Reductions in body measurements promoted by a garment containing ceramic nanoparticles: a 4-month follow-up study

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Summary

Background Published literature reports significant improvements in pathological conditions, such as pain, blood dyscrasias, and cellulite, after using topical occlusive accessories containing particulate ceramic materials. Recent work reported a reduction in body measurements after 30 days of daily use of high-waist undershorts made of synthetic fabrics with embedded ceramic particles.

Objectives In this study, we investigated whether the use of a garment made with synthetic fibers embedded with powdered ceramic could lead to reductions in body measurements at a longer time span (120 day).

Methods Thirty-two female volunteers wore clothing containing ceramic powder for at least 8 h a day for 120 days. The efficacy of the treatment was evaluated through anthropometric measurements taken before treatment and after 30, 60, and 120 days of treatment.

Results The experimental data showed a more pronounced reduction in body measurements at the beginning of treatment with a trend of stabilization in measured body circumferences during the final 60 days of the experimental period.

Conclusions The experimental data showed that the occlusive treatment with a garment composed of ceramic particles promoted reductions in body measurements during a 120-day experimental period.

Keywords: body measurements, infrared therapy, bioceramic, ceramic nanoparticles, aesthetic, cellulite

Introduction

Published works report that far infrared (FIR) electromagnetic waves are biologically active.[1–3] In addition to increasing the local temperature and inducing vasodilatation, the FIR light triggers analgesic and anti-inflammatory actions[1] among other biological effects. Moreover, some types of ceramics have been reported to emit FIR light when placed in a thermal equilibrium with body temperature; as a consequence of such emissions, therapeutic properties have been attributed to the devices, creams and clothing containing those ceramics.[2,3] The intensities of infrared (IR) light emitted by ceramic devices exposed to human body temperatures are much smaller than those emitted by electrically heated plates and other sources, raising some doubt that the IR ceramic emission is solely responsible for the observed biological effects. Despite the unclear mechanism of action, the modulation of biological parameters by the devices, creams and clothing containing those inorganic particulates has been demonstrated,[4–8] encouraging further investigation on the subject.

Significant improvements in pathological conditions, such as pain, blood dyscrasias,[4–6] and cellulite,[7,8] have

been reported for individuals wearing accessories containing ceramics. A more recent work[9] reported reductions in body measurements after 30 days of daily use of high-waist undershorts made of synthetic fabrics with embedded ceramic particles. However, the time span over which the beneficial effects could be maintained is unknown.

The present investigation was motivated by our previously reported results[9] showing that ceramic-containing garments can be effective, in the short-term, in reducing body perimeter measurements of the waist and the thighs. Therefore, in this work, the biomodulatory effects promoted by the ceramic-containing clothing were evaluated over a longer time period (120 days) by quantifying the reduction in body measurements after daily use of a garment made with 90% polyamide and 10% elastane fibers with embedded ceramic particles.

Material and methods

The study protocol and consent form for participation were approved by an ethics committee. All subjects provided written informed consent for their participation in the study.

The subjects of this research were 32 sedentary female volunteers who ranged from 20 to 60 years old and who were not undergoing any kind of treatment or diet. We refer herein to sedentary people as those people with daily professional activities who do not participate in any type of sport-related activities. Sedentary patients with regular everyday activities and no participation in sports were chosen because they are often overweight to some degree, which matches the inclusion requirements for the present study. The distribution of the body mass index measurements of the sampled population are shown in Figure 1. The participants of the present study were requested to wear the high-waist undershorts made of synthetic fabrics with embedded inorganic particles for at least 8 h a day or even to wear them while sleeping. The clothing used for the study was manufactured with Emana™ fibers and has been previously described.[9]

The exclusion criteria included currently being pregnant or lactating; having an endocrine disease (hypothyroidism, diabetes mellitus), respiratory or circulatory disease, osteoporosis, severe obesity, silicone prosthesis, or dermatitis; using anabolic steroids; and experiencing events of diarrhea during the experimental period.

The biomodulatory effects promoted by the ceramic-containing clothes were evaluated by measuring the change in the measurements of the body perimeters at the anatomical regions defined in Figure 2 and the change in the subject's mass from before treatment to after treatment. The perimeter C1 was measured at the umbilicus, while C2 and C3 were measured 5 cm above and 5 cm below umbilicus, respectively. H, B, and T stands for the hips, the breeches and the thighs, respectively. H was taken at the iliac crest reference and B at the greatest diameter reference.

