarthritis. Z. Phys. Med. Balneol. Med. Kimatol 11 (1982), p. 196
- [16] Mense, S.: Effects of Temperature of Muscle Spindles und Tendon Organs.



Pflügers Archiv. Berlin 374 (1978). p. 159.

[17] Pohlen, B., Fricke, R.: Verhalten der Lymphozytenpopulation nach Kältekammer-Therapie. Z. phys. Med. Balneol. Med. Klimatol. Gräfelting 17 (1988), p. 363.

[18] Scheible, H. G.: Neurophysiologie des Gelenkschmerzes, periphere und spinale Mechanismen: Habilitationsschrift. Med. Fakultät Würzburg, (1986).

[19] Taghawinejad, M., Birwe, G., Fricke, R., Hartmann, R.: Ganzkörper-Kältetherapie – Beeinflussung von Kreislauf und Stoffwechselfparametern: Z. phys. Med. Balneol. Med. Klimatol, Gräfelting 18 (1989), S. 23

[20] Yamauchi, T., Nogami, S., Miura, K., Sakawoto, K.: the cryogenic therapy, the exercising therapy and the 24 hours rehabilitation: IX Europäischer Kongreß für Rheumatologie Abstractband (1979), .p. 1025.

[21] Yamauchi, T.: Whole Body Cryotherapy is a method of extreme cold -175°C treatment initially used for Rheumatoid Arthritis: Z. phys. Med. Balneol. Med. Klimatol (1986) p. 311

[22] Richter, Claudia. Fricke, R. study results to be released soon

KEY WORDS:

Local cryotherapy

Whole-body cryotherapy

Rheumatism

Pain reduction

Decrease of tissue temperature

Anti-inflammatory effect

Cold packs

Cold chamber

A 2-minute whole-body cryotherapy at -110°C increases muscle strength and performance

R. Fricke, G. Grappow, T. Nobbe, G. Gnauer



2-MINUTE WHOLE-BODY CRYOTHERAPY AT -110°C INCREASES MUSCLE STRENGTH AND PERFORMANCE

Whole-body cryotherapy at -110°C over 1, 2 and 3 minutes resulted in a maximum increase of muscle strength and performance of knee joints when applied over 2 min. To define optimal intervals for conditioning in sports, pause intervals of 5 instead of 2 min after cold chamber application have been used in this study.

METHOD:

After a 5-min warm-up phase on the ergometer, one healthy knee joint of each of 7 women and men was examined using a Cybex. After an interval of 5 min whole-body cold treatment over 2 min at -110°C was performed. After another pause interval of 5 min a retest on the Cybex was carried out.

Results: Examination of flexion $120^{\circ}/\text{s}$, flexion $60^{\circ}/\text{s}$, extension $120^{\circ}/\text{s}$, extension $60^{\circ}/\text{s}$ showed an increase in peak strength between 2.83% and 3.76% – except for the $120^{\circ}/\text{s}$ extension with a value of -3.35% . Performance examination showed an increase between 3.30% and 18.6%.

DISCUSSION:

Examination results suggest an additional increase of muscle strength and performance in the case of a 5-min pause interval as compared to the pre-tests with a 2-min pause interval.

Examination results of women and men have to be analyzed separately using larger test groups. Further investigations are necessary to determine optimal time intervals of cold chamber application for sports conditioning.

REFERENCES:

Fricke R, Grapow G, Knauer G. Steigerung von Muskelkraft und Leistung durch Ganzkörper-Kältetherapie



SPRINT AFTER 2-MIN WHOLE-BODY EXPOSURE AT -110°C

R. FRICKE, K. HOFFMEISTER, TH. NOBBE, G. KNAUER

WESERLANDKLINIK BAD SEEBRUCH, VLOTHO/GERMANY

Kältetherapie -110°C über 1, 2 und 3 Minuten (*Cryotherapy at -110°C over 1, 2 and 3 minutes*) DRV-Schriften Band 12 (1999) 166-167

Prof. Reinhard Fricke (MD)

Weserlandklinik Bad Seebruch, D-32602 Vlotho

The realization that more red than white muscle fibers are activated during work under cool conditions (fast twitch = FT) strongly suggest further studies in which the influence of whole-body cold exposure on red muscle fibers is tested. In an initial study carried out during a sprint test after WBCE, Esslinger has measured an increase in sprint performance (using a stop watch).

