STUDIES ON "KANSETSU-WAZA"

(4) Studies on "Kansetsu-waza" with Special Reference to the Reaction of the Circulatory and Respiratory Systems

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This paper is one of a series of studies on "Kansetsu-waza" and deals with its effect on the body and mind when the technique is applied to an individual. In the present study, investigations were made on changes observed in the respiratory and circulatory systems.

The object of the "Kansetsu-waza" is to put the arm of the opponent in a disadvantageous position, and in order to effect this, in most cases, such as the "Juji-katame" (cross armlock) and "Ude-garami" (entangled armlock), the elbow joint becomes the object of the application of the technique. So far, studies in "Kansetsu-waza" were mainly centered on the art of the application of the technique, however, studies on the physiologic changes that accompany the application of the technique have not yet been done.

It is not possible to make scientific measurements on individuals during an actual Judo tournament, and consequently, a condition very much resembling the actual performance of the "Juji-katame" was simulated in the laboratory. This was done by applying varying mechanical loads to the arm in extension, and its effect on the body was studied by investigating changes in respiration, electrocardiogram (ECG), galvanic skin reaction (GSR), and photoelectric plethysmogram.

METHOD OF EXPERIMENT

Five university students, all expert Judoists, with normal elbow joints were selected as experimental subjects (Table 1). Six university students with no experience in Judo were selected as controls (Table 1).

The experimental subject was made to lie in a supine position on a bed with one arm in extension and with a pillow placed under the elbow. Around the wrist which was also extended a protective cotton wad was wrapped, and around which encircled a metal ring. To this ring was attached a spring balance so that by pulling on the string attached to the balance, the load applied to the forearm could be measured (Fig. 1). When the experimental subject could no more bear the pull on his wrist, he gave a sign indicating "I surrender" with the other hand (free hand).

It has been generally recognized by experience that depending on the position of the elbow of the individual on whom the "Kansetsu-waza" is performed, and also on the direction of pull and degree of rotation, there is some difference in how much one can resist the "Kansetsu-waza". Consequently, in the present investigation mechanical load was applied to the forearm 1) when

Table 1. Physical fitness of experimental subjects

	Subjects	Height (cm)	Body wgt. (kg)	Chest circum. (cm)	Age (yrs.)	Judo experience (yrs.)	Dan
Judoist	Sugiyama	167.5	71.0	100.5	21	7	4
	Kataoka	173.5	80.5	99.5	21	7	4
	Matsuura	161.0	61.5	87.5	20	6	3
	Kanamori	166.5	69.5	93.5	19	3	1
	Umeeara	170.5	76.0	98.0	19	2	2
	average	167.8	71.7	95.9	20	5	2.8
University student	Matsuda	175.0	68.0	85.5	21		
	Satō	163.0	54.5	82.5	22		
	Saitō	165.0	50.0	82.0	25		
	Yamane	156.5	47.5	83.0	22		
	Hisatani	161.5	56.5	84.5	22		
	Karaki	182.0	72.0	91.0	20		
	average	167.1	58.8	84.8	22		

the palm of the hand of the experimental subject was facing up (Juji-katame, Type 1,) and 2) when the thumb of the experimental subject was pointing up (Juji-katame, Tape 2). In each case the experiment was subdivided into that in which the experimental subject resisted the pull as much as possible and that in which he offered no resistance.

Measurements were conducted with the experimental subject in a supine postion. The mechanical load was applied until the experimental subject gave the signal "I surrender", but measurements were continued until normal conditions at rest were resumed.

ECG was recorded by using front chest leads, respiratory movement was recorded by means of a thermistor attached to the nostril, and circulation in the distal blood vessels was measured by means of a finger-tip photoelectric plethysmograph. As a means of studying reflex function of the nervous system, GSR of the experimental arm and the free arm was also investigated (Fig. 2).

In order to obviate possible injury to the elbow joint during experiment, the application of mechanical load to the forearm was done gradually, so that it took 3–5 seconds before the signal "I surrender" was given.

