# 4–3. A STUDY OF THE INFLUENCE OF JUVENESCENT JUDO PRACTICE ON THEIR BODIES

**Report 2. Respiro-circulatory Function and Workout Intensity in the case of Boy Judoists**

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The characteristic of physical fitness of boy Judoists was described in Report I. As the school year goes up from 5th to 8th grade (2nd year of junior high school), the children who are practicing Judo showed the superiority in both morphology of growth of length and growth of volume to the ones who are playing soccer or baseball. The boy Judoists are superior to others in muscle strength and vital capacity because of their large physique. In spite of the traditional opinion of Judoists being slow in movement, the new fact was found that they are superior in some degree to other groups in agility. But it was also found that they are extremely inferior to other groups in circulatory function. The result shows that there are some factors raised by the physical stimulation of Judo, however, it is also suggested there are other factors lowered at the same time.

The participation in Judo practice has aerobic and anaerobic aspects. The maximum oxygen intake is often used to measure aerobic function. What kind of influence was exerted upon children's aerobic working function from boyhood Judo practice? Are they inferior in endurance because of the heavy weight and high ration of body fat? In this survey the measurement of Judoists' maximum oxygen intake was made in order to investigate their respiro-circulatory function and also to find out the average exercise intensity of workout method in Judo.

## I. METHOD

The subjects were 21 in total, five each from 5th grade to 7th grade, and six of 8th grade. The standard of subjects was set in the case of elementary school children on those who have more than three years of experience in Judo, practice at least more than four days a week, and are well-trained. For the junior high school students, the standard was set on those who have capability to keep upper rank at a big tournament in Tokyo, and who are well practiced. Three of junior high school subjects were the regular members of the champion team in the National Tournament.

The morphology measurement of the subjects were made in the same method as the Report I. The 13 items investigated are height, body weight, sitting height, neck girth, chest girth, waist girth, abdomen girth, wrist girth, forearm girth, upperarm girth (extension, flexion), ankle girth, calf girth, and thigh girth.

The exhaustion test was given by using Bicycle-Ergometer in order to get the relative formula between maximum oxygen intake and heart rate. In work load method for elementary school boys, it started with 1.0 kp, increased 0.5 kp in every two minutes, 0.5 kp in every minute after 6 minutes, and reached the stage of exhaustion. In the case of junior high school students, it was same as that of elementary school boys except it started with 2.0 kp. Accordingly, expiration was taken by Douglas-Bag Method, and the density of $O_2$ and $CO_2$ was measured by instantaneous gas analysis equipment