To verify this observation we determined the sprint performance before and after 2-min cold chamber exposure at -110°C using an electronic measurement barrier. In two test groups, the sprint performance after 5m, 10m and 15m was measured. On the 1. day, the medical student group performed two sprint test to familiarize with the study conditions. On the following day, cold chamber exposure at -110°C was carried out. 5 minutes later, the sprint performance was tested again. The results were analyzed separately for men and women. An additional group of physiotherapeutic students (several female and 1 male) performed 3 sprints on the first day. On the 2. day, WBCE was carried out after 3 test runs. 5 min later, 2 additional test runs were measured with a 5-minute interval between tests, and the mean values were calculated.

The results of the sprint tests of untrained men and women showed an increase in sprint performance for both groups, though with different values.

While for the medical student group an increase in performance was measured only after 10m and 15m, the female physiotherapy students increased their sprint performance at all three measurement points. When dividing the medical students in men and women, a performance increase in all three parameters was observed in the men, in the women only for the 15m distance.

The differences between the two groups may probably be explained with a different training condition. It may be assumed that physiotherapy students are physically better trained than medical students.

The differences between men and women are caused by the fact that men have a relatively larger mass of red muscle fibers than women.

The study results suggest an improvement of sprint performance after 2-min whole-body cold exposure at -110°C .

To further verify the study results, an improved standardization of study conditions with respect to technical prerequisites and training condition is planned.



IMPROVEMENT OF MUSCLE STRENGTH AND PERFORMANCE BY MEANS OF WHOLE-BODY CRYOTHERAPY AT -110°C OVER 1, 2 AND 3 MINUTES

FRICKE R., GRAPOW G., KNAUER G.

WESERLANDKLINIK BAD SEEBRUCH, VLOTHO/GERMANY

Test persons who exercised with decreased skin temperature showed a significant higher training effect than controls (Schuh, 1991). During work under cool temperature conditions relatively more red muscle fibers are activated (Brück, 1987). A muscle at rest is activated when rubbed with ice. Whole-body cryotherapy of -110°C over a period of 1 to 3 minutes offers these conditions for activation of the musculature. Therefore, studies to examine the influence of cold on strength and performance of healthy musculature in the lower extremities were carried out.

METHOD:

30 test persons were divided in 3 test groups of 10 persons each. After a warm-up phase, the test groups were treated separately in a cold chamber at -110°C over a period of 3, 2 and 1 minute respectively. Directly prior to therapy, peak strength and performance at flexion rates of 120°/s and 60°/s were tested on the Cybex. Two minutes after cold chamber treatment the same values were examined for each relevant group.

DISCUSSION:

Whole-body cryotherapy at -110°C results in an increase of the peak strength and performance. The best results were obtained after an application time of 2 minutes.

Optimum speeds obtained were flexion 120°/s and extension 60°/s. The rather negative results for flexion 60°/s and extension 120°/s suggest an unfavorable speed for the relevant function. On the other hand, this may also indicate a different distribution and activation of muscle fibers in untrained persons.

The therapeutic effect of whole-body cold therapy may be explained in part by the cool body shell and increase of the aerobic capacity of the muscular metabolism which facilitates the actual aerobic execution of the work. In further studies the impact of cold chamber treatment is examined with reference to intervals between warm-up phase and tests after therapy.

RESULTS:

		1 min	2 min	3 min
Peak strength	Flexion 120 °/s	- 18,3 %	+ 27,6 %	+ 16,9 %
	Flexion 60°/s	+ 18,5 %	+ 36,1 %	- 27,8 %
	Extension 60°/s	+ 3,6 %	+ 84,7 %	+ 28,4 %
	Extension 120°/s	- 52,4 %	- 26,8 %	- 52,4 %
		1 min	2 min	3 min

Performance	Flexion 120°/s	- 16,6 %	+ 39,0 %	+ 49,7 %
	Flexion 60°/s	- 6,6 %	- 45,7 %	- 41,7 %
	Extension 110°/s	- 54,1 %	- 29,3 %	+ 51,8 %
	Extension 60°/s	+ 38,5 %	+ 100,1 %	+ 41,8 %

REFERENCES:

Brück, K. (1987): Warmlaufen oder Kaltstart? Sportliche Höchstleistung durch Kälte Spieg.

Forsch 5. pp. 13-16.

Schuh, A. (1991) Ausdauertraining bei gleichzeitiger Kälteadaption. Phys. Rehab. Kur. Med. 1. pp. 22-28.