RESULTS AND DISCUSSION

1) Load Applied to the Forearm.

The maximum load which each of the five experimental subject and six controls could endure (critical load) is shown in Table 2. Measurements were made 1) with the position of

the forearm as in Type 1 (palm facing up), with and without resistance; and 2) with the position of the forearm as in Type 2 (thumb pointing up), with and without resistance.

Fig. 1

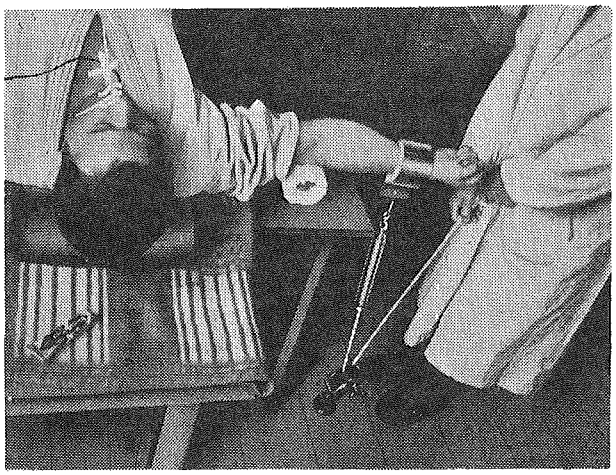
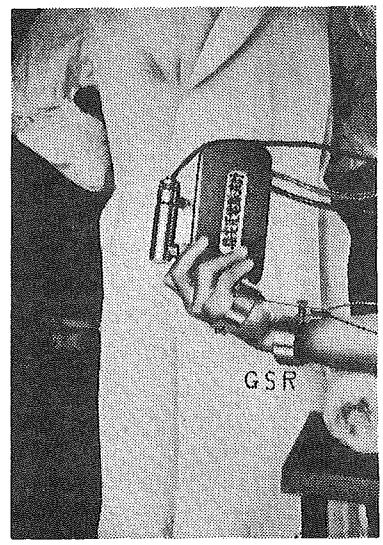


Fig. 2



Each individual was measured twice under the same conditions, and Table 2 shows the readings taken at each measurement together with the average.

For both Types 1 and 2, the "critical load" was greater by 4–6 kg. when the experimental subject was resisting. This was a common tendency for both the Judoists and the non-Judoists (controls).

As regards position of the forearm, in all the individuals, with or without resistance, more force (approx. 4 kg. more) was required when the palm of the hand was facing up (Type 2). This was also a tendency common to both the Judoists and the non-Judoists, and experimentally confirms the fact that in actual practice, it requires less force to overcome the opponent by the "Kansetsu-waza" when the opponent's forearm is put in Type 2 position (i.e., thumb pointing up). This is assumed to be due to the anatomical structure of the elbow joint.

A comparison of the "critical load" of the Judoists and that of the non-Judoists indicate that, in general, more force was required for the Judoists than for the non-Judoists before they gave the signal "I surrender". This is assumed to be due to the stronger resistance of the elbow of the Judoists as a result of training.

2) Changes in Respiratory Movement.

Respiratory movement was studied by means of a beat type thermistor attached to the nostril. Changes in temperature of the air current within the nostril due to respiratory movement was thus recorded in the form of a curve which in turn was interpreted as changes in respiratory movement. Fig. 3 shows the manner in which the thermistor was applied to the nostril.

