THERMAL RESPONSE IN RHEUMATOID ARTHRITIS

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It is well known that the application of heat or cold to one limb results after a shorter or longer period in an increase or decrease in the temperature of the surface of the other limbs. This response is part of the heat-regulating mechanism of the body and is due to changes in blood flow brought about mainly by dilatation or constriction of the smaller arteries and arterioles (Lewis, 1936). Indirect, or reflex, vasodilatation has been studied by Gibbon and Landis (1932), and Fatherree and Allen (1938). The mechanism has been fully discussed by Richards (1946).

The thermal vascular response is excited by the warm venous blood, returned from a limb heated by immersion in hot water, finally reaching the heat-regulating centre in the hypothalamus. Some workers claim that there are special afferent dilator fibres acting as well (Martin, 1930), in which case the mechanism would be a true nervous reflex. The existence of these dilator fibres has not been universally accepted though fibres conveying constrictor impulses do in fact exist. This may explain the greater rapidity of response to a cold stimulus. The response is effected by efferent nervous impulses and whether the pathway is actively dilator, with or without local liberation of dilator substances, or whether it is produced by inhibition of constrictor nerves, need not concern us here.

Variations can be observed in the promptness and extent of the thermal response in different patients. This can form the basis of circulatory tests as was first shown by Gibbon and Landis (1932). Benatt and Taylor (1940) used the contrast bath as a test for vascular response by immersing one arm alternately in hot and cold water and recording the skin temperature of the finger-nail bed. The recovery time from a cold application was used by Woodmansey (1946) as a test for vasomotor disturbances in rheumatism.

Indirect vasodilatation is often used as a test to determine the extent of vasospasm in considering the advisability of sympathectomy (Abramson, 1944). The test has been widely used by Richards in occlusive vascular diseases.

Method

Since environmental temperatures have a marked effect on vasodilatation in the extremities (Martin and others, 1946), in order to standardize the test a room was equipped with an electric fan for circulating an adjustable amount of cool air from outside through a heating element. The latter, controlled by a thermostat, keeps the room at a constant temperature of 65° F. (18.3° C.). This is nearly always possible except on some very hot summer days; expense precluded the installation of refrigerating plant for these few

occasions. The patient sits comfortably for at least 30 minutes with hands resting and legs exposed to the knees. Skin temperatures* are taken periodically on the plantar and volar aspects of the terminal phalanges of great toes and thumbs, and a point on the forehead. This last provided a convenient indication of body temperature, usually rising a degree or so during the test. The figure has been omitted from the graphs.

Having arrived at a stage of reasonable stability, one foot is then immersed to a depth of 15 inches in hot water at 44° C. and readings are continued at the other sites.

These particular points on thumb and toe are chosen because they are close to dense arteriolo-venular anastomotic areas where local changes in the amount of circulating blood are most rapidly reflected in wide ranges of skin temperature. Other points are much less suitable. For instance, in the tests shown in Figs 2 and 5 (pp. 70 and 71), three other points were taken besides the toe:

- (1) 1 inch from base of toe,
- (2) on dorsum of foot,
- (3) to left of tibia, 4 inches below patella.

It is clear from the curves that the toe temperature provides the most convincing criterion of circulatory change.

During the rest period there is frequently observed a rise in temperature of the hands, often quite considerable, followed by a more or less rapid fall. This is illustrated in Fig. 1 (p. 70). The rise may be explained by a normal vasodilatation induced by entry into a comfortable room with perhaps a psychological factor

* The thermocouple method was used formerly for this class of work but a recent improved apparatus made by Light Laboratories, 31a Shanklin Road, Brighton, 7, is found quicker in action and more convenient. It is based on the Wheatstone bridge principle—one resistance arm being fitted to a probe on a flexible lead, which is placed in contact with the skin at any point. The point of this probe is a minute glass capsule containing a special compound with a high temperature-resistance coefficient. The current is produced by a valve-oscillator and a three-valve amplifier ensures the accurate determination of the null point. The variable resistance is calibrated in degrees centigrade. See Bourne (1946).