## Table 1 Comparison of physical Characteristics of Subjects

| | | height | body weight | sitting height | neck girth | chest girth | waist girth | abdomen girth | Wrist girth | | forearm girth | | | | Wrist girth | | thigh girth | | Calf girth | | amkle girth | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (right) cm | (left) cm | (right ext.) cm | (right flex.) cm | (left ext.) cm | (left flex.) cm | (right) cm | (left) cm | (right) cm | (left) cm | (right) cm | (left) cm | (right) cm | (left) cm |
| 5th graders | $\bar{X}$ | 150.1 | 44.9 | 79.9 | 30.6 | 76.0 | 69.0 | 73.4 | 22.1 | 22.0 | 23.2 | 25.0 | 23.1 | 24.7 | 15.0 | 15.0 | 47.0 | 46.9 | 31.6 | 31.9 | 20.6 | 20.6 |
| | SD | 3.76 | 6.80 | 2.66 | 1.92 | 5.60 | 5.50 | 7.40 | 0.93 | 1.22 | 1.90 | 1.72 | 2.30 | 1.92 | 0.84 | 0.84 | 4.92 | 4.48 | 2.02 | 1.74 | 1.81 | 1.67 |
| Sub. in Report 1 | $\bar{X}$ | 145.2 | 40.0 | 77.9 | 30.1 | 71.1 | 62.5 | 65.4 | 21.4 | 21.4 | 21.8 | 23.7 | 21.5 | 23.2 | 14.6 | 14.7 | 44.5 | 43.6 | 30.7 | 30.8 | 19.9 | 19.7 |
| | SD | 4.98 | 8.55 | 2.58 | 1.92 | 7.36 | 8.19 | 7.86 | 1.56 | 1.69 | 2.34 | 2.51 | 1.96 | 2.17 | 0.75 | 0.76 | 4.36 | 4.02 | 2.83 | 2.93 | 1.65 | 1.65 |
| National Average | $\bar{X}$ | 137.4 | 32.0 | 74.3 | 27.6 | 66.4 | 57.0 | 66.1 | 19.1 | | 18.2 | 19.7 | | | | | 37.6 | | | 26.5 | | |
| | SD | 5.84 | 5.42 | 3.18 | 1.30 | 5.06 | 3.96 | 4.06 | 1.18 | | 1.36 | 1.59 | | | | | 2.08 | | | 1.75 | | |
| 6th graders | $\bar{X}$ | 155.1 | 61.9 | 82.3 | 35.1 | 88.7 | 83.9 | 87.1 | 25.5 | 25.2 | 27.6 | 29.1 | 27.5 | 29.3 | 16.4 | 16.4 | 55.7 | 55.8 | 37.1 | 37.1 | 22.7 | 22.9 |
| | SD | 4.04 | 15.60 | 2.73 | 2.74 | 11.00 | 12.76 | 13.20 | 2.23 | 2.20 | 3.63 | 3.86 | 3.85 | 3.69 | 0.97 | 0.91 | 6.98 | 7.06 | 4.55 | 4.50 | 1.91 | 1.81 |
| Sub. in Report 1 | $\bar{X}$ | 152.8 | 47.3 | 81.5 | 31.4 | 76.5 | 66.2 | 66.3 | 23.5 | 22.9 | 23.7 | 25.1 | 23.1 | 24.8 | 15.8 | 15.8 | 47.3 | 46.2 | 31.6 | 32.1 | 21.1 | 20.9 |
| | SD | 10.35 | 12.23 | 6.21 | 2.32 | 7.62 | 7.29 | 7.57 | 2.36 | 2.66 | 3.12 | 2.67 | 2.91 | 2.95 | 1.29 | 1.30 | 6.20 | 5.92 | 4.89 | 2.90 | 2.10 | 1.79 |
| National Average | $\bar{X}$ | 142.7 | 35.5 | 76.7 | 27.7 | 68.9 | 58.7 | 68.4 | 19.5 | | 18.4 | 19.9 | | | | | 42.4 | | | 27.2 | | |
| | SD | 6.47 | 6.54 | 3.46 | 1.28 | 5.67 | 4.26 | 4.14 | 1.28 | | 1.54 | 1.60 | | | | | 4.31 | | | 2.06 | | |
| 7th graders | $\bar{X}$ | 163.7 | 70.2 | 87.7 | 36.5 | 92.1 | 82.8 | 86.7 | 27.0 | 26.8 | 29.7 | 31.6 | 29.6 | 31.9 | 17.9 | 17.6 | 56.5 | 55.9 | 39.2 | 39.1 | 23.6 | 23.7 |
| | SD | 3.18 | 9.52 | 2.30 | 0.80 | 8.09 | 7.16 | 7.03 | 1.32 | 1.18 | 2.82 | 3.00 | 2.82 | 3.72 | 0.62 | 0.30 | 6.90 | 5.57 | 3.80 | 2.74 | 1.71 | 1.80 |
| Sub. in Report 1 | $\bar{X}$ | 163.5 | 58.9 | 87.2 | 34.9 | 84.1 | 72.2 | 73.8 | 24.9 | 24.9 | 25.7 | 28.9 | 25.9 | 28.2 | 16.2 | 16.2 | 50.7 | 50.2 | 36.2 | 34.8 | 22.3 | 22.0 |
| | SD | 7.61 | 10.05 | 3.95 | 1.68 | 6.56 | 8.41 | 7.82 | 1.62 | 1.87 | 2.94 | 2.57 | 2.69 | 2.34 | 0.82 | 0.79 | 4.08 | 3.50 | 4.34 | 2.39 | 1.08 | 1.19 |
| National Average | $\bar{X}$ | 150.7 | 41.3 | 79.6 | 29.1 | 72.5 | 60.1 | 70.8 | 20.4 | | 19.8 | 21.3 | | | | | 42.2 | | | 28.6 | | |
| | SD | 7.97 | 7.95 | 4.78 | 1.48 | 6.35 | 4.06 | 4.02 | 1.25 | | 1.39 | 1.62 | | | | | 4.38 | | | 2.15 | | |
| 8th graders | $\bar{X}$ | 171.2 | 67.5 | 91.6 | 37.1 | 92.7 | 75.4 | 78.2 | 26.7 | 26.1 | 28.7 | 31.4 | 28.4 | 30.9 | 17.0 | 16.8 | 54.7 | 54.6 | 36.8 | 36.7 | 22.8 | 22.8 |
| | SD | 6.95 | 9.91 | 3.44 | 1.63 | 2.74 | 6.60 | 7.66 | 1.14 | 1.23 | 2.39 | 1.86 | 2.28 | 2.11 | 0.42 | 0.48 | 3.49 | 3.44 | 2.82 | 2.72 | 0.80 | 0.93 |
| Sub. in Report 1 | $\bar{X}$ | 167.2 | 67.0 | 90.3 | 35.9 | 89.0 | 76.7 | 79.6 | 26.5 | 26.1 | 28.4 | 31.2 | 27.9 | 30.1 | 16.7 | 16.9 | 55.5 | 54.9 | 37.5 | 37.3 | 22.7 | 22.5 |
| | SD | 5.26 | 12.53 | 2.79 | 2.28 | 6.61 | 8.98 | 9.80 | 1.90 | 1.78 | 3.35 | 3.13 | 3.26 | 3.28 | 1.31 | 1.10 | 5.78 | 5.51 | 3.78 | 3.16 | 1.73 | 1.27 |
| National Average | $\bar{X}$ | 157.8 | 47.0 | 83.1 | 30.9 | 76.0 | 62.7 | 76.4 | 21.6 | | 21.0 | 22.9 | | | | | 43.7 | | | 29.9 | | |
| | SD | 7.66 | 8.16 | 5.23 | 2.15 | 5.82 | 4.59 | 5.55 | 1.66 | | 2.02 | 2.22 | | | | | 4.62 | | | 2.36 | | |

