Investigation of the impact of a body-own reflection of electro-magnetic waves on the functional state of microcirculation thanks to the use of a special skin patch

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Introduction and mission

Today, it is generally recognized that very many diseases are caused by disturbances to local blood circulation regulation or that restrictions to blood circulation regulation accompany disease process with their own dynamics [6, 15].

In blood vessels with diameters smaller than 100 µm, the microcirculation of human blood has an impact on all supply procedures between blood and tissue cells.

Therefore, in terms of function, this is the most important part of blood circulation, because this is where the exchange between blood and somatic cells as well as where the first immunological reactions take place [6, 15, 17, 18, 19].

Disturbances to microcirculation always lead to restrictions or disturbances of cell and organ functions – all the way to cell death. Without an adequate functioning of microcirculation, restitution and a complete recovery are not possible. This explains the major prophylactic and protective significance of therapy able to influence restricted or disturbed microcirculation relevantly [4,5,6–15].

According to today's state of knowledge, for local blood circulation regulation, the vasomotion of large and small caliber arteriole sections is essential.
Circulation is regulated by diameter periodicities steered by nerves and / or hormones.
Spontaneous and autorhythmic vasomotion, however, occurs in small caliber arterioles.

This is how blood circulation is adapted in a metabolism-conform manner, i.e. by the distribution of a plasma blood cell mixture in the capillary networks. Shear stress-dependent arteriole tonus regulation, ensured by endothelium via nitrogen monoxide, plays a tremendous role.

In addition to these mechanisms, most probably, other mechanisms are also involved that, to date, have only been explored insufficiently (molecular-biological processes, channels, membrane phenomena, etc.) [2–19].

The energy radiated from the surface of a body to the environment (mainly electro-magnetic waves in the infrared range), consists of thermal radiation in form of complex waves, ergo information on the cell activity of those tissue structures from which convection and conduction as well as radiation are dissipated.
Correspondingly, the amplitude frequency spectrum of these complex waves is not only an indicator of the functional state of the tissue, it also stands to reason that the reflection of body-own radiation is able to influence regulation mechanisms and ensure the body's own stimulation. The following observations will focus on the significant characteristics of local blood circulation regulation.

Based on the hypothesis described above, a multi-layer skin patch (test product) offering a self-stimulation effect, according to the inventors, was developed empirically.*

Within the scope of GCP-compliant clinical research, random samples were checked by means of valid measuring methods, based on representative characteristics, in order to determine whether and to which degree, body-own radiation can have a medically-relevant impact on microcirculation, thanks to the use of a special product ensuring back reflection.

Materials and methods

Figure 1 shows the build-up of layers of the test product and its layout on the skin surface (diameter of approx. 3 cm, local application).

Four series of investigations involving the test product in use as an insole were carried out within the scope of general clinical research.

Combined white light spectroscopy and a laser DOPPLER micro flow measurement (system LEA, D) were used as validated, state-of-the-art measurement methods. Measurement values were checked simultaneously at 2 different penetration levels, every 20 ms (approx. 2 mm — subcutaneous 6–8 mm micro-vessels in skeletal muscles).

The following literature provides validation information: 2, 6–16, 20, 21].

Measuring points were the left ankle area and the left calf (micro-vascular networks in the subcutis and in the skeletal muscle).

The characteristics investigated were:

- Venule oxygen saturation, ΔpO_2.
- Flow of red blood cells, Q_{RBC}.

All test persons were submitted to light 60-minute exercise on the treadmill.

* Company: Delin GmbH, Rotkreuz CH
Swiss Federal Institute of Intellectual Property (IPI), Department for patents. CH-3003 Bern.
Patent application no. 00930/17.

The measurements were carried out at specific times:

a – Definition of output values
b –Immediately after 60 minutes on the treadmill
c –After 15 minutes on the treadmill
d -After 30 minutes on the treadmill

The samples were taken randomly (random generator) and subdivided into 2 partial random samples of the same size, i.e.:

The control group (placebo insole).
The verum group (use of the test product)

For statistical verification purposes, the measurement data was compiled by means of the WILCOXON rank-sum test application (alpha=5%). Information on the critical T values was derived from standard literature [1].

1st research series

Examination of a mainly homogenous overall random sample group consisting of 32 male and female (untrained) test persons (examined by GPs, without pathological findings, exposed to infections and stress) who were subdivided into 2 partial same-sized random samples of male and female test persons (control group, verum group).

Table 1 informs of the constitution of these test persons:

2nd research series

Examination of an overall random sample consisting of 32 male and female (untrained) test persons with diabetes mellitus type II (diabetes controlled, no or very low dosages of insulin, diet and exercise prescribed, other than this, without pathological findings by GPs). The test persons were subdivided into 2 partial random sample groups of the same size, with the same number of male and female test persons (control group, verum group).