TABLE I
NORMAL CONTROLS

Case No.	Sex	Age	Thermal Response			
			Delay (mins)	Rise in Temperature of Toe (°C.)	Duration of Rise (mins)	Index * (°C. per min.)
1	M.	55	21	22·6-31·2	9	0·41
2	M.	35	22	23·6-26·8	5	0·29
3	F.	18	12	21·0-28·6	15	0·36
4	F.	19	0	25·6-29·5	5	1·0
5	F.	42	7	21·6-26·7	19	0·30
6	M.	41	0	High	0	1·0
7	F.	38	6	24·4-29·2	20	0·39
8	F.	22	6	25·0-30·4	10	0·71
9	M.	22	13	23·4-31·2	10	0·53
10	F.	20	7	19·2-23·8	22	0·17
11	F.	22	0	19·0-22·0	30	0·10
12	M.	45	—	0	—	—
13	F.	24	10	20·8-31·0	20	0·4

* In all Tables cases showing a high initial temperature or a very rapid rise in the curve are arbitrarily given the index 1·0.

dependent on the temporary interest aroused by the experimental equipment and the reassurance of the pleasant nature of the test to be imposed. The subsequent cooling off may be the result of muscular inactivity and mental relaxation.

Material

Normal Controls.—Tests were made on thirteen healthy subjects between 18 and 55 years of age (Table I). This group of controls, though small, gives a fair picture of the variations to be expected.

Hands.—In eight cases the hands were warm before the immersion began; in the other five there was some degree of vasospasm, but this was speedily released in the test.

Feet.—Although in ten cases the toes were at first cold, only one gave no response and one a negligible response.

All workers in this field have recorded the fact that the lower extremities are ordinarily in a state of higher vasoconstrictor tone than the upper. Both upper and lower limbs participate in the thermoregulatory requirements of the body, but the vessels of the fingers retain a greater degree of patency in a cool environment, perhaps because they have a greater need than the toes to carry out delicate muscular and tactile functions.

As for the two persons who gave no response or a negligible one, Richards (1946) also found in certain of his normals that vasodilatation failed to occur. He quotes other investigators who had had the same experience, saying:

This does not necessarily indicate a defect in nervous conduction or any structural change in the blood vessels of the lower extremity.

Woodmansey and others (1938) noted a failure of adaptability to the temperature changes of a contrast bath, in the hands of some otherwise apparently healthy females. It can, however, be argued that such persons though acting as normals, have a certain abnormality. In the above two cases the discomfort of unduly cold extremities was admitted.

Occlusive Vascular Diseases.—At the other end of the scale and as a basis for comparison another group was taken consisting of 51 patients from the Harrogate General Hospital with very marked circulatory inadequacy of the limbs; 43 suffering intermittent claudication and eight showing Raynaud's syndrome or other vascular defect in the upper limbs (Table II, p. 68).

Hands.—About half showed a fair or good response in the hands. The rest showed varying degrees of sluggishness or delay, but none was entirely without response.

Feet.—33 showed no response; twelve showed some delay or sluggishness; only six could be said to have reacted well (normally) and in two at least of these six, the symptoms could be attributed to psychoneurotic rather than organic disturbance.

Rheumatoid Arthritis.—76 patients with rheumatoid arthritis were tested at the Royal Bath Hospital (Table III, pp. 69 to 70).*

Hands.—Out of these at least 66 showed what might be accepted as a normal response.

Feet.—In the toes, however, 29 patients showed no response whatever and in some others the response was slow and uncertain.

* In Table III are given some additional data : duration of disease, erythrocyte sedimentation rate, plasma viscosity, and haemoglobin content, where the figures were available. A comparison of the thermal response index with each of these, however, shows no correlation whatever.

