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Temperature distribution in rheumatoid hand after standard infrared treatment

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Introduction. Comprehensive therapy of rheumatoid arthritis (RA), apart from pharmacological treatment, also necessitates an implementation of specialized procedures aimed at improving the mobility, stamina and strength of affected joints. Physical treatments used for the rehabilitation of patients with RA are most often related to thermal stimuli and change the temperature of the tissues. Each change of that kind is linked to the adequate vascular reaction and the changes in blood circulation within the affected area. Aim of the Study. The aim of this present study was to examine vascular changes in rheumatoid hand occurring as a physiological response to the mild thermal stimulus being applied, accounting for individual differences in its progress. Material and Methods.The research embraced 32 patients aged 54.9 ± 6.8 with diagnosed RA according to the standards of American College of Rheumatology. For physical therapy a conventional infrared lamp emitting A, B, C waves with a red colour filter was used. The area under treatment was the dorsal side of the hand. Each subject had eight thermographic pictures taken at the pre-defined time intervals: before the application, immediately after the application, and 5, 15, 30, 45, 60 and 120 minutes after the application. Results. The results were shown in a form of graphic reaction progress of the heated and unheated (contralateral) hand. Average static temperatures of both hands did not show any differences (31.8 ± 1.7°C – heated hand; 31.9 ± 1.8°C – unheated hand). Maximum temperature was obtained immediately following the IR lamp application: 35.0 ± 1.2°C for the heated hand and 32.2 ± 2.1°C for the unheated one. Among all analyzed diagrams showing reaction progress following IR application, four individual groups with the most similar results were formed. Conclusions. For all the patients in the study, a comparable decrease in tissue temperature initially increased by IR application was noted within the next 45 minutes following the application. No subject observed any undesirable reactions.

KEY WORDS: rheumatoid hand, thermotherapy, microcirculation, concensual reaction.

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What is already known on this topic?
The use of IR radiation on the hand leads to a physiological vascular reaction. Vasodilation as a reaction to IR warming is a well-known phenomenon, also in patients with rheumatoid illnesses.

Introduction

Comprehensive management of rheumatoid arthritis (RA), apart from pharmacological treatment, requires an implementation of specialised procedures aimed at improving the mobility, stamina and strength of affected joints. Physiotherapeutic procedures used in rehabilitation of patients with RA are usually related to thermal stimuli.

The effects of cooling procedures generally accepted by patients and, depending on the activity of the disease, also procedures aimed at heating up the tissues include the analgesic effect [1]. Each change in tissue temperature is mainly related to an appropriate vascular reaction and changes in the blood flow in the area [2]. Therefore, as a result of an increase in tissue temperature, there is a gradual dilation of blood vessels, capillary arterioles and skin veins as well as opening of previously closed capillaries. The described changes depend on the activity of the autonomic nervous system which reacts to changes in tissue temperature by nervous fibres supplying appropriate receptive fields [3, 4, 5].

Taking into account the fact that circulating blood distributes heat in the body, any changes to blood flow may be reflected in changes of heat emission on the surface of a given area [6]. Observations of various researchers on the mechanism and dynamics of changes in local microcirculation reveal that such changes are correlated with surface temperature [7, 8, 9]. It also should be noted that body temperature depends on many exogenous factors, such as ambient humidity and temperature, including momentary metabolism, adaptive capabilities of the body [10] and, in particular, in the case of temperature of fingers, time of the day and individual conditions [11].

Some authors indicate that the reactions of microcirculation and distribution of skin temperature after local thermal procedures are characterised by individual variability, which in the case of cryotherapy was confirmed by Mekjavic et al. [12], who identified a different graphic progress of a vascular reaction after stimulation with cold water.

The present study was undertaken since no scientific reports had been found analysing vascular reaction as a physiological response to applied gentle thermal stimuli in view of individual differences. It seemed particularly interesting, from a practical point of view, to carry out such a study in patients with RA who underwent IR procedures in the period of low activity of the disease to facilitate their performance of kinesitherapeutic exercises.