Results

The box charts in Figure 3a–c shows the measurement results for C1, C2, and C3, respectively, over the 120 day experimental period. Figure 4a-c shows the measurement results for the hips, the breeches and the
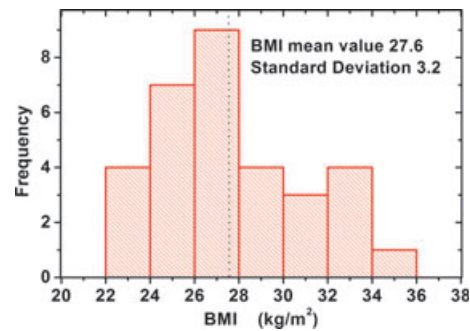

Figure 1 The body mass index distribution for the studied population.
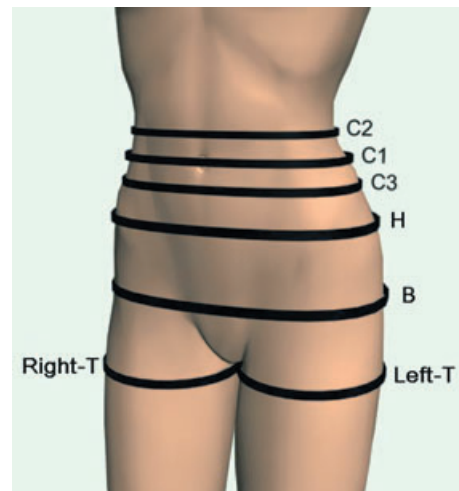

Figure 2 The anatomical locations for the anthropometric measurements. C2 and C3 were taken 5 cm above and below umbilicus, respectively. H, B, and T stand for hip, breeches, and thigh, respectively. The hip measurements were taken at the iliac crest reference point and the breeches measurements were taken at the greatest diameter reference.
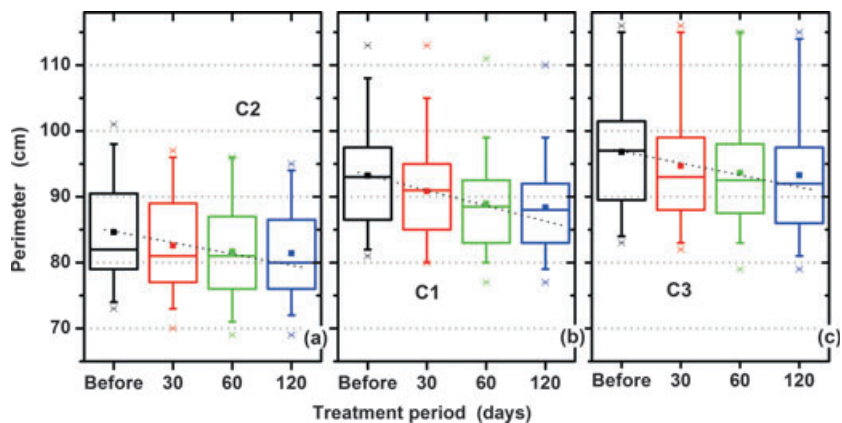
Figure 3 The statistical results before treatment and at the 30th, 60th, and 120th day of treatment for the perimeters for C2 (a), C1 (b), and C3 (c). The dotted lines serve as a visual guide.
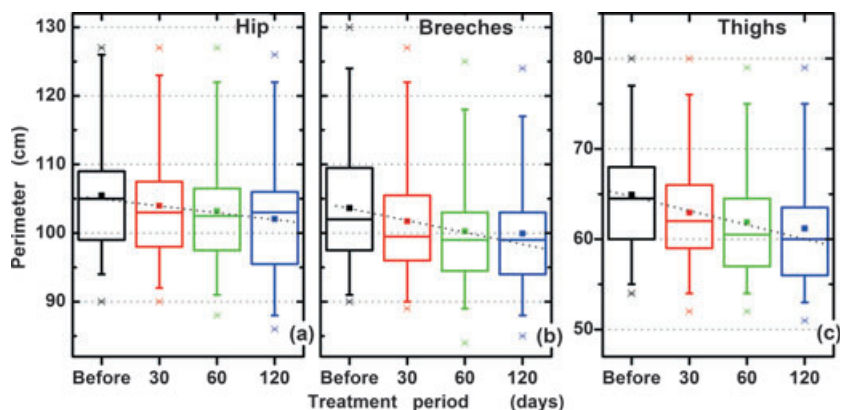

Figure 4 Statistical results before treatment and at the 30th, 60th, and 120th day of treatment for the hips (a), the breeches (b), and the thighs (c). The dotted lines serve as a visual guide.

thighs, respectively. Figure 5 shows the measurement results for the body mass before treatment and after 30, 60, and 120 days of treatment. The results obtained by the Tukey–Kramer multiple comparison statistical test are shown in Tables 1 and 2.