TABLE II
CASES OF OCCLUSIVE VASCULAR DISEASE

Case No.	Sex	Age	Thermal Response			
			Delay (min).	Rise in Temperature of toe (°C.)	Duration of Rise (min.)	Index (°C. per min.)
1	F.	41	—	0	—	—
2	M.	49	—	0	—	—
3	M.	52	—	0	—	—
4	M.	56	5	22·0-26·6	25	0·25
5	F.	42	7	23·2-31·4	22	0·43
6	M.	53	—	0	—	—
7	F.	73	16	24·2-31·6	5	0·60
8	M.	68	—	0	—	—
9	M.	53	0	25·2-27·6	30	0·29
10	M.	62	0	25·0-29·0	21	0·48
11	M.	49	—	0	—	—
12	M.	70	—	0	—	—
13	M.	67	—	0	—	—
14	M.	54	5	21·0-25·6	25	0·22
15	M.	52	—	0	—	—
16	M.	—	—	0	—	—
17	M.	68	7	22·2-26·2	23	0·24
18	F.	25	12	21·0-26·0	17	0·24
19	F.	—	—	0	—	—
20	M.	53	0	25·0-27·3	27	0·31
21	F.	47	—	0	—	—
22	M.	35	—	0	—	—
23	M.	70	—	0	—	—
24	M.	48	—	0	—	—
25	M.	—	—	0	—	—
26	M.	66	—	0	—	—
27	M.	73	—	0	—	—
28	M.	55	—	0	—	—
29	M.	32	10	20·0-30·0	20	0·37
30	F.	70	—	0	—	—
31	M.	61	—	0	—	—
32	F.	47	0	20·0-30·0	16	0·69
33	M.	66	—	0	—	—
34	F.	71	—	0	—	—
35	M.	62	—	0	—	—
36	M.	18	—	0	—	—
37	M.	58	—	0	—	—
38	M.	54	10	20·4-26·0	20	0·23
39	M.	46	10	20·4-27·4	20	0·28
40	F.	29	—	0	—	—
41	M.	69	15	22·0-26·0	15	0·23
42	M.	54	—	0	—	—
43	M.	62	20	26·0-30·4	10	0·38
44	F.	35	7	23·6-28·4	15	0·43
45	F.	40	—	0	—	—
46	F.	62	3	20·0-24·0	26	0·17
47	F.	41	—	0	—	—
48	F.	—	—	0	—	—
49	M.	47	13	24·2-31·0	17	0·40
50	M.	54	—	0	—	—
51	M.	61	—	0	—	—

TABLE III
CASES OF RHEUMATOID ARTHRITIS

Case No.	Sex	Age	Duration of Disease (years)	Corrected E.S.R.	Plasma Viscosity (Water = 100)	Haemoglobin (%)	Thermal Response			
							Delay (min.)	Rise in Temperature (°C.)	Duration of Rise (min.)	Index (°C. per min.)
1	F.	24	7	25	204	75	15	20.4-28.2	7	0.42
2	F.	21	11	25	211	81	22	21.2-27.6	8	0.29
3	F.	30	2	9	200	88	—	0	—	—
4	F.	21	1	11	187	86	12	20.2-23	18	0.13
5	F.	36	7	33	206	75	0	18.6-25.2	27	0.23
6	F.	24	9	19	202	70	—	0	—	—
7	F.	36	—	17	194	85	16	22.6-27.6	10	0.33
8	F.	23	2	16	200	87	12	21.4-28.4	18	0.31
9	F.	24	3	3	169	90	19	22.4-28	11	0.30
10	F.	25	1	9	187	78	22	22.4-27.9	8	0.29
11	F.	54	2	30	190	88	—	0	—	—
12	F.	34	11	32	—	72	11	24.5-30.1	14	0.44
13	F.	45	20	38	230	62	10	21.0-23.2	10	0.21
14	F.	34	1	9	180	90	—	0	—	—
15	F.	18	2	32	—	90	9	22.6-27.4	20	0.29
16	M.	46	2	42	218	84	0	High	0	1.0
17	F.	37	5	5	184	94	19	19.7-23.4	11	0.15
18	F.	37	—	8	197	84	—	0	—	—
19	F.	19	3	41	226	78	10	21.4-28	20	0.30
20	F.	23	1	43	265	76	25	20.4-24.2	4	0.18
21	M.	18	3	12	186	90	17	19.5-23	13	0.15
22	M.	15	1	9	175	100	0	25.4-29.1	20	0.51
23	F.	24	6	42	215	72	10	21.6-28	18	0.32
24	F.	15	2	3	196	67	0	24.8-32	25	0.52
25	M.	47	2	—	161	82	—	0	—	—
26	M.	42	8	36	214	84	10	20.0-27.4	14	0.35
27	M.	40	20	14	186	91	0	High	0	1.0
28	M.	52	5	43	238	90	0	High	0	1.0
29	M.	26	5	35	196	96	26	22.4-28	4	0.30
30	M.	40	1	25	192	86	13	24.4-30.8	11	0.51
31	M.	62	10	20	182	90	12	21.4-29.8	18	0.36
32	M.	49	10	34	194	84	—	0	—	—
33	M.	44	5	44	229	84	9	21.0-24.8	21	0.19
34	M.	50	10	44	227	97	26	22.6-24	4	0.17
35	M.	28	2	16	186	96	—	0	—	—
36	M.	41	1	11	—	90	—	0	—	—
37	M.	48	1	—	—	—	—	0	—	—
38	M.	26	5	4	181	96	—	0	—	—
39	M.	50	14	9	—	—	—	0	—	—
40	M.	47	5	—	—	—	—	0	—	—
41	M.	53	2	22	198	91	—	0	—	—
42	M.	34	5	—	—	—	—	0	—	—
43	M.	45	3	14	169	90	—	0	—	—
44	F.	45	20	41	—	77	10	22.0-32.2	20	0.44
45	F.	48	14	40	202	—	15	21.4-24	6	0.24
46	F.	46	13	16	184	87	14	22.8-29.6	13	0.39
47	F.	59	4	38	208	85	7	25.2-30.2	6	0.86
48	F.	45	7	10	185	87	14	22.2-30.0	14	0.32
49	F.	53	6	43	224	74	17	24.1-28.0	8	0.36
50	F.	37	1	11	200	68	0	High	0	1.0
51	F.	61	10	31	—	91	0	High	0	1.0
52	F.	53	1	30	209	—	—	0	—	—
53	F.	—	—	—	—	—	—	0	—	—