Table 2. Maximum Load (kg.) endured

condition / exp. subject		Type 1				Type 2			
		with resist.		without resist.		with resist.		without resist.	
Judoists	S	26.0 27.0	26.5	15.0 14.6	14.8	18.2 19.6	18.9	11.4 11.4	11.4
	K	25.0 28.0	26.5	17.0 21.5	19.3	24.5 25.0	24.8	10.8 13.8	12.3
	M	23.5 26.5	25.0	18.4 19.0 19.8	19.1	20.5 20.5	20.5	13.8 15.6	14.7
	K	20.0 21.0	20.5	16.4 17.8	17.1	18.6 20.2	19.4	16.5 17.4	17.0
	U	19.5 20.5	20.0	16.8 16.8	16.8	14.8 15.0	14.9	12.2 13.5	12.9
	$\bar{x}$	23.7		17.5		19.7		13.7	
non-Judoists (controls)	M	21.0 21.5	21.3	15.4 16.0	15.7	17.0 17.0	17.0	12.4 13.2	12.8
	SA	16.1 16.5	16.3	13.0 13.4	13.2	11.8 13.6	12.7	10.0 10.8	10.4
	SM	17.8 19.2	18.5	11.4 12.0	12.5	11.2 11.8	11.5	9.2 9.5	9.1
	Y	15.0 15.8	15.4	7.8 8.6	8.2	11.8 14.8	13.3	7.2 8.4	7.8
	H	14.0 14.4	14.2	10.2 11.6	10.9	7.0 8.2	7.6	4.4 4.5	4.5
	K	15.0 18.2	16.6	10.5 13.2	11.9	18.0 18.2	18.1	10.8 12.2	11.5
	$\bar{x}$	17.1		12.0		13.4		9.5	

From the characteristics of the thermistor it was not possible it determine quantitatively changes in respiratory volume, however, the time relation between inspiration and expiration, and also the increase or decrease in respiration was comparatively satisfactorily recorded.

The curve reproduced in Fig. 4 are representative examples of changes in the respiratory curve. The descending phase indicate inspiration, and the ascending phase expiration. It will be noted that respiration became somewhat accelerated even before the load was applied. With the application of the load respiratory movement entered the inspiratory phase, and as the load was increased respiration either stopped or showed small and interrupted expiratory movement. At the moment of the signal "I surrender" or when the subject was offering resistance respiratory movement completely stopped. As soon as the load was released, rapid and shallow respiration began to be observed. In general, this began with a short inspiratory phase, although some individual difference in the respiratory phase was observed.

The time required for normal respiratory movement to be resumed after release of the load was longer when the forearm was in the position of Type 2 (thumb pointing up) than when it was in the position of Type 1 (palm facing up); and more time was required when the subject

offered resistance than when he was not resisting. Also, the non-Judoists took more time to resume normal respiration than the Judoists. From these facts it may be assumed that the time required for normal respiration to be resumed is related to the intensity of the pain felt at the moment the signal "I surrender" is given.

The fact that as soon as the load was applied, respiration shifted to the inspiratory phase and stopped in this condition very closely resembles changes in respiratory movement observed during the performance of the "Shime" (strangling, choking) (1). This holding of breath in the inspiratory phase increases muscle tension and helps one in his effort to hold out. The comparatively delayed revival of normal respiration after releasing the load in the experiment in which the forearm was in the position of Type 2 (thumb pointing up) is assumed to be due to the fact that in this case pain is more intense than in the other case.

Fig. 3

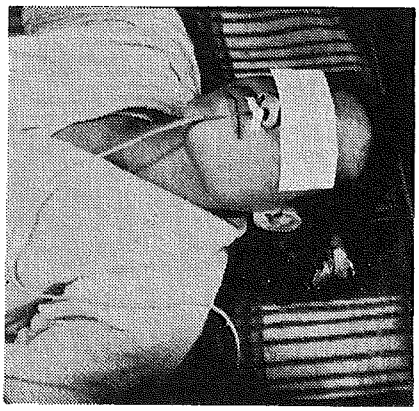
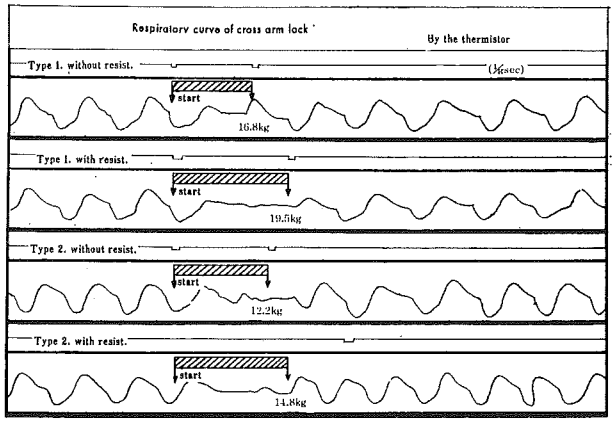


Fig. 4



3) Changes in Cardiac Function.

