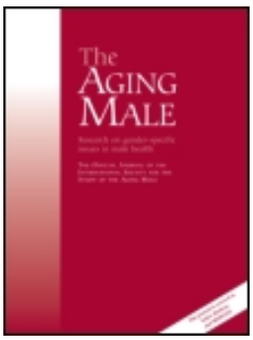

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ORIGINAL ARTICLE

Effect of cryotherapy on the lumbar spine in elderly men with back pain

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Abstract

Whole-body cryotherapy (WBC) is a procedure which is more and more often successfully applied in medicine. Used in physiotherapy programs improves the efficiency of physiotherapeutic exercises applied in different aliments. The aim of the research was to determine the influence of WBC treatment on the improvement of spine activity in elderly men. The evaluation was based on subjects suffering from chronic lower back pain. The research was conducted on 96 male in the age of 65–75 years suffering from chronic pain in the lumbar spine, lasting >3 months. All the subjects performed physical exercises at a gym. Half of the examined patients performed only physical exercises while the second half of the group participated in WBC before performing the same exercises. The research evaluated the mobility of lumbar spine at all movement planes and examined the values of active potentials of erector spinae in the lumbar part of the spine. The group of men who participated in WBC showed significantly lower values of active potentials of erector spinae muscles in the lumbar part of the spine and a significant increase in the range of the lumbar spine mobility, in comparison to the group which did not use WBC.

Keywords

Elderly men, lumbar spine pain symptoms, whole-body cryotherapy

History

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Introduction

Mean increase in the range of spine mobility in patients who were subject to whole-body cryotherapy (WBC) was 69.06% while in the subjects who were not treated with WBC it was only 21.26%. Muscles tension in the WBC group observed after the procedure decreased by 59.25% while the decrease reported in the second group was 32.25%.

Cold therapy is one of the oldest methods of physiotherapy. The first mention of cold treatment dates back to ancient Egypt, 2500 BC. Hippocrates also recommended the use of cold water, flour mush, ice and snow to treat fresh injuries. His point of view was presented in a collection of medical works *Corpus Hippocraticum*. Such treatment effectively stopped bleeding and reduced pain and swelling [1]. Temperatures observed in nature were used in medical treatment until the middle of 19th century. However, temperatures significantly lower than −100 °C were obtained only after scientific progress and the development of gas liquefaction methods. The production of liquefied gases on an industrial-scale, and their storage and applied use in medicine led to the development of cryobiology, a science which studies the effect of freezing temperatures on cells and tissues. In many treatments, low temperatures were initially used to destroy neoplastic and non-neoplastic lesions. But in the 1970s, the Japanese developed the idea of using cold for stimulation. In order to distinguish this method of treatment, it was called cryostimulation. Its creator's name was T. Yamauchi [2,3]. Cryotherapy is the application of a stimulus of a cryotherapeutic temperature (below −100 °C) in a very short time period (2–3 min). It aims to stimulate and use physiological reactions to cold in order to support basic medical treatment and to facilitate the treatment of movement ailments. Clinical results of cryotherapy include: pain relief [4–6] and reflexive congestion of skin and limbs [7]. It has an anti-inflammatory and anti-oedematous effect [8,9]; it reduces muscle tone [10,11], increases muscle strength [12–14], improves mood [15] and additionally has a strong influence on physical capacity [16,17] and the ability to intensify the healing process [18]. Cryotherapy is a safe procedure which does not cause risk of injury [19–21], the activities performed after cryotherapy having a therapeutic effect.

There are articles in world literature presenting the effects of WBC on the human body. But very few of them describe the influence of using low temperatures in treatment of motor organs and low back pain. What is more, research to date has been conducted on young subjects, hence there is no data on the effect of WBC on elderly subjects, particularly in their general treatment or physiotherapy. With the human lifespan increasing, there is encouragement to search for more effective, long-lasting and conservative treatment methods for

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motor organ issues – the life quality of people who suffer from such ailments frequently diminished, resulting in the fact many are often excluded from social life.