**Table 2 Respiratory, Circulatory response to exhaustion test**

| | | $\dot{V}O_2$ max | | HR max | $\dot{V}E$ max | FR max | $O_2$ removal | $O_2$ pulse | Tidal Volume | Time to exhaustion | Work load |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mℓ/min | mℓ/kg/min | beats/min | ℓ/min | round/min. | mℓ/ℓ | mℓ/beat | ℓ/round | min. sec | kpm |
| 5th graders | $\bar{X}$ | 2053.8 | 46.3 | 196.4 | 66.6 | 63.0 | 30.8 | 10.4 | 1.16 | 11′ 02″ 51 | 7326.8 |
| | SD | 205.70 | 4.56 | 8.01 | 5.07 | 5.80 | 1.49 | 0.83 | 0.103 | 30″ 26 | 228.79 |
| 6th graders | $\bar{X}$ | 2207.1 | 37.5 | 199.2 | 69.5 | 64.4 | 31.9 | 11.1 | 1.09 | 12′ 15″ 30 | 8284.8 |
| | SD | 156.51 | 7.89 | 6.05 | 6.44 | 8.52 | 2.49 | 1.08 | 0.102 | 1′ 42″ 49 | 1151.28 |
| 7th graders | $\bar{X}$ | 3430.2 | 49.3 | 191.6 | 90.0 | 63.0 | 38.2 | 17.9 | 1.43 | 14′ 54″ 72 | 18636.6 |
| | SD | 297.82 | 6.51 | 7.70 | 9.04 | 4.00 | 2.13 | 1.98 | 0.141 | 37″ 80 | 1176.84 |
| 8th graders | $\bar{X}$ | 3390.2 | 50.8 | 188.8 | 95.9 | 69.0 | 35.5 | 18.1 | 1.40 | 14′ 28″ 80 | 17385.0 |
| | SD | 376.91 | 5.60 | 10.25 | 12.53 | 7.59 | 2.45 | 2.82 | 0.203 | 1′ 00″ 48 | 1910.27 |

manufacturered by *Sanei Sokki*. Heart rate was measured from ECG, R-R space taken by chest lead, and respiratory rate was measured from respiratory curve taken by thermister set inside of the gas mask.