Since the load was applied to the forearm, chest leads were employed in ECG studies. Fig. 5 shows ECG of one of the Judoists taken during each of the above mentioned four conditions.

It will be seen in Fig. 5 that with the inception of application of the load marked changes occurred in the ECG, and following release of the load normal ECG pattern was rapidly resumed.

Let us first consider the R-R interval. Figs. 6 and 7 are graphic representations of the R-R intervals of a Judoist (experimental subject) and a non-Judoist (control), respectively.

Shortening of the R-R interval was seen in some individuals prior to application of the load, presumably due to psychological reasons. In others no recognizable change was observed in the R-R interval in this period. However, as soon as the load was applied, shortening of the R-R interval was seen, and at the moment the signal "I surrender" was given the R-R interval was the shortest. Normal interval was resumed following release of the load.

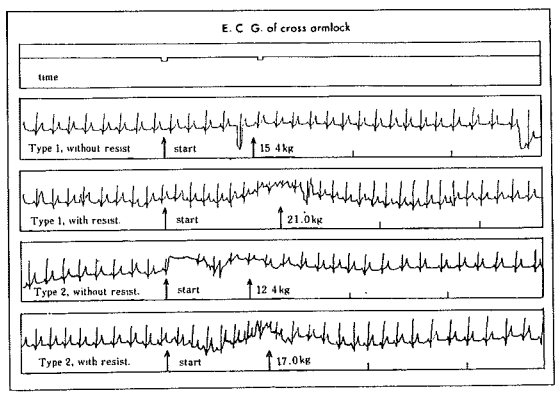
The heart beat interval observed during the experiment in which the experimental subject was resisting was markedly shorter than that observed during the experiment in which the experimental subject was not resisting (Fig. 6 and 7). This is to be expected, because the duration of application of the load and also the "critical value" are both increased due to the effort of the experimental subject to resist.

There was no significant difference between the changes in the R-R interval observed during the experiment in which the forearm was in Type 1 position (palm of hand facing up) and those observed during the experiment in which the forearm was in Type 2 position (thumb pointing up). Also, no significant difference in the revival process of the R-R interval of the two groups of experiments was recognized. There was no significant difference in the changes in R-R interval of the Judoists and the non-Judoists.

A shortening of the heart beat interval was also observed during the "Hadaka-jime" (Naked Chokelock), however, an extension of the heart beat interval was observed in the "Okuri-eri-jime" (Lapel lock), and the "Kata-juji-jime" (Single wing lock) (1). The shortening of the heart beat interval during the "Hadaka-jime" is presumed to be due to the pain produced in the laryngeal region, just as the shortening of the heart beat interval during the "Kansetsu-waza" is also due to pain.

As previously stated the position (Type 1 or 2) of the forearm during the experiment did not affect the changes of the R-R interval differently. This is thought to be due to the fact that the limit of one's effort to resist or to bear the effect of the load is determined by the intensity of pain, consequently, when the pain reached the same intensity, regardless of the position of the forearm, the experimental subject gave up (i.e., gave the signal "I surrender"). For the same reason, there was no significant difference in the changes in the R-R interval of the Judoists and non-Judoists. Experience in Judo may increase the amount of load which one can bear, but there is no difference in the intensity of pain felt at the moment of the signal "I surrender".

Fig. 5



4) Distal Blood Flow.