Table 2 informs of the constitution of these test persons:

3rd research series

Examination of a mainly homogenous overall random sample group consisting of 16 male and female (untrained) test persons (examined by GPs, without pathological findings, exposed to infections and stress). An intra-individual blind comparison was carried out in this group (time period between the comparison of the control and the verum group: 7 days).

Table 3 informs of the constitution of these test persons:

4th research series

Examination of an overall random sample consisting of 24 male and female (untrained) test persons with diabetes mellitus type II (diabetes controlled, no or very low dosages of insulin, diet and exercise prescribed, other than this, without pathological findings by GPs). The test persons were subdivided into 2 partial random sample groups of the same size, with the same number of male and female test persons (control group, verum group).

The test product, that is to say the placebo, was worn day and night, thanks to a special fixture, across a period of 7 days.

Every day, the test persons carried out light exercise on the treadmill for approx. 60 minutes.

The daily measurement times were:

Day 0: (initial values), days 1 to 7 (always at the same time of day, i.e. 1 hour after exercising on the treadmill).

Table 4 informs of the constitution of these test persons:

To examine wound healing, 2 research series were carried out. The test product was worn over common wound dressing

Within the scope of a GCP-compliant (placebo-controlled) research series, a random sample group of 28 male and female patients (examined by GPs, without pathological findings) for whom a nevus (in the breast or stomach area) had been removed, were examined. The length of the surgical incision amounted to 3 to 4 cm. The random sample group was subdivided into 2 partial random sample groups of the same size, composed of male and female test persons (control and verum group).

Control group: Common wound dressing, without use of the test product on the wound dressing.

Verum group: Common wound dressing, with use of the test product on the wound dressing.

Constitution data of the test persons: ~ 45 years of age, ~ 75 kg, ~ 174 cm.

Venule oxygen saturation in the subcutaneous micro-vessel networks was measured (combined white light spectroscopy and laser DOPPLER micro-flow measurements) at a distance of 3 to 4 mm from a surgical cut (wound edge) as well as in uninjured skin tissue, at a distance of approx. 5 cm from the edge of the wound.

The measurements were carried out at the following times:

0.d - Immediately after surgery and from then on, daily (days 1 to 10).

The differences in characteristics between the wound edge and in the uninjured skin area were compared.

A further research series served to evaluate scarring.

A random sample group consisting of 24 male test persons between 50 and 60 years of age, with a slight form of diabetes mellitus type II (corrected) were subdivided into 2 partial random sample groups of the same size and examined, post-surgical nevus removal.

Control group: (common wound treatment without the test product).

Verum group: (common wound treatment with the test product, use of the test product up until day 10 after surgery, on common wound dressing).

On the 60th day after surgery, a special reflected light microscope and computer-aided image processing (reference: perthometer) as well as surface thermogrammetry, based on use of cholesterol liquid crystal mixtures, according to international standard [3], were used for examination purposes. The scar tissue was measured at its center (red scar) as well as in the same area of uninjured skin tissue as before, i.e. at a distance of approx. 6 cm from the edge of the scar. Thus, the following parameters were determined:

Maximum surface roughness,
Rmax.
Skin surface temperature, T.

The statistical evaluation of the measurement data was carried out in compliance with the WILCOXON rank-sum test (alpha = 5%).

Results of the general clinical examination

Tables 5 and 6 as well as 7 and 8 inform of venule oxygen saturation and the flow of red blood cells in both target regions during the 1st research series (test persons without pathological findings). All measurement data demonstrates significant differences between the initial values and the values determined at the measurement times listed below.

Figures 2 and 3 show the measurement data for the parameters venule oxygen saturation, ΔpO_2, and red blood cell flow, Q_{RBC} in both target regions, in summary, during the 2nd research series (diabetes mellitus type II patients). All parameters measured in both target regions demonstrate significant differences between the initial values and the measurement times listed in the following.

Table 1. *Constitution data of the test persons in the 1st research series*

	Gender m / f	Age (years)	Height	Weight (kg)	BMI
Mean value	16 m / 16 w	39,3	175,3	77,6	25,3
Standard deviation		2,40	2,68	2,12	0,47

Table 2. *Constitution data of the test persons in the 2nd research series*

	Gender m / f	Age (years)	Height (cm)	Weight (kg)	BMI
Mean value	16 m / 16 w	54,4	174,3	84,4	27,8
Standard deviation		4,47	3,79	5,44	1,66

Table 3. *Constitution data of the test persons in the 3rd research series*

	Gender m / f	Age (years)	Height (cm)	Weight (kg)	BMI
Mean value	8 m / 8 w	47,8	175,5	77,3	25,1
Standard deviation		4,61	4,86	4,32	0,54

Table 4. *Constitution data of the test persons in the 4th research series*

	Gender m / f	Age (years)	Height (cm)	Weight (kg)	BMI
Mean value	12 m / 12 w	50,3	176,0	77,9	25,2
Standard deviation		4,16	3,73	4,22	1,29

Table 5. *Measurement data 1st research series - parameter: venule oxygen saturation, ΔpO_2, in the left ankle region*