The following were adopted as daily practice. *Ukemi* was practiced in the pace of once in every 4 seconds, in standing posture for 2 minutes to backward and for 1 minute each to side and forward. In *uchikomi*, after *ohgoshi*, *taiotoshi*, *seoinage*, and *ohsotogari* were practiced in the pace of once in every 4 seconds for one minute each, every *waza* was practiced as fast as possible and accurately for 30 seconds each. Also the number of trial frequency was recorded. In *randori* 2 *tachiwaza* in 3 minutes, and 2 *newaza* in 2 minutes were practiced. *Kakari-geiko* was practiced twice in one minute. In order to record the heart rate during Judo workout, a "Life-Scope 8" made by *Nippon Koden* was used and conveyed by telemetry system. The recorded heart rate was inserted into the relative formula between oxygen intake at the exhaustion test recorded by Bicycle-Ergometer and heart rate. The exercise intensity of Judo workout was shown as percentage of $\dot{V}O_2$ max.[1)]

## II. RESULT

The results of morphology measurement of the subjects in this survey are shown in Table 1. The comparison was made among the subjects of this survey, the subjects in Report I, and the national average in each school grade. As it was declared in the Table, the subjects of this survey were superior in all items to national average and the subjects in Report I. These large physique boy Judoists were chosen by the workout quantity and technique, as indicated in Report I, and it seems hard to meet theory that "Gentle turns away sturdy".

A comparison by each school year was made in Table 2 for the physical response at the exhaustion test of respiro-circulatory system. The maximum oxygen intake per 1 kg of body weight was 46.3 ml/kg/min. in 5th grade, 37.5 in 6th grade, 49.3 in 7th grade, and 50.8 in 8th grade. The junior high school boys showed larger value than the elementary school boys examined. In $\dot{V}E$ max., and $O_2$ pulse, and $O_2$ removal the junior high school boys were far superior to the elementary school boys, and, therefore, in the maximum oxygen intake per minute also, the junior high school boys were superior to the elementary school boys. The elementary school boys' average body weight was 53.4 kg and that of junior high school boys was 68.9 kg. Probably because of the large difference of body weight, the gap between elementary school boys and junior high school boys by body weight was very small.

According to Ishiko's[6] report, the value of elementary school boys was 40.2 ml/kg per minute, and that of junior high school boys was 42.6. The value of junior high school boys in this survey is very high in comparison with Ishiko's case. Also according to Ikuyama's report,[5] the value of junior high school boys was 53.5 ml/kg/min. The same value of this survey was lower than this report. The height and body weight of Ishiko's subjects were closer to national average. Ikuyama's subjects were the members of basketball and gymnastic clubs. The difference of the results from each report must come from these facts.