Changes in the vasomotor nerves were investigated by means of a photoelectric plethysmograph placed on the finger tip (Fig. 8) in order to study the degree of stress upon the body during performance of "Kansetsu-waza".

A pick-up was attached to the finger tip, and after confirming normal blood flow conditions, the load was gradually applied and recording was continued until one minute after the signal "I surrender" was given.

Measurement of distal blood flow was made with the forearm in Type 1 position, with and without resistance, respectively. Also, measurement was performed with the arm in the position of "Ude-garami" (Entangled armlock). Simultaneously with these measurements, distal blood flow of the free arm (i.e., the non-experimental arm) was measured.

Fig. 6

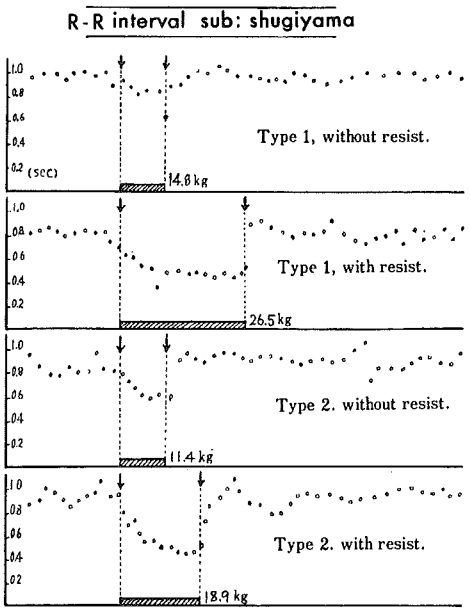


Fig. 7

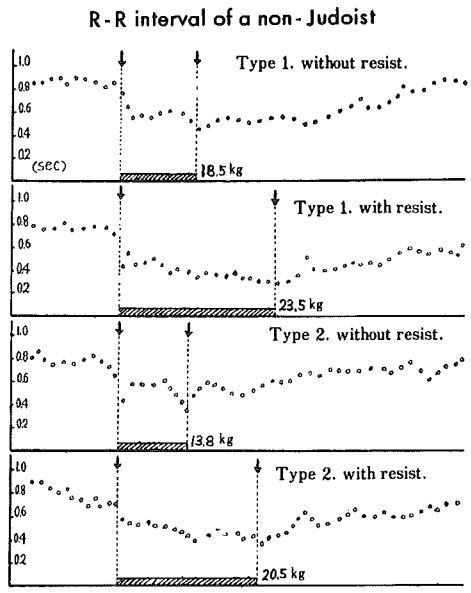
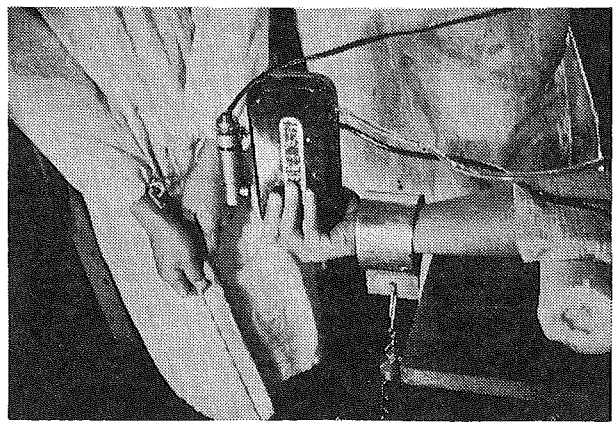


Fig. 8



As seen in Fig. 9, distal blood flow already began to decrease at the signal "Ready", and when the load was applied, a further decrease was seen and reached minimal value at the signal "I surrender" after which normal value was resumed in 5–10 seconds.