It is intuitive that reductions in circumference, in absolute values, should be larger for subjects having larger body perimeters before treatment. The expectations for reductions in the measurements should also depend on the body mass index (BMI). Therefore, we defined a correction factor F as the following ratio:

$$F = \frac{\text{BMI}}{<\text{BMI}>}, \qquad (1)$$

where BMI was the body mass index for a given subject before the beginning of the treatment and the <BMI> was the mean value of the BMI for the study group, which equals 27.6 kg/m^2 for the population sampled in the present study.
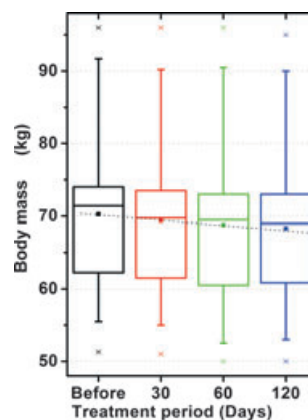

Figure 5 The body mass measurement before treatment and at the 30th, 60th, and 120th day of treatment.

In Figure 6a–c, the F-corrected changes in C1, C2, and C3 after 120 days treatment are plotted against the values of the respective perimeter measured before

Table 1 The results of the Tukey–Kramer multiple comparisons test for C1, C2, C3 and the hip. The differences among the group means are represented by Δ in units of centimetre

Comparison	C1		C2		C3		Hip	
	Δ	*P*	Δ	*P*	Δ	*P*	Δ	*P*
Before × 30	2.38	<0.001***	2.03	<0.001***	2.13	<0.001***	1.50	<0.001***
Before × 60	4.28	<0.001***	2.94	<0.001***	3.19	<0.001***	2.28	<0.001***
Before × 120	4.84	<0.001***	3.22	<0.001***	3.53	<0.001***	3.41	<0.001***
30 × 60	1.91	<0.001***	0.906	ns >0.05	1.06	<0.05*	0.781	ns >0.05
30 × 120	2.47	<0.001***	1.19	<0.05*	1.41	<0.001***	1.91	<0.001***
60 × 120	0.563	ns >0.05	0.281	ns >0.05	0.344	ns >0.05	1.13	<0.01**

ns, the differences between the compared means were not significant.
*The differences between the compared means were significant.
**The differences between the compared means were very significant.
***The differences between the compared means were extremely significant.

Table 2 The results of the Tukey–Kramer multiple comparisons test for the breeches, the thighs, and the body mass measurements. The differences among the group means are represented by Δ in units of cm for the breeches and the thighs and in units of kg for body mass

Comparison	Breeches		Thighs		Mass	
	Δ	*P*	Δ	*P*	Δ	*P*
Before × 30	1.94	<0.01**	1.98	<0.001***	0.872	<0.001***
Before × 60	3.41	<0.001***	3.06	<0.001***	1.47	<0.001***
Before × 120	3.72	<0.001***	3.75	<0.001***	1.92	<0.001***
30 × 60	1.47	<0.05*	1.08	<0.001***	0.600	<0.05*
30 × 120	1.78	<0.01**	1.77	<0.001***	1.05	<0.001***
60 × 120	0.313	ns >0.05	0.688	<0.05*	0.450	ns >0.05

ns, the differences between the compared means were not significant.
*The differences between the compared means were significant.
**The differences between the compared means were very significant.
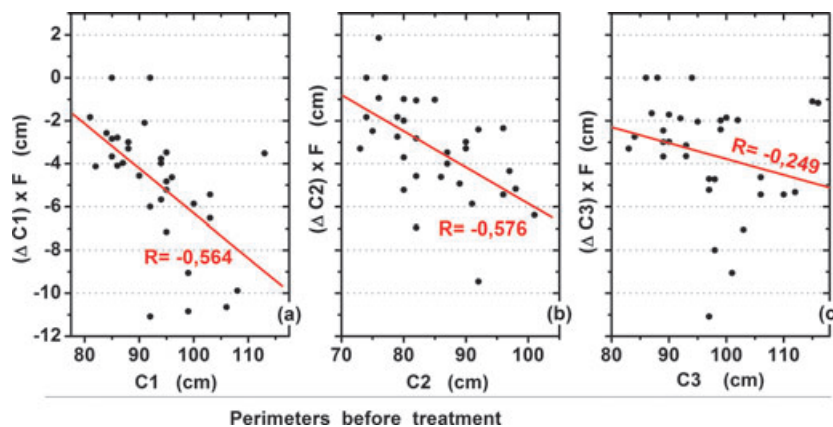***The differences between the compared means were extremely significant.