(continued overleaf)

TABLE III—continued

Case No.	Sex	Age	Duration of Disease (years)	Corrected E.S.R.	Plasma Viscosity (Water = 100)	Haemoglobin (%)	Thermal Response			
							Delay (min.)	Rise in Temperature (°C.)	Duration of Rise (min.)	Index (° C. per min.)
54	F.	23	3	6	171	—	—	0	—	—
55	F.	40	8	40	200	80	0	High	0	1.0
56	F.	51	10	45	214	80	—	0	—	—
57	F.	50	10	42	231	91	—	0	—	—
58	M.	37	6	42	216	85	—	0	—	—
59	M.	58	15	—	—	—	—	0	—	—
60	M.	34	7	44	248	104	—	0	—	—
61	M.	53	—	28	191	104	—	0	—	—
62	M.	55	30	42	218	95	2	20.4-29.0	28	0.33
63	F.	40	12	8	168	84	—	0	—	—
64	F.	39	6	22	188	91	21	19.6-30.2	9	0.37
65	F.	44	3	13	186	86	20	21.6-29.8	9	0.37
66	F.	51	2	42	242	74	—	0	—	—
67	F.	—	—	—	—	—	—	0	—	—
68	F.	25	1	35	196	—	11	17.4-25.6	19	0.22
69	M.	43	9	20	177	—	13	20.0-24.0	16	0.17
70	F.	19	9	2	179	—	15	21.6-30	4	0.58
71	M.	34	3	13	184	—	21	19.8-29.0	6	0.37
72	M.	42	1	—	—	—	—	0	—	—
73	M.	42	12	4	168	—	1	21.8-28.2	12	0.71
74	M.	20	6	16	—	—	23	21.4-29.4	7	0.35
75	F.	33	—	—	—	—	20	22.8-32.2	10	0.41
76	F.	—	—	—	—	—	22	22.0-23.8	8	0.16

Discussion

As vasoconstrictor tone appears to be almost as readily released under the strong influence of a thermal stimulus in the upper limbs of rheumatoid arthritics

FIG. 1.—Normal, Case 1. Male, 55 years. Normal labile vasomotor control in hands. Toe cold at beginning, but response complete.