Material and Methods

The study included 32 patients (12 men, 20 women) aged 54.9 ± 6.8 years with diagnosed RA according to the criteria of the American College of Rheumatology (ACR) [13] (valid at the time of the study). The patients' mean BMI was 26.7 ± 4.7 kg/m^2. All patients were informed about the course of the experiment. The study excluded patients who did not express their written consent to participate, or patients with contraindications for thermotherapy and phototherapy. The study was approved by the local Bioethical Committee.

The device used for the procedure was a conventional Lumina infrared lamp (Astar-Polska), emitting IR-A, B, C radiation with a red filter. The area under treatment was the dorsal side of a hand chosen by the patient. During the procedure the IR lamp was placed 30 cm from the body surface, emitting the radiation at a 90 degree angle. The duration of the procedure was 15 minutes.

The analysis of skin surface temperature was carried out using a SC 640 thermal imaging camera (Flir, Sweden), according to the guidelines of the European Association of Thermology [14]. In the study room stable thermal conditions of 22 ± 1°C were maintained as well as humidity of approx. 40%.

Each subject had eight thermographic pictures taken at the pre-defined time intervals, i.e. before the application, immediately after the application, and 5, 15, 30, 45, 60 and 120 minutes after the application.

Results

Figure 1 presents the results in the form of graphic reaction progress of the heated and unheated (contralateral) hands. Mean static temperatures of both hands did not show any differences (31.8 ± 1.7°C – heated hand; 31.9 ± 1.8°C – unheated hand). Maximum temperature was obtained in the measurement immediately following the application: 35.0 ± 1.2°C for the heated hand and 32.2 ± 2.1°C for the unheated one.

From all analysed diagrams showing reaction progress following IR application, four individual groups with the most similar results were isolated: Group I – 15 patients, Group II – 8 patients, Group III – 6 patients and Group IV – 3 patients.

A comparative statistical analysis was carried out with the use of Kruskal-Wallis test between groups, with the exception of Group IV due to its small size. A significant difference was noted between Groups I and III ($p < 0.05$) in mean temperatures, 60 minutes after the procedure (33.1 ± 1.3°C vs. 30.3 ± 3.1°C – heated hand; 32.5 ± 1.9°C vs. 30.6 ± 3.0°C – unheated hand).

What this paper adds?

This is the first study that has attempted to determine different physiological patterns of vascular reaction to heating. The study was performed on rheumatoid arthritis patients.

Discussion

The study results revealed that after an IR radiation procedure all studied RA patients experienced an increase in temperature as a result of direct thermal stimulation, and then a decrease in hand temperature in the first 5 minutes after the procedure. It may suggest that the response to the increase of tissue temperature by a few degrees caused by the procedure was the dilation of skin blood vessels and gradual loss of heat. It should be noted that the course of reaction of microcirculation of the heated and unheated hands in response to the same thermal stimulus was not identical in all patients. Some characteristic properties of vascular reaction, repeatable in many patients could be noted, which made it possible to isolate four different courses of the reaction.

In response to a local increase in tissue temperature blood vessels dilate. This is caused by releasing neuropeptides, such as calcitonin gene-related peptide (CGRP), substance P (SP) and neurokinin A (NKA) by the sensory nerves [15]. The appearance of erythema is probably caused by the release of histamine from skin mast cells, whose strong activators include neuropeptides SP, CGRP and vasoactive intestinal peptide VIP. They cause direct relaxation of vascular smooth muscles and increased production of nitric oxide by endothelial cells [16, 17].

Chorakoudian [2] described a two-phase vascular response in healthy subjects to a local 30-minute stimulus (warm water) heating up the tissue. The first phase, lasting from 3 to 5 minutes, is characterised by a sudden increase in local flow. Then, between 20 and 30 minutes, the second phase is visible, characterised by moderate slowing down of blood transport related probably to a slower vessel dilation, which may be determined by nitric oxide appearing in the area of procedure.