The aim of the research in this article was to evaluate the effect of WBC on elderly men with chronic lumbar pain.

Materials and methods

The research was conducted on 96 males in the age range of 65–75 years (mean 69.2) suffering from chronic (lasting >3 months) lower back pain. Interviews with the subjects enabled researchers to determine the characteristics of the pain and its long term effects, while the cause of pain was established on the basis of doctors' diagnosis (X-ray, MRI). In 49 subjects, chronic pain was observed in the discopathy of the lumbar spine. In 25 subjects, it was caused by degenerative changes in the remaining 24 patients the reasons of pain were unspecified.

Patients excluded from the research suffered from acute pain aliments, damage to nerve roots (Lasègue sign of sensory disturbance, paresis) or different diseases, such as: irregular hypertension, osteoporosis or circulatory failure. There were also patients who were unable to participate in the WBC due to health conditions. The current knowledge enables us to determine the following limitations: claustrophobia, cold intolerance, Raynaud's disease, hypothyroidism, acute respiratory disease, cancer, cardiovascular diseases (unstable angina pectoris, aortic valve stenosis or venous stenosis of the left mouth, circulatory failure, dangerous arrhythmias) gangrenous skin lesions, sympathetic neuropathies, local circulatory disorders, emaciation and hypothermia [18,22].

The research was conducted on subjects from a health centre who suffered from the lower back pain. Those with limitations were excluded from the research. The remaining 96 subjects who did participate were randomly divided into two separate groups. Each group contained 46 subjects. Group 1 consisted of the subjects who performed only physical exercises without taking any additional treatments. The exercises were performed at a gym. The subjects in group 2 participated in WBC before performing the same exercises.

Examinations were conducted twice. The first examination was conducted before the commencement of the therapy (Table 1) while the second (Table 2) was a day after the 3-week course. All measurements were taken by the same person and at the same time of day.

Table 1. Examination 1.

Parameter	Group 1	Group 2	*p*
Extension (°)	25.26 (4.73)	26.87 (5.20)	0.1027
Flexion (°)	31.35 (4.21)	30.78 (4.30)	0.5043
Rotation R (°)	31.24 (6.70)	29.04 (5.12)	0.1521
Rotation L (°)	32.04 (7.55)	29.28 (5.17)	0.0712
Flexion R (°)	35.43 (6.08)	33.85 (6.39)	0.2462
Flexion L (°)	32.67 (6.31)	31.43 (5.64)	0.3138
EMG at rest L (μV)	27.78 (4.95)	27.71 (6.33)	0.9315
EMG at rest R (μV)	27.69 (4.68)	28.34 (5.75)	0.5321
EMG flexion L (μV)	36.09 (10.81)	38.07 (7.21)	0.0947
EMG flexion R (μV)	36.41 (11.46)	38.17 (7.76)	0.1598
Pain (mm)	56.21 (11.03)	54.49 (12.25)	0.2568
ADL (pt)	13.32 (4.32)	14.01 (4.99)	0.3487

The WBC treatments were conducted in a Cryotherapeutic chamber type CR 2002, consisting of a vestibule and main chamber (Figure 1) with treatments lasting 3 min. When a subject entered the vestibule, they spent ~30 s at a temperature of −60 °C to adapt to the cold. Next, the subject moved to the main chamber. At a temperature of −120 °C they spent another 3 min, during which they were subject to WBC. After the procedure, the subject joined Group 1 at a gym. The subjects performed the same therapeutic exercises 5 days a week, 45 min a day for a period of 3 weeks, with all exercises being supervised by a qualified physiotherapist. During the research none of the patients used other physical therapy or applied pharmacological treatment.

All subjects were assessed according to DBC (Documentation Based Care) protocol [23]. During research the following measurements of the lumbar spine were taken: active flexion and extension, rotation to the right and left, and lateral flexion to the right and left. Static EMG examined the lumbar erector spinae muscles separately on the right and left side. The research was conducted in a free standing position and at maximum flexion. The researchers also took into account subjective parameters, including a pain scale by the use of VAS and functional limitations determined by ADL (Activities of Daily Living).