FIG. 2.—Normal, Case 13. Female, 24 years. Active vasodilatation in hands; toe cold at beginning, but response rapid.

FIG. 3.—Occlusive vascular disease, Case 1. Female, 41 years. Erythrocyanosis. Delay in response in hands; no response in toe.

FIG. 4.—Occlusive vascular disease, Case 26. Male, 66 years. Buerger's disease. Little, if any, response in hands; no response in toe.

FIG. 5.—Rheumatoid arthritis, Case 17. Female, 37 years. Active vasodilatation in hands; response in toe delayed and small in extent.

FIG. 6.—Rheumatoid arthritis, Case 41. Male, 53 years. Active response in hands; none in toe.

as in those of healthy people, in this study we confine our attention, in the Tables of results, to the toes, from which more information may be gathered.

Diagrams.—From each group two typical graphs are shown (Figs 1-6). In the examination of a graph (limiting our attention to the curve of toe temperature, solid black line) the features to be noted are:

- (1) The delay between the time of immersion and the time the rise commences. This delay may depend on the degree of vasospasm at the outset and the promptness or sluggishness with which this vasospasm is released in the immersed limb, for the efferent impulse is not initiated until sufficient warm venous blood returns. The presence of much or little subcutaneous body fat seems of little account as an insulator.
- (2) The extent of the rise. This presumably depends upon the degree of vasodilatation of which the peripheral vessels are capable.

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La Réponse Thermale dans l'Arthrite Rhumatismale

RÉSUMÉ

- (1) On décrit une simple méthode pour effectuer l'épreuve de la reponse thermique.
- (2) On énumère les résultats de cette épreuve chez 76 malades atteints d'arthrite rhumatismale.
- (3) On démontre la grande fréquence de l'insuffisance vasomotrice dans cette maladie.

La Respuesta Termal en la Artritis Reumatoide

RESUMEN

- (1) Descripción de un simple método para efectuar la prueba de la respuesta termal.
- (2) Tablas de los resultados de esta prueba en 76 enfermos con artritis reumatoide.
- (3) Demostración de la gran frecuencia del defecto vasomotor en esta enfermedad.

- (3) The time lag between the initiation and completion of the rise. The rise may show a steep or shallow gradient. One might suggest that the latter signifies a sluggish vasodilating mechanism at the efferent end.

An attempt has been made to calculate a single figure index of thermal response, but it is difficult to incorporate all the factors concerned.

For instance, a curve may pursue a horizontal course for 20 minutes and then rise steeply in 4 or 5 minutes from 20° to 27°. Another may begin rising almost immediately from 20° to 27° in a uniform but shallow gradient. It is realized that the physiological mechanism involved in the two cases must differ and that the difference may be of diagnostic significance. Yet if the time required to attain the peak is the same, there is justification for giving these two curves the same index because the final degree of vasodilatation is apparently the same.

For this "Index of Thermal Response" the most satisfactory compromise seems to be to use a figure expressing the average gradient (in fractions of a degree per minute). The rise is measured from 19° (the nearest whole number of degrees above room temperature). Thus a rise from 25° to 29° is given the same value as a rise from 20° to 29°, as it is considered that the partial initial vasodilatation should not be prejudicial to any numerical assessment. The results (Table IV) show the figures for rheumatoid arthritis to be intermediate between the normal state and that of established occlusive vascular conditions. A high incidence of a peripheral vasomotor defect is shown in patients with rheumatoid arthritis.

TABLE IV
SUMMARY OF RESULTS

Thermal Response		Normal Controls		Occlusive Vascular Disease		Rheumatoid Arthritis	
Grade	Index	%	Number of observations	%	Number of observations	%	Number of observations
Absent or poor	0 to 0.1	15.4	2	64	33	38.2	29
Fair	0.1 to 0.5	53.8	7	32	12	46.0	35
Good	above 0.5	30.8	4	4	6	15.8	12

Summary

- (1) A simple method of carrying out a thermal response test is described.
- (2) Results of tests on 76 patients with rheumatoid arthritis are tabulated.
- (3) Evidence is shown of the high incidence of a vasomotor defect in this disease.

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