In the interpretation of the profiles obtained in the present study it can be stated that the maximum increase in temperature in the case of both hands occurred immediately after the procedure, which is related directly to the thermal stimulus. In the first 5 minutes a sudden decrease in temperature was noted in all patients, which may indicate a thermoregulatory response of the body to the applied thermal stimulus. In approximately 47% of the patients (Group I) there was a plateau from 5 to 60 minutes after the procedure, described earlier by Charkoudian [2]. In other patients, there was a steady decrease in temperature, including one that lasted until 45 minutes after the procedure in Group II (25%) and until 60 minutes after the procedure in Group III (19%). Differences in temperatures of both hands (heated and unheated) between Groups I and III, 60 minutes after the procedure were statistically significant. The observed differences could be the effect of endogenous factors and individual factors, e.g. local inflammatory processes [18], disturbed metabolism [19, 20] or efficiency of blood vessels. Rutkowski et al. [21] also demonstrated a relationship between the BMI and temperature of hand skin following thermal procedures [21].

In the present study also non-significant differences in distribution of temperatures of the non-stimulated hand (contralateral) were shown. The consensual effect during the application of IR radiation on one hand was confirmed in earlier studies [21]. Although the contralateral reaction had lower dynamics of temperature changes than in the hand subjected to the procedure, in the majority of patients it followed, however, a similar course.

It should be noted that the consensual effect was noted by various authors, both after warm [22] and cold [23] procedures; however, its mechanism has not been explained. Some authors claim that it is a systemic response related to the vegetative system [4, 19], others suggest

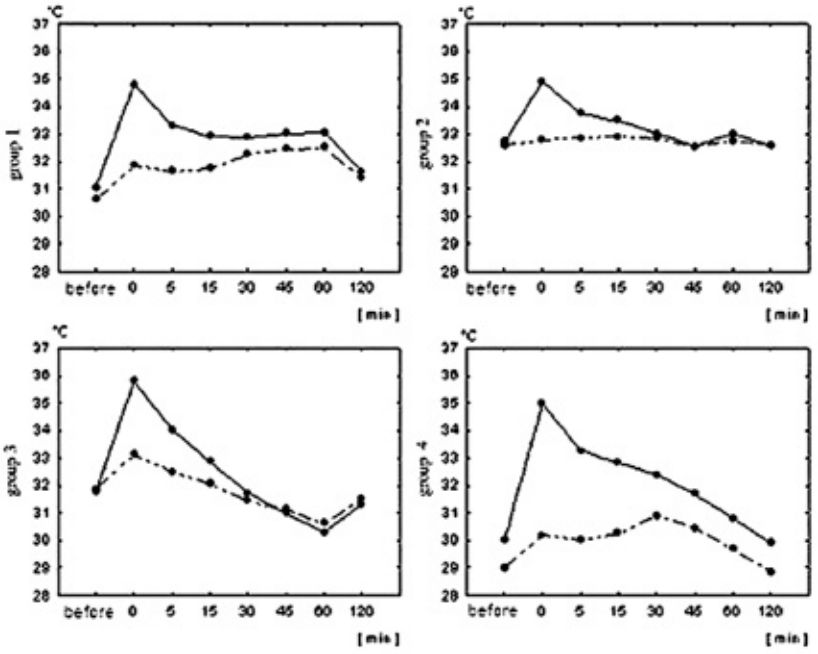

Figure 1. Reaction of heated hand (solid line) and contralateral hand (broken line) in 4 groups during a 120 minute observation

a spinal reflex in which central thermoregulation is not involved [24].

Conclusions

1. In all patients, a comparable decrease of tissue temperature that had increased as a result of IR procedure was noted in the first 45 minutes after the procedure.
2. Some characteristic, repeatable features of the vascular reaction can be noted in many patients, which makes it possible to isolate four different courses of the reaction.
3. None of the patents participating in the study experienced any undesirable reactions.

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