Spine mobility was measured by the use of devices applied in the DBC method – devices which are used in functional diagnostics and therapy. Their construction enables

Table 2. Examination 2.

Parameter	Group 1	Group 2	*p*
Extension (°)	25.20 (6.40)	39.72 (5.42)	0.0000
Flexion (°)	41.00 (9.36)	52.85 (3.97)	0.0000
Rotation R (°)	41.13 (9.40)	52.74 (9.87)	0.0000
Rotation L (°)	39.67 (9.69)	52.15 (9.45)	0.0000
Flexion R (°)	40.65 (8.76)	55.20 (5.28)	0.0000
Flexion L (°)	41.43 (7.18)	54.09 (5.65)	0.0000
EMG at rest L (μV)	17.63 (8.04)	7.28 (5.08)	0.0000
EMG at rest P (μV)	16.21 (10.66)	7.58 (6.17)	0.0000
EMG flexion L (μV)	27.50 (11.67)	21.17 (16.29)	0.0071
EMG flexion R (μV)	26.50 (12.91)	20.76 (13.13)	0.0407
Pain (mm)	50.32 (9.98)	21.39 (8.24)	0.0064
ADL (pt)	12.92 (5.01)	12.58 (4.68)	0.3502

Figure 1. Cryo chamber.

the performance of a movement of a selected part of the spine. An angle scale embedded in each device makes it possible to measure the mobility of different parts of a spine (Figure 2). Complete lower limb stabilization was possible due to supports built-in to each device which facilitated taking precise measurements. In order to maintain constant measurement conditions, the settings of the devices were recorded magnetically (height of a seat and feet supporting platform) [23].

Measurement of active flexion and extension of the lumbo-thoracic spine

The measurement of a movement in the sagittal plane was conducted by the use of the device with the symbol LTL (Figure 2A) [23]. During these measurements, the subject remained in a sitting position and their feet were placed on a platform. In order to eliminate compensatory movements, researchers adjusted the height of the platform for each subject and used the mechanism to stabilize hip joint inflexion. The thighs and pelvis were supported by cushions preventing those body parts from rotating. The range of movement was measured by the measurement system set at the height of the spine at the scapula. Upon a signal, the subject performed maximum flexion until reaching the first sensation of pain, then maximum extension to the same extent. Angle values were taken from a scale attached to the device.

Measurement of an active rotation of the lumbo–thoracic spine

The measurement of a movement in the transverse plane was conducted by the use of the device with the symbol LTR (Figure 2B) [23]. During these measurements, the subject remained in a sitting position. The angle between the thighs and trunk was 90°. This position was stabilized by the mechanism. The shoulders of the subject were stabilized by pads which prevented the subject from moving the upper part of the thoracic spine. Upon a signal, a subject performed a maximum rotation to the right and then to the left until the first sensation of pain. Angle values were taken from a scale attached to the device.

Measurement of an active side bend of the lumbo-thoracic spine

The measurement of movement in the frontal plane was conducted by the use of the device with the symbol LTL (Figure 2C) [23]. During these measurements, the subject remained in a sitting position. The angle between the trunk, thighs and lower leg was 90° and the feet rested on a platform. The seat was adjusted to each subject so the rotation axis for all was within the area of the L2 vertebra. The subject was stabilized in that position by a suitable mechanism, an applicator at the height of shoulders. Upon a signal, the subject performed a maximum flexion to the right and then to the left until the first sensation of pain. Angle values were taken from a scale attached to the device.