Deviations in percentages, in comparison to the initial measurement values / times:
a — Initial values.
b — Immediately after 60 min. on the treadmill
c — After 15 minutes on the treadmill.
d — After 30 minutes on the treadmill

Ankle/subcutis — Control

	a	B	c	d
Mean value	0	-3,6	-3,5	-3,3
Standard deviation	0	3,80	3,66	3,49

Ankle/subcutis — Verum

	a	B	c	d
Mean value	0	15,9	5,9	3,4
Standard deviation	0	5,33	2,32	2,64

Ankle/muscle — Control

	a	B	c	d
Mean value	0	-4,1	-3,8	-3,5
Standard deviation	0	4,98	4,81	4,52

Ankle/muscle — Verum

	a	B	c	d
Mean value	0	-3,6	-3,5	-3,3
Standard deviation	0	3,80	3,66	3,49

Table 6. *Measurement data from the 1st research series on the parameter venule oxygen saturation, ΔpO_2, in the left calf*

Deviations in percentages, in comparison to the initial measurement values / times:

Measurement times:

a — Definition of initial values.
b — Immediately after 60 minutes on the treadmill
c — After 15 minutes on the treadmill
d — After 30 minutes on the treadmill

Calf/subcutis — Control group

	A	b	c	d
Mean value	0	-5,9	-5,5	-5,0
Standard deviation	0	1,45	1,44	1,37

Calf/subcutis — Verum group

	A	b	c	d
Mean value	0	4,8	3,2	2,0
Standard deviation	0	2,02	1,68	1,29

Calf/muscle — Control group

	A	b	c	d
Mean value	0	-5,5	-5,0	-4,5
Standard deviation	0	1,64	1,68	1,70

Calf/muscle — Verum group

	A	b	c	d
Mean value	0	15,1	6,8	4,1
Standard deviation	0	4,73	2,33	1,86

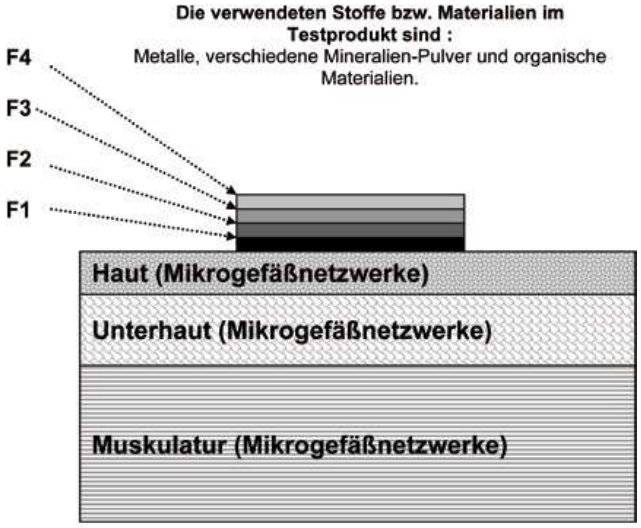
Select measurement results of the intra-individual comparison (3rd research series)for the parameters venule oxygen saturation, ΔpO_2, and red blood cell flow, Q_{RBC}, in the ankle region are illustrated in figures 4 and 5, with significant differences determined between the initial values and the measurement times listed in the following.

The measurement data from the 4th research series (7 day-use of the test product)is shown in figures 6and7.Significant differences between the control and the verum groups were determined for all parameters investigated as of day 1, up until day 7.

Wound healing results

Within the scope of the research series, across a time period of 10 days, venule oxygen saturation, ΔpO_2, in the skin was measured at a distance of 3 to 4 mm from the surgical cut as well as at a distance of 5 cm in the uninjured skin tissue. Immediately after surgery (day 0), the difference between the measurement data from both skin regions was set to 100%. Thus, a difference of 0% would mean that there is no difference between the parameters measured at the surgical cut and in the surrounding uninjured skin tissue. Figure 8 shows the measurement data recorded. As of day1, significant differences in the control group could be made out, i.e. 37,1%, in comparison to 13,4% in the verum group

A further research series investigated scarring on the 60th day after surgery (red scar). The following parameter were measured: maximum ***roughness depth***, ΔRmax acc. to DIN; indicated as the difference, in percentages, in comparison to the value determined in the surrounding skin tissue which equals 100%. Moreover, the skin surface temperature, ΔT, was determined and indicated as the difference in °Cin the surrounding skin tissue. The measurement data is provided in table 8. The data measured for the control and the verum group varied significantly.



F1 – Basisfolie und Klebeschicht.
F2 – Organischer Halbleiter db-21.
F3 – Schutzfolie.
F4 – Abschlussfolie mit Schutzschicht (Verguß oder transparente Folie).