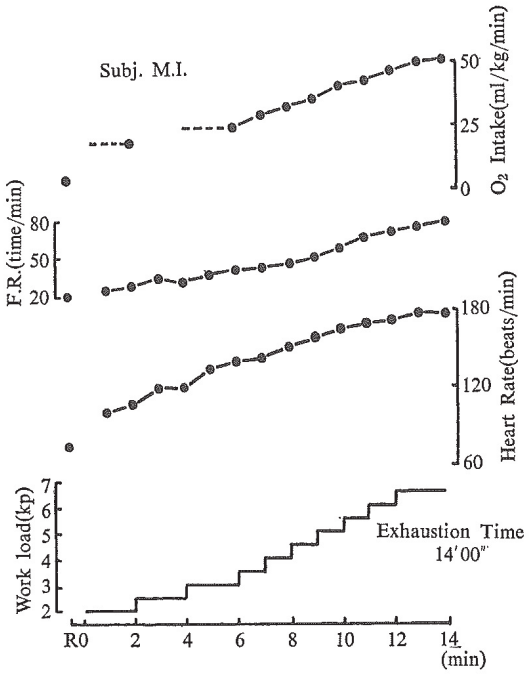


**Fig. 1 Physiological response to exhaustion test**

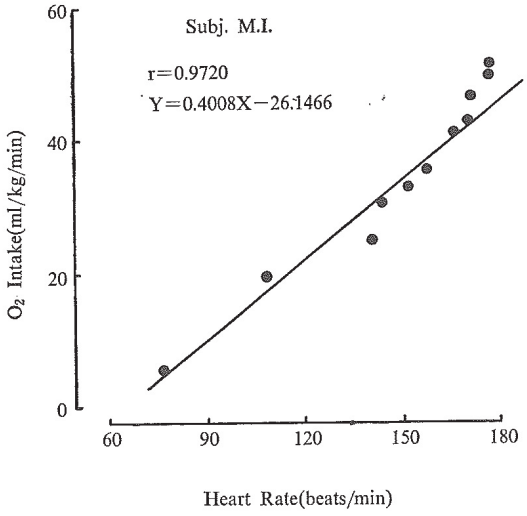


**Fig. 2 Relation between heart rate and oxygen intake**

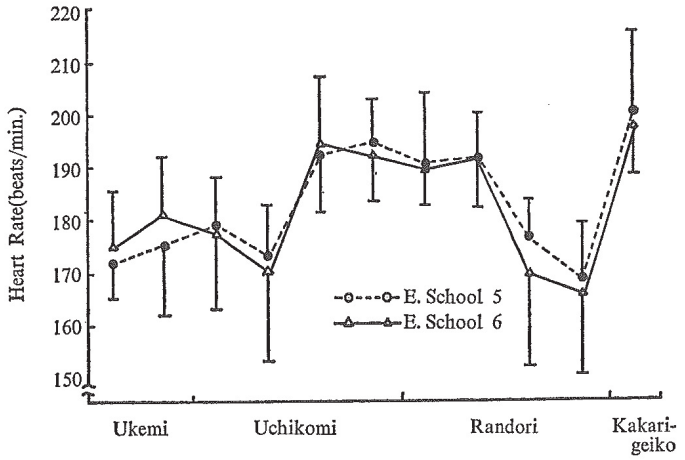


**Fig. 3 Heart rate response during Judo workout (Elementary school boy)**

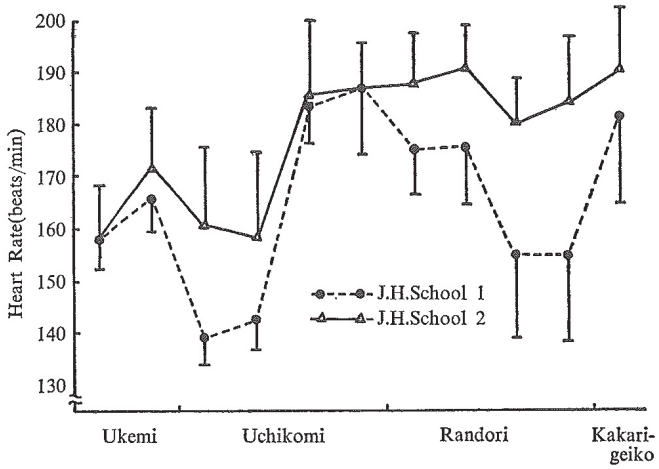


**Fig. 4 Heart rate response during Judo workout (Junior high school boy)**

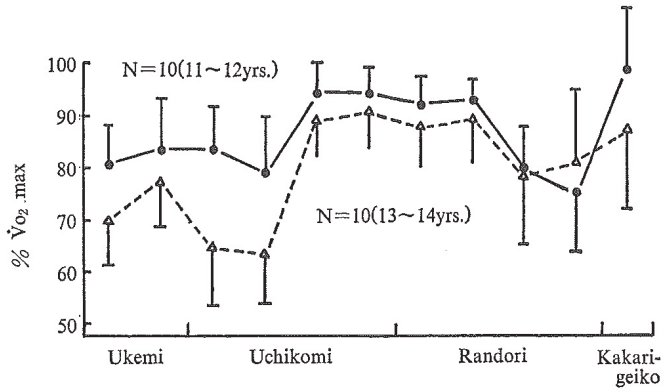


**Fig. 5 Comparison of intensity of Judo workout between elementary and junior high school boy.**

The load employed for the above two investigations was all measured by Bicycle-Ergometer. The load on respiro-circulatory system is not so heavy at elementary school Judo practice that it is possible to think there was no difference found in maximum oxygen intake.