EMG measurement of erector spinae in the lumbar part of the spine performed at rest and in flexion

The area to be examined was shaved and cleaned with an abrasive paste and alcohol in order to decrease skin resistance [23]. During the placement of electrodes, the patient's body was leaned slightly forward. This position facilitated the optimum placement of electrodes on the skin for examination. Electrodes were placed symmetrically on both sides of the lumbar spine. The first set of electrodes was attached at the

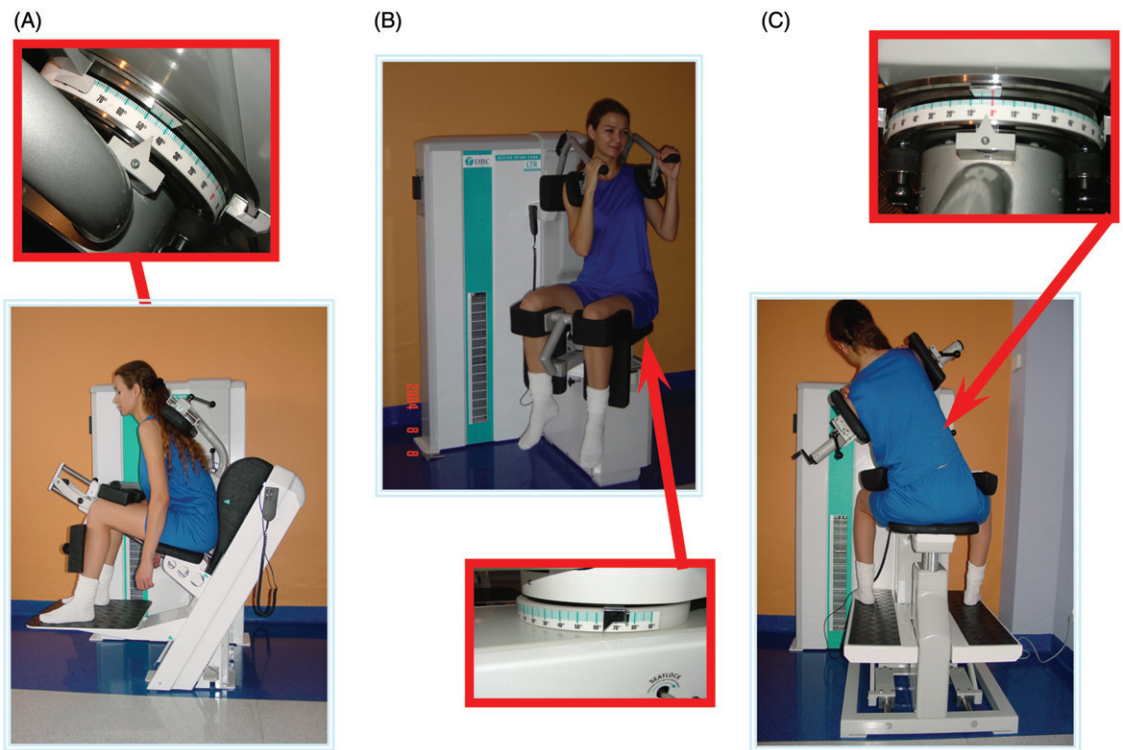

Figure 2. DBC devices applied in the research.

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Figure 3. The placement of EMG electrodes.

level of the L4 and L5 vertebra, while the second was placed at a greater distance from the spine at the level of the L5 and S1 (Figure 3). In order to obtain a comparable EMG signal, researchers used the same configuration for both sets of electrodes (the same resistance between electrodes and signal amplification, and a constant distance between electrodes).

Before being examined, subjects performed a few lumbar flexions and extensions with the aim of checking the reception of EMG signals from both sides of the spine.

The evaluation of patient response was based on a standardized DBC questionnaire. For the purpose of this research, researchers evaluated actual pain measured at the beginning and end of the research. Pain was evaluated on the basis of the VAS scale (Visual Analogue Scale) from 0 to 100 mm. The patient's task was to evaluate the intensity of the pain, regardless of the level of physical fitness. The patient had to put an ''x'' on the scale: the left extreme meant ''no pain'' and the right ''the strongest pain''. At the beginning and end of research, researchers evaluated patients' functional limitations (ADL – Acivities of Daily Living). To accomplish this, they used a scale from 0 to 3 points: 0 stood for ''I don't have any problems with that activity.'', while 3 meant ''I can't do it''. A subject selected the number which corresponded to their ability to perform each activity listed on the questionnaire.