[1] ***Figure 1.***

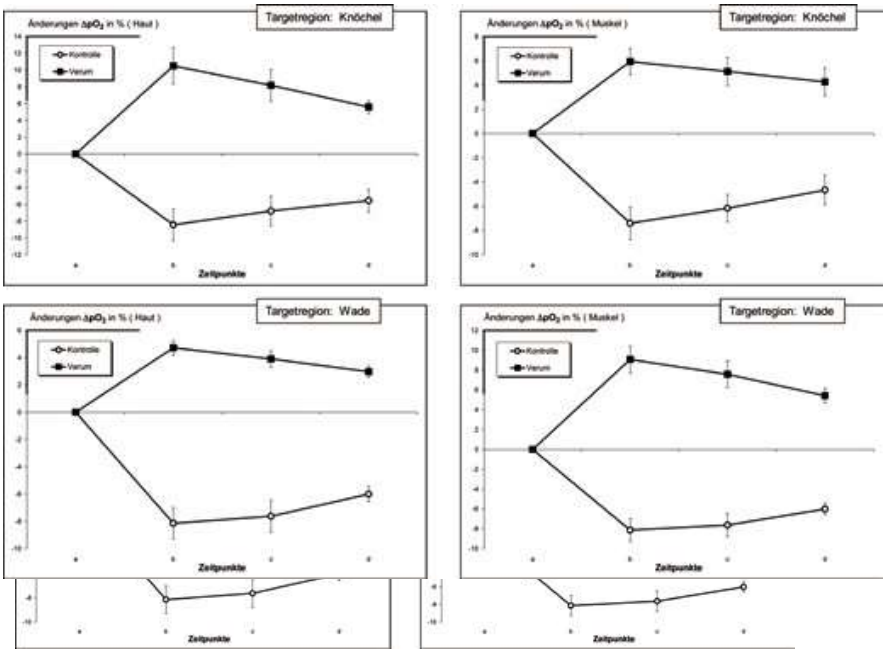


Figure 2. *Layers and structure of the test object on the skin surface (scheme)*

[1] Test product materials used: metals, various different mineral powders and organic materials
Skin (micro-vessel networks)
Subcutis (micro-vessel networks)
Muscles (micro-vessel networks)
F1 – basic foil and adhesive layer
F2 – organic semi-conductor db-21
F3 – protective foil
F4 – closing foil with protective layer (e.g. transparent foil)
Differences in % (skin), (muscle) / Target region: calf / ankle
Measurement times

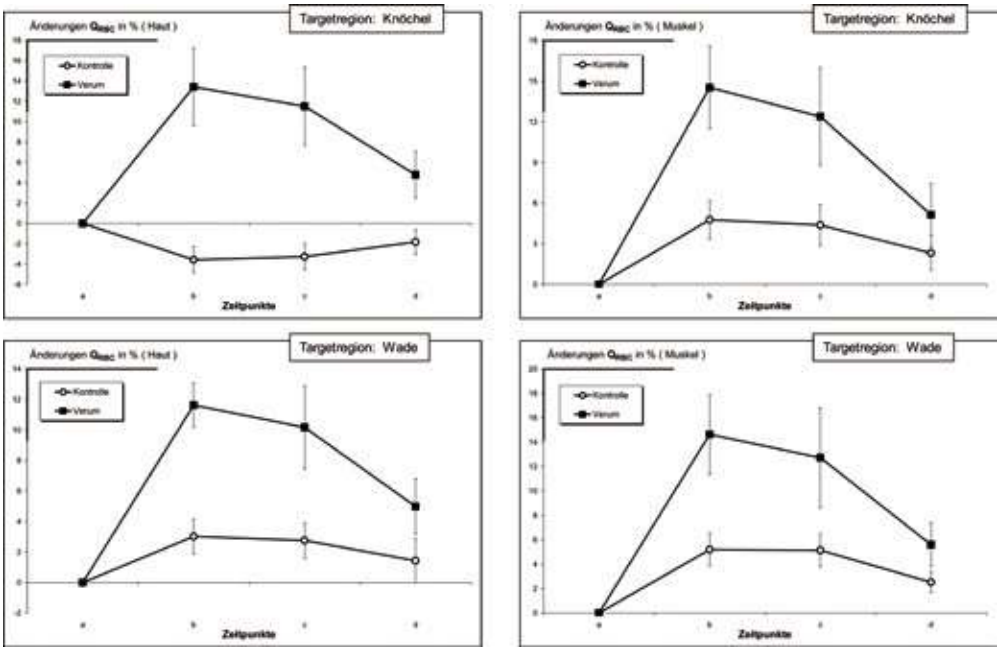


Figure **3.** *Summary of the measurement data from the 2nd research series on the parameter venule oxygen saturation, ΔpO_2, in the left ankle region and the left calf (mean values and standard deviation) differences in comparison to the initial values in percentages*

Measurement times:

a — Definition of the initial values.

b — Immediately after 60 minutes on the treadmill

c — After 15 minutes on the treadmill

d — After 30 minutes on the treadmill

Discussion

Taking into consideration the results of the general clinical tests (research series 1 to 4), significant differences between the control and the verum group could be made out. Use of the test product led to improvements of the functional state of subcutis and skeletal muscle microcirculation in the ankle and calf regions examined.