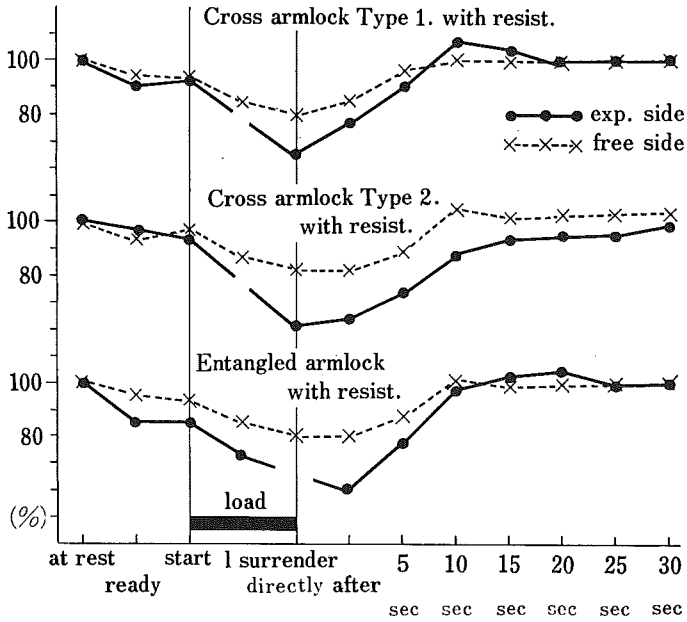
Distal blood flow showed a marked decrease in both the experimental arm and the free arm. Fig. 9 shows changes in distal blood flow during "Juji-katame", and "Ude-garami", with and without resistance. The decrease in distal blood flow was more marked on the experimental side than on the free side, and at the moment the signal "I surrender" was given, as much as 40% decrease was observed in the experimental side, whereas in the free side a decrease of only 20% was seen. This marked difference is presumed to be due to the pressure (over 20 kg.) of the band around the wrist hindering normal blood flow. However, since a 20% decrease in distal blood flow was observed in the opposite arm (free arm), there is no doubt that vascular reflex was also involved in decreasing the distal blood flow.

Table 3. Changes in distal blood flow

		Type 1		Type 2		"Udegarami"	
		Resist (+)	Resist (−)	Resist (+)	Resist (−)	Resist (+)	Resist (−)
experiment. arm	normal	100 %	100 %	100 %	100 %	100 %	100 %
	"Ready"	90	100	98	96	85	93
	"Begin"	92	80	93	96	85	95
	sec. stage	?	76	?	85	72	90
	"I surrender"	65	77	62	?	?	84
	dir. after	77	90	64	74	60	81
	5 sec.	90	98	73	90	77	90
	10 "	105	101	89	92	98	98
	15 "	104	105	94	105	102	98
	20 "	100	105	95	106	104	98
	25 "	100	105	95	100	100	98
	30 "	100	105	97	100	100	96
	60 "	100	105	95	100	100	98
free arm	normal	100 %	100 %	100 %	100 %	100 %	100 %
	"Ready"	92	98	98	94	95	100
	"Begin"	92	93	98	90	94	100
	sec. stage	85	86	88	88	85	94
	"I surrender"	80	86	84	84	80	90
	dir. after	85	94	84	86	80	94
	5 sec.	96	102	88	80	88	100
	10 "	101	104	107	98	100	100
	15 "	100	100	104	97	102	102
	20 "	100	100	104	98	100	102
	25 "	100	100	104	98	100	100
	30 "	100	100	104	97	100	100
	60 "	100	100	104	97	100	100

Changes seen in the recordings of the photoelectric plethysmograph are considered to be parallel to changes in the distal blood flow. Fig. 9 shows changes in percentage of blood flow (normal blood flow: 100%).