Statistical analysis was performed by the use of Statistica 9 PL software. Both Shapiro-Wilk and Levene's tests were applied to check normal distribution and the homogeneity of variance. The Mann–Whitney *U* test was used to compare the results obtained for both groups. The Wilcoxon signed-rank test evaluated the efficacy results of the therapy for each group. Statistical significance observed was $p < 0.05$.

Results

Tables 1–3 present statistical analysis of the results obtained in the research. Values presented in Table 1 taken for both groups before the beginning of the treatment show no significant differences between the mean values of the examined active parameters of the lumbar spine, values of active potentials of erector spinae in the lumbar part of the spine and subjective pain parameters. This suggests that the function of the spine, subjective feeling of pain and the level of functional difficulties were at the same level.

Table 3. The efficacy of the therapy for the examined groups.

	Group 1	Group 2
Parameter	Exam 2–Exam 1	Exam 2–Exam 1
Extension (°)	0.08570	0.00006
Flexion (°)	0.92010	0.00000
Rotation R (°)	0.16582	0.00072
Rotation L (°)	0.42310	0.00023
Flexion R (°)	0.77210	0.00016
Flexion L (°)	0.82100	0.00021
EMG at rest L (μV)	0.69701	0.00004
EMG at rest R (μV)	0.67752	0.00008
EMG flexion L (μV)	0.87200	0.00015
EMG flexion R (μV)	0.33123	0.00001
Pain (mm)	0.82403	0.00006
ADL (pt)	0.68701	0.00032

The results after the cycle of therapeutic treatment are presented in Table 2. The analysis of these parameters reveals statistically significant differences between the examined groups in all the parameters but the level of functional difficulty. The patients who exercised and participated in WBC showed significantly lower values of active potentials of erector spinae muscles in the lumbar part of the spine and a significant increase in the range of the lumbar spine mobility. The level of pain was also significantly decreased. However, the researchers did not observe any changes at the level of functional difficulty caused by pain. Table 3 contains the results of the comparative analysis of therapy efficacy for both groups. The analysis of the results of the examinations conducted at the beginning and at the end of the therapy did not reveal any significant differences in Group 1. However, differences observed in Group 2 are statistically significant. This enables the researchers to conclude that WBC is effective in treating patients with lower back pain.

Discussion

The aim of the research was to determine the influence of WBC treatment on the improvement of the functional condition of elderly men suffering from lower back pain. Simple measurement methods applied in the study enabled the determination of lumbar spine activity and patients' sensations. Those methods can easily be used in any therapeutic facility.

Lumbar spine activity observed in all patients involved in the therapy was at the same level, no matter the group they were assigned to. Also, the patients did not differ at the level of pain and functional difficulties. The results of Table 2 confirm there were no statistically significant differences in the measurements taken of lumbar spine movement, values of active potentials of the lumbar erector spinae muscles and the level of subjective parameters between the groups.

Statistically significant differences between the groups were, however, observed after the second examination: the cryotherapy treatment. There are many international publications related to an influence of WBC on the human body. These mainly focus on research into biochemical blood

parameters in patients who were subject to WBC. The most popular are those routinely performed in clinical practice, such as morphology [24] or lipid profile [25], those more technical at the hormone level, coagulation and fibrinolysis parameters [24], markers of inflammation [25] and finally those used in scientific research, such as selected components of the antioxidant capacity of the body. Studies were performed on both people who suffered from many diseases to whom cryotherapy was a method of treatment and healthy people who actively participated in competitive sports [26,27]. The positive influence of WBC on elderly men with low back pain proved in this research has been confirmed in the results obtained by other researchers.