Figure 6 The *F*-corrected variation after 120 days of treatment plotted against the respective perimeter measured before treatment for C1 (a), C2 (b), and C3 (c). A reasonable correlation with the linear model was obtained for the variables C1 and C2. For C3, the experimental data were weakly correlated with a line.
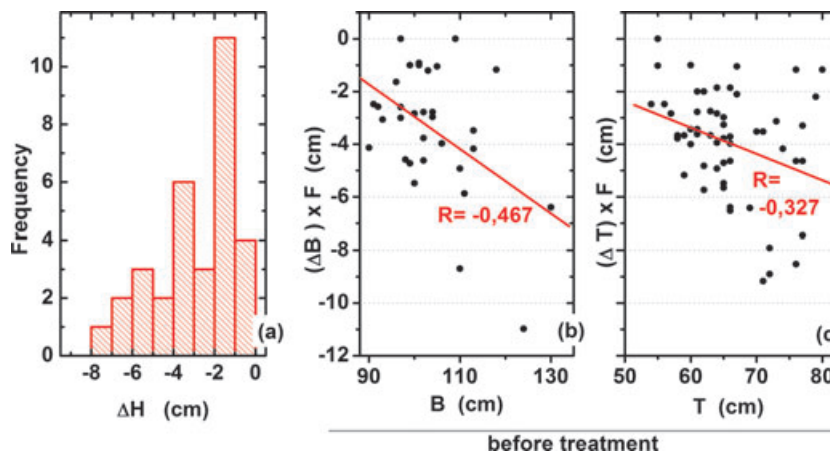
Figure 7 Statistical results for the variation in hip parametric measurements (a) and *F*-corrected variation in breech (b), and thigh (c) measurements after 120 days treatment against respective variable values before treatment.

treatment. The variations in the measurements are represented by $\Delta C1$, $\Delta C2$, and $\Delta C3$. The negative changes represent reductions in the perimeter or in the body mass. The correlation obtained with the linear model for C1 data was $R = -0.564$. A linear fitting of the raw data (not shown), without multiplying by F, returned a correlation value of $R = -0.448$. Thus, the BMI correction factor improved the predictability of the treatment result. Similarly, the correlation obtained with a linear model for the F-corrected reduction in C2 was $R = -0.576$. The linear fitting of the raw C2 data, without multiplying by F, returned a correlation value of $R = -0.469$. For C3, a plot of the F-corrected variation after treatment against the values of C3 measured before treatment showed a poor correlation with the linear model ($R = -0.249$). However, it can be visually observed in the graph that most subjects with a high initial value for C3 were able to achieve large reductions in the C3 perimeter.

In Figure 7a–c, the statistical variations in hip measurements and the F-corrected measurements for the breeches and the thighs are presented. The changes in the hip measurements after treatment showed no linear correlation with the values measured before treatment. In this case, we preferred to show the results in a histogram (Fig. 7a). It should be noted that all experimental subjects reduced their hip perimeters.

Figure 8 shows the F-corrected variation in body mass, resulting from the 120-day treatment, against the measurements taken before treatment and the correlation with a line model.

The photographs in Figure 9 show the front and back view for one of the subjects of the present research before and after treatment. The aesthetic
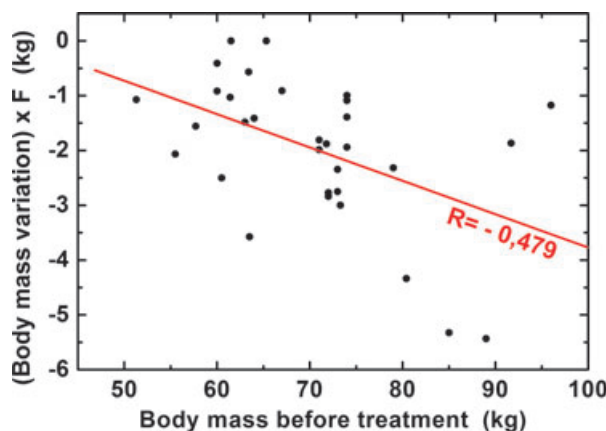

Figure 8 The *F*-corrected variation in body mass after 120 days of treatment plotted against the body mass measured before treatment.

improvement in the body silhouette is evident, as is the improvement in skin texture due to a reduction in cellulite.