The proven effect of the test product speaks in favor of the body's own stimulation of the most important local regulation mechanism of circulation, i.e. spontaneous auto-rhythmic vasomotion of arteriolar micro-vessels. This is proven by the venule oxygen saturation and the red blood cell flow values. The wave reflected back into the tissue by the test product is obviously configured so that this regulation mechanism is stimulated physiologically. Whether other (intracellular) phenomena are involved or not, cannot be assessed at the moment, given the current state of knowledge.

The examinations were carried out in the ankle region of the lower extremities – a preferred tissue area for the development and manifestation of circulatory disturbances (in particular for diabetes mellitus type II patients but also for persons subjected to extraordinary physical burdens). In addition, the calf region subjected to particular stress during the treadmill exercise was also examined.

Thus, an evaluation of circulation physiology and metabolism was included in the measurement results [3, 6, 15, 17, 18, 19].

In the event of serious diseases, because of the insufficient contribution to parameter changes, no causal-therapeutic efficacy can be attributed to the test product. The test product is, however, suitable as a complementary measure to recognized treatment measures (prophylaxis and protection, increase of the therapeutic success of established treatment options).

The effect of the test product, as determined, allows for recommendation for use in the following fields: Prophylaxis, in particular for persons professionally exposed to wetness, cold, etc.; sports, and primarily elderly persons with restricted circulation regulation, etc. as well as enhancing the ability to support greater physical burdens.

The prophylactic and adjuvant-therapeutic significance of use of the test product involves a better adaptation of microcirculation to changing metabolic requirements. Furthermore, the research results show that use of the test product can lead to a better regulation of body heat, a lessening of susceptibility for infections, i.e. a better immune response thus, to a certain degree, to a better quality of life and greater performance.

Table 7 *Measurement data from the 1st research series on the characteristic red blood cell flow, Q_{RBC}, in the left ankle region*

Differences to the initial values (measurement times) provided in percentages

Time measurement points

a — Definition of initial values
b — Immediately after 60 minutes on the treadmill
c — After 15 minutes on the treadmill
d — After 30 minutes on the treadmill

Ankle/subcutis — Control

	a	b	c	d
Mean value	0	1,4	1,2	1,4
Standard deviation	0	0,86	0,81	1,61

Ankle/subcutis — Verum

	a	b	c	d
Mean value	0	26,1	9,6	5,2
Standard deviation	0	8,86	4,30	2,21

Ankle/muscle — Control

	a	b	c	d

Mean value	0	2,8	2,5	2,3
Standard deviation	0	1,09	1,12	1,06

Ankle/muscle Verum

	a	b	c	d
Mean value	0	21,9	8,4	4,5
Standard deviation	0	9,27	2,82	2,05

Table 8. *Measurement data from the 1st research series on the parameter red blood cell flow, Q_{RBC}, in the left calf*

Differences to the initial values (measurement times) provided in percentages

Measurement times:

a — Definition of the initial values.
b — Immediately after 60 minutes on the treadmill
c — After 15 minutes on the treadmill
d — After 30 minutes on the treadmill