Pain related to this ailment [28] causes significant limitation in the movement possibility of patients, and is a reason why patients avoid movement for fear of its increase. Long-lasting, strong pain may also lead to depression [29]. The results obtained by Ramyszewska et al. [15] indicate the positive influence of WBC treatments as a method supporting treatment of patients with a depressive syndrome and anxiety. This treatment may constitute one of the factors which has a positive influence on the improvement of mobility in examined patients.

Another significant factor described by Lange et al. [8] and Algafly et al. [9] is related to anti-inflammatory and analgesic activity of WBC. Anti-inflammatory effect of WBC may result from the influence of low temperatures on the production of inflammatory mediators as well as pro-oxidant – antioxidant balance. It is important in the treatment of nociceptive and neuropathic pain. Nociceptive pain is frequently observed in the course of degenerative joint diseases, rheumatic diseases, spinal pain syndromes and fibromyalgia [30–32]. The therapy decreases pain, muscle tension, inflammatory factors and improves mobility. In the research conducted, cryotherapy enabled the patients to increase work load during exercises and improved their range of movement, resulting in better final results in comparison to the group which did not use WBC.

A study performed by Stanek et al. [33] on ankylosing spondylitis patients treated with WBC showed improved spinal movement, muscle relaxation and an increase in the pain threshold. Metzger et al. [34] used cryotherapy treatment on patients with rheumatoid diseases and observed a significant decrease of pain in those patients. Similar results were obtained by Hirvonen et al. [35] whose research on subjects with rheumatic diseases also shows a reduction in pain. Offenbächer et al. [36] have shown a decrease in pain and in the clinical conditions of patients suffering from fibromyalgia. This has been confirmed by the current research conducted by Bettoni et al. who have established that WBC ease the pain in patients suffering from fibromyalgia. What is more Bettoni et al. [37] used a standardized questionnaire to confirm the improvement quality of life of those patients. Bettoni et al. do oceny bólu i jakości życia zastosował następujące wskaźniki jakościowe: skalę VAS, Short Form-36 [38], Global Heath Status [39] oraz Fatigue Severity Scale [40].

Analgesic activity and an increase in the level of β-endorphin after WBC reported by Zagrobelny [18] has shown a potential increase in patients' willingness to perform physical exercises and to have an influence on better treatment results.

Even though WBC enabled patients to have better spine mobility, decrease muscle tension in the lumbar spine and decrease the sensation of pain, it did not improve functional abilities caused by their ailments. Improvement may have been observed if the treatment had lasted longer. Due to the chronic nature of the ailments observed in patients, the changes which occurred in the body may be too strong, meaning the 3-week treatment may have been too short for the patients to undergo a change. Hence, any observable improvement would require longer observation and research.

Existing textbooks [18] on cryotherapy treat the age of 65 years as the borderline for relative contradiction to using WBC. However, the results obtained in this research have proven that WBC treatments used in elderly men is a safe procedure and effectively improves the process of healing people with lumbar spine pain. This contradiction formed at the beginning of the period when WBC was introduced to medicine as a form of treatment, and was not supported by any scientific research. Its creators had probably in mind the safety of patients, which is why they based the age limit on their knowledge of philosophy, geriatrics and other medical specialties not widely researched. To this day the age limit in using WBC has not changed, but the authors of this article hope their findings will shed a different light on the issue regarding using such treatments on the elderly. They also hope their work will inspire others to further research into the matter.

In summing up, it can be stated that WBC is a procedure which is safe to elderly people. It also significantly improves physiotherapy of people suffering from lower back pain making it more effective.

The limitations of the research acknowledged by its authors are related to the lack of results evaluating the influence of WBC after the procedures have ended. This issue is a subject to further research conducted by the said authors which results will be soon presented.

The authors of the research are aware that chronic pain may cause depression. Such tendency can be also observed in patients with lower back pain. At the same time, lower back pain may be one of its symptoms. This research was mainly focused on the evaluation of functional parameters of the spine, which can be a certain limitation of this article.

Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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