Fig. 9



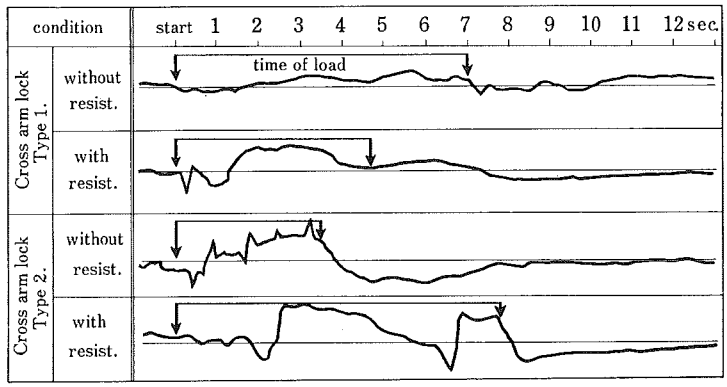
The position of the forearm (i.e., Type 1 or 2, or Ude-garami position) had very little influence on the changes in distal blood flow. However, sometimes during the experiment, an irregular wave-like disturbance was observed in the recording of distal blood flow of the experimental arm, and consequently, precise quantitative calculations were not possible.

There was a further decrease of 10%-20% when the experimental subject offered resistance, and especially in the "Ude-garami" when the experimental subject was offering resistance, distal blood flow decreased 20% more than when he was not offering resistance.

5) Galvanic Skin Reaction (GSR)

GSR measurement (Fig. 2) was made with the forearm in Types 1 and 2, with and without resistance.

Fig. 10



Considerable oscillation was seen even before the load was applied to the forearm, and with the signal "Ready", oscillation was further increased. Fig. 10 is a reproduction of the GSR of the free arm of an expert Judoist. A marked oscillation was observed when the load was ap-

plied to the forearm, however, when the load was released, fine oscillations disappeared and soon thereafter no more oscillation was seen. Larger oscillations were seen when the experimental subject was resisting than when he was not resisting; and also, larger oscillations were seen when the forearm was in Type 2 position (thumb pointing up) than in Type 1 position (palm facing up).

SUMMARY

1) Respiration. In most individuals, as soon as the load was applied to the forearm, respiration stopped in the inspiratory phase, or became interrupted; and as soon as the load was released rapid shallow expiration was observed.

2) Heart beat interval. Changes in heart beat interval was closely related to changes in GSR, and showed irregularities even before the load was applied. Shortening of the heart beat interval was observed as soon as the load was applied, and at the moment the signal "I surrender" was given heart beat interval showed a minimal value of 0.3–0.4 second. When the experimental subject was offering resistance, the duration of application of the load became longer, and the decrease in heart beat interval was more marked than when he was not resisting. Also, when the forearm was in Type 2 position (thumb pointing up), the decrease in heart beat interval was more pronounced than when it was in Type 1 position (palm facing up).

There was considerable individual variation in the recovery process of normal heart beat: In some experimental subjects normal heart beat interval was resumed as soon as the load was released, whilst in others it took 20 seconds before normal heart beat interval was resumed. However, in general, recovery time was longer in the experiment in which the subject offered resistance than in the experiment in which no resistance was offered, and also, recovery time was longer in the non-Judoists than in the Judoists.

3) Distal blood flow. Recordings taken by means of the photoelectric plethysmograph indicate that decrease in distal blood flow occurred even in the getting ready period, and with the application of the load it decreased rapidly and markedly, reaching a minimal value of 60% at the moment the signal "I surrender" was given. The decrease was more pronounced when the experimental subject offered resistance than when he was not resisting. A similar tendency, although not so pronounced, was observed in the distal blood flow of the other arm (free arm). These facts indicate that the decreased distal blood flow of the experimental arm was due to the mechanical pressure of the load on the blood vessels, and also to the contraction of the distal vessels as a result of pain reflex.

In the "Ude-garami" the decrease in distal blood flow was more pronounced than in the "Juji-katame". This is thought to be due to the fact that in the former technique torsion is added to hyperextension, thereby further complicating the process.

4) Marked changes were observed in the GSR. Changes were particularly marked when the experimental subject was offering resistance, and when his forearm was in Type 2 position (thumb pointing up).

From the aforementioned observations on changes in the autonomic nervous function (respiratory and circulatory systems, and GSR), it is assumed that the "Kansetsu-waza" is quite a stress on the living body.