Calf/subcutis Control

	a	b	c	d
Mean value	0	3,1	2,9	2,6
Standard deviation	0	0,83	0,88	0,93

Calf/subcutis Verum

	a	b	c	d
Mean value	0	21,0	8,3	4,5
Standard deviation	0	8,33	2,81	2,12

Calf/muscle Control

	a	b	c	d
Mean value	0	4,4	4,0	3,4
Standard deviation	0	0,92	1,02	0,99

Calf/muscle Verum

	a	b	c	d
Mean value	0	26,3	10,0	5,6
Standard deviation	0	7,94	4,27	2,29

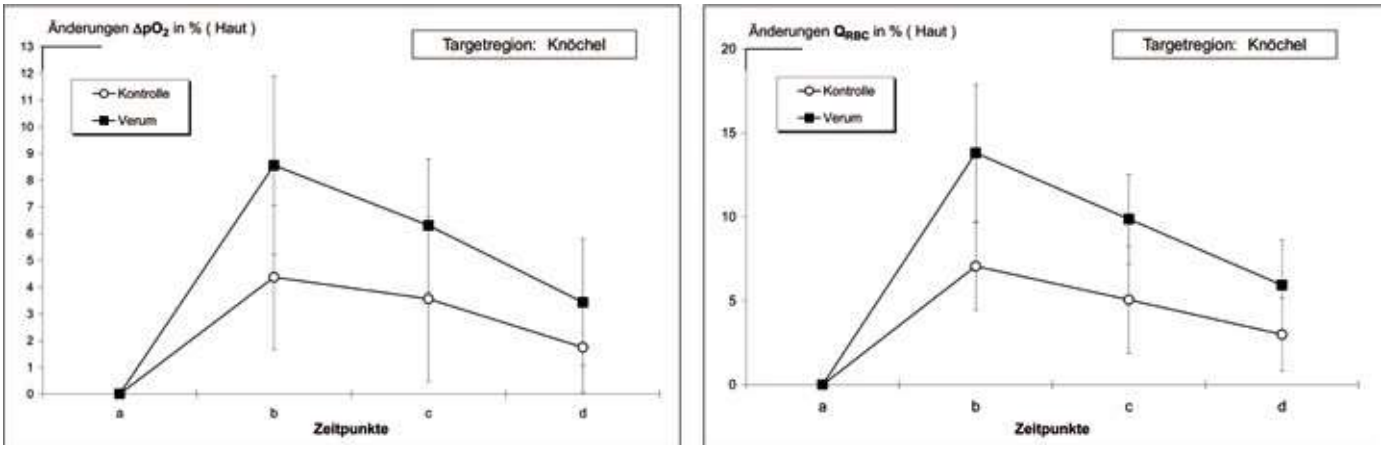


Figure 4. *Summary of measurement data from the 3rd research series on venule oxygen saturation, ΔpO_2, in the left ankle region(subcutis).(Mean values and standard deviations). Differences in percentages in comparison to the initial values.*

Measurement times:

a — Definition of the initial values

b — Immediately after 60 on the treadmill

c — After 15 minutes on the treadmill

d — After 30 minutes on the treadmill.

Figure.5. *Summary of measurement data from the 3rd research series on red blood cell flow, Q_{RBC}, in the left ankle region(subcutis). (Mean values and standard deviations). Differences in percentages in comparison to the initial values.*

Measurement times:

a — Definition of the initial values

b — Immediately after 60 minutes on the treadmill

c — After 15 minutes on the treadmill

d — After 30 minutes on the treadmill.

The research results also demonstrate that using the test object on common clinical wound dressings, to a certain degree, has a favorable impact on wound healing. Thus, based on the measurement data for venule oxygen saturation, evidence could be provided that most probably, influence can be exerted on the formation of new micro-vessels on the wound's edges (during the infectious phase of wound healing). In addition, use of the test product also has a positive impact on the later state of scarring (smoother skin surface and better temperature regulation).

The test product is therefore also recommended for use on top of common wound dressings, in view of enhancing the therapeutic success of tried and tested wound healing options, especially in the event of delayed or disturbed wound healing.

This leads to the following possibilities of use as a treatment option:

As an insole.

As part of movement therapy for patients suffering from diabetes mellitus type II.

Moreover, the test product can help to avoid fatigue fractures (e.g. in the foot area) for persons exposed to greater corresponding professional risk, for rehab patients, athletes, soldiers, etc.

It can also be used as part of (protective) clothing (vest, jacket, gloves, etc.) for persons in corresponding professions or athletes (winter sports), etc. as well as being built into sleeping systems (mattress, cover, etc.)

Use of the test product in addition to common clinical treatment options for wound healing, in particular impaired wound healing, is promising (on top of common wound dressings, bandages or directly as a wound dressing / bandage).

Closing remarks:

With regard to the effectiveness of the test product, focus is placed on the rules of interaction between waves and matter, i.e.:

– The interaction between body-own radiation and the test object. The „sources" of body-own