Discussion

A continued decrease in the mean values was observed for all the perimetric and body mass measurements taken before treatment and after 30, 60, and 120 days of treatment. The statistical comparisons among the mean differences of before treatment *vs.* the 30th treatment day were extremely significant for all the studied variables. For the thigh and hip measurements, the applied test returned statistically significant differences between the means when comparing all sequential measurement periods, i.e. (before × 30th day,

Figure 9 The front and back view of one subject of the present research before and after treatment. The shown subject had an initial BMI of 27.2 kg/m^2, which was close to the mean value of 27.6 kg/m^2 for the sampled population.

30th day × 60th day and 60th day × 120th day). The remaining variables showed no statistically significant differences between the means for the sequential measurement periods of days 60 and 120. Therefore, the reductions in the body measurements promoted by the ceramic-containing garment were more pronounced during the first half of the experimental 120-day period with a trend to plateau during the second half of the experimental period. Although the reductions in some of the perimeters and in the body mass were not statistically significant among the last two data collection periods (60 × 120 days), the subjects who continued to use the ceramic-containing garment until the end of the experiment did not return to their baseline measurements. Instead, these patients were able to maintain the reduced measurements that they had achieved, which is an important result.

Figures 6 and 7 show that only a few subjects had no change in the measured variable values. For instance, only 3 of the 32 subjects showed no change in the C3 perimeter after 120 days of treatment (Fig. 6c), while 100% of the subjects reduced their hip measurement to some extent (Fig. 7a). Only 2 of the 32 subjects had no reduction in body mass (Fig. 8). The mean reduction in body mass was 1.94 kg (with a 1.27 standard deviation); one subject lost 5 kg, and two subjects did not show any loss after 120 days. Figures 6–8 show that subjects with similar initial characteristics responded with different intensities to the treatment. The differences in response may be, to some extent, due to the subjects' adherence to and compliance with the proposed treatment.

Although the mechanism of action is not well established yet, the modulation of biological parameters by devices, creams and clothing containing ceramic particulates has been proven.[4–8] The results of the present work further support the efficacy of wearing an accessory made with synthetic fibers containing inorganic particulates for reducing body measurements and mass over 120 days. The short-term (1 month) results published from our previous work[9] raised the issues that the observed results could be simply a consequence of hydric losses; the consistency of the data along the 120-day experimental period shown in the present work suggests that the observed reductions in anatomic perimeters and in body mass may be effective and not due only to hydric losses. As a consequence, garments similar to those used in this study may find practical clinical application as an effective supplemental therapy for aesthetic treatments.

The results described from the current study are possibly due to an improvement in blood perfusion and stimulation in lymphatic drainage, which may be primarily a consequence of an incremental increase in the local temperature. It has been cited that a 1 °C rise in tissue temperature may increase the local metabolic rate by as much as 13%.[10]

In addition, a rise in tissue temperature induced by the topical use of inorganic powders has been reported. Yoo *et al.*[2] prepared emulsion creams containing powdered tourmaline or jade. On one side of the study volunteers' faces, the researchers applied the sample creams containing the jewelry powder; on the other side of their faces, the researchers applied a control cream containing no jewelry powder. The authors measured a temperature increase of 1 °C on the side of the face that received the cream containing jewelry powder, and they associated this temperature elevation with the augmented microcirculation induced by the treatment. This hypothesis is strengthened by the work

reported by Gordon and Berbrayer,[4] who treated Raynaud's syndrome patients with ceramic-containing gloves. A mean temperature increase of 1 °C in the finger dorsum of the patients who wore the ceramic gloves was reported, suggesting that the gloves, made active by the incorporated ceramic, were beneficial in the management of Raynaud's symptoms. Several published works have attributed the observed biological effects to the intrinsic infrared emission capability of the ceramic devices and accessories.[2,3,5] It has also been suggested that a wearable piece of clothing, such as the one used in this work, may interfere with the radiant heat exchange between the body and the surrounding medium, thereby working as a radiation trap that sends some amount of the infrared rays back toward the body.[9] A thorough discussion of how each of these hypotheses participates as contributing factor has been presented elsewhere.[9] Further experiments are required for a better mechanistic understanding of the processes responsible for the results presented here.

Conclusion

The biomodulatory effects promoted by a piece of clothing made with ceramic-containing polyamide and elastane fibers were evaluated through anthropometric measurements along an experimental period of 120 days. The reductions in body measurements and body mass were observed. More prominent reductions in body circumferences and mass were observed during the first half of the experimental period, with a trend for maintenance during the second half of the experimental period. The observed results might have been promoted by a manipulation of the infrared radiation by the occluding garment. The obtained results show that garments of the type used in the present research may find practical clinical application in aesthetic treatments for improvement in skin health, acting as effective supplemental therapies for the treatment of cellulite and striae distensae.

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