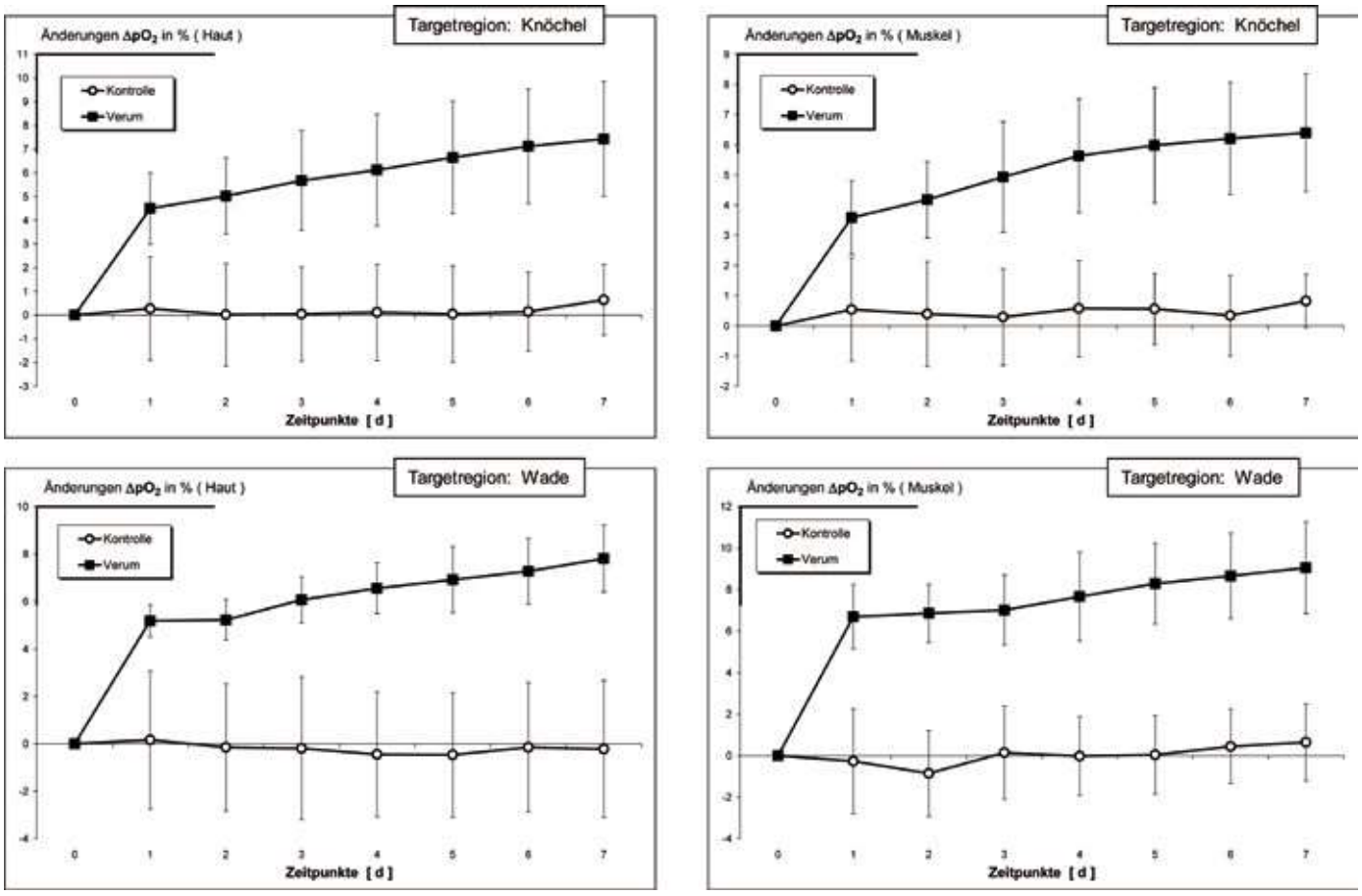


Figure 6. *Summary of the measurement data of the 4th research series on the parameter of venule oxygen saturation, ΔpO_2, in the left calf (mean values and standard deviations)*
0. Differences indicated in percentages, in comparison to the initial values. Measurement times: Day 0 (initial values), days 1 to 7

radiation, radiating from the skin surface to the surrounding environment: Activities of the nervous system, certain activities of body cells, activities of the smooth muscle cells surrounding, amongst others, the vessel walls (in this case, of the smaller blood vessels). In the latter case, we are dealing with different electro-magnetic waves (transversal waves) that radiate from the skin surface, primarily in form of what is referred to as heat radiation. It is in every border area, that is to say boundary layer, of the test product (F1 to F4 in figure 1) that these interactions have an impact on the following physical principles determining the energy reflected back into the tissue by the test product: reflection, spread, bending , breaking, energy absorption (transformation of energy) as well as interferences (obliteration, strengthening) of the various different electro-magnetic wave lengths.

It is also of interest that, according to the

manufacturer, what we have in layer F2 in figure 1 is an organic semi-conductor (organic semi-conductor db-21).

Thus, in terms of frequency, wave lengths and phase shifts, the waves reflected back into the tissue, in their parts, differ somewhat from those radiated by the body. The electro-magnetic waves radiated by the body, just as the waves that are reflected back, are a mixture of various different spectral elements.

There is need to intensify research into this. Therefore, currently, it is still not possible to attribute clear scientifically-founded explanations to the proven effectiveness of the test product.

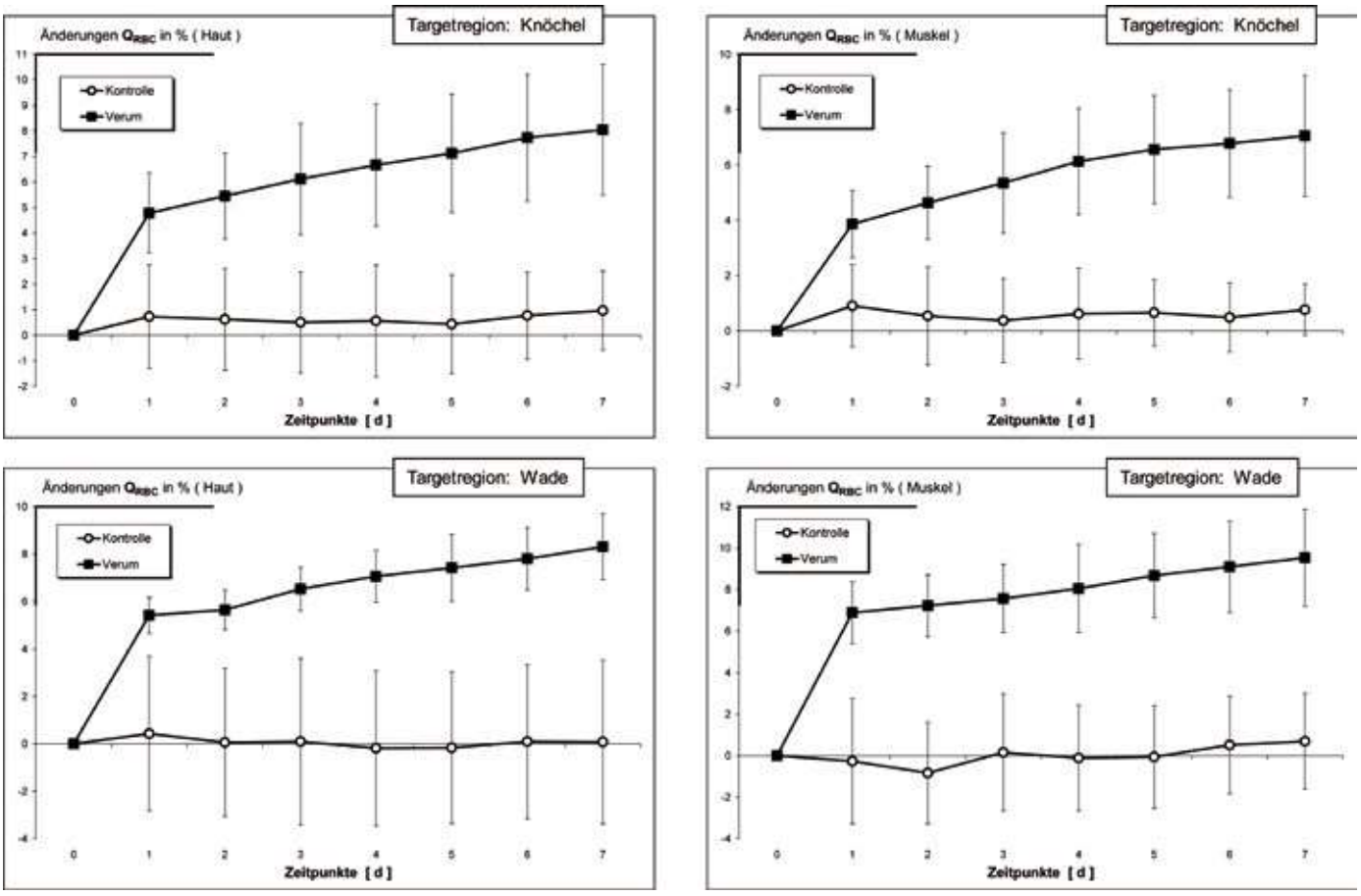


Figure 7. *Summary of the measurement data from the 4th research series on the parameter flow of red blood cells, $Q_{RBC,}$ in the left ankle region and the left calf (mean values and standard deviations) Differences in percentages in comparison to the initial values (measurement times): Day 0 (initial values), days 1 to 7*

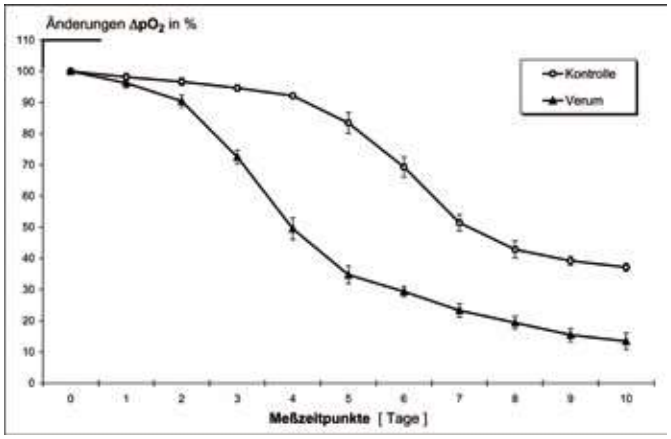


Figure 8. *Summary of the measurement data on the parameter venule oxygen saturation, ΔpO_2, i.e. as the difference between the values measured at the edge of the wound and in the uninjured surrounding skin tissue (mean values and standard deviations). The difference between the measurement data on day 0 (immediately after surgery) was assumed as being 100 %. Differences indicated in percentages, in comparison to the initial value.*

Measurement times: day 0 (initial values), day 1 to 7

Table 9. *Measurement data on the parameter of maximum surface roughness, ΔRmax, (difference in percentages, in comparison to the value determined in the surrounding skin surface that is assumed as being 100 %)in the control and in the verum group (mean values and standard deviations).*

	Control	Verum
Mean value	133,1	126,4
Standard deviation	6,02	4,44

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Measurement data on skin surface temperature, ΔT, (difference in °C betweenthe surrounding uninjured skin tissue and the scar tissue) in both the control and verum groups (mean values and standard deviations).

	Control	Verum
Mean value	- 0,6° C	- 0,5° C
Standard deviation	0,14	0,15

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