An example of physical response at exhaustion test was shown in Fig. 1. In spite of having accomplished 2-minute maximum work in 6.5 kp as junior high school boys, heart rate was about 180 per minute, which was low. The increase of respiratory rate seems to be appropriate.

A linear relation was recognized between heart rate and oxygen intake, and it was shown in Fig. 2. The heart rate at Judo workout was also inserted to the above relation and the relative exercise intensity was measured.

Concerning heart beat response at Judo workout, the results of elementary school children was shown in Fig. 3 and those of junior high school students were shown in Fig. 4 in average value by school year for comparison.

In the case of elementary school boys there was practically no difference between 5th and 6th grades. In *ukemi* the heart rate was 170–180 beats per minute. The first half of *uchikomi* was same as *ukemi* and from the latter half to *tachiwaza-randori* the heart rate increased to 190 beats per minute.

In *newaza-randori* it was declined largely, however, and it reached 200 beats per minute in the last *kakari-geiko*.

These values are approximately 10 beats higher than Ezaki's report.[2] Since the subjects (elementary school boys) in Ezaki's report were at national level, their practice must have been very hard. However, we were unable to find out why the heart rate of elementary school boys was higher than that of junior high school boys.

In the case of junior high school students some differences can be seen between 7th and 8th graders. There is no big difference in *ukemi*, however, and in the first half of *uchikomi* 7th graders' heart rate decreased sharply into 140 beats per minute. In the latter half of *uchikomi* the heart rates of both subjects investigated incidentally had the same score. Again in *randori* the 7th graders' heart rate began to decline. Their heart rates were 170–180 beats per minute in *tachiwaza* and 150–160 in *newaza*. They showed big difference from 190 beats per minute of 8th graders. Also in *kakari-geiko* 7th graders could not beat 8th graders. We were unable to determine the cause of such a big difference between 7th and 8th graders in spite of the same kind of practice in the same period of time.

As to the relative intensity of Judo practice, the comparison between elementary and junior high school boys was shown in Fig. 5. Here the higher intensity of junior high school boys in every item is clearly shown. Especially in the first half of *ukemi* and *uchikomi* (each *waza* was employed in every 4 seconds). In spite of elementary school boys' intensity was quite high—80% of maximum oxygen intake (shown as 80% $\dot{V}O_2$ max.), it was within 60–70% in junior high school boys. This might be due to the difference of skillfulness.

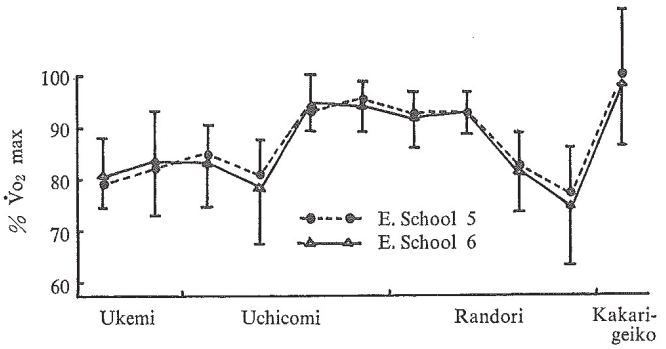


**Fig. 6 Relative exercise intensity of Judo workout (Elementary school boy)**

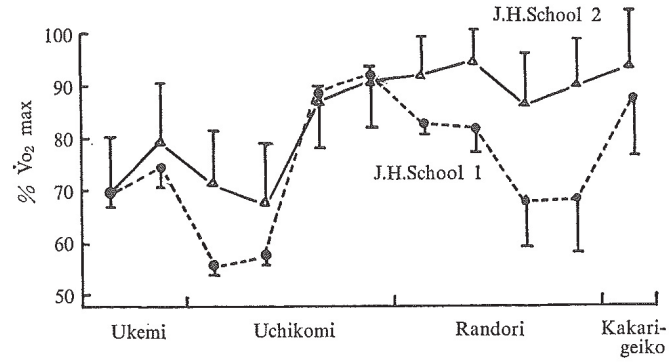


**Fig. 7 Relative exercise intensity of Judo workout (Junior High school boy)**

Also Hisanaga[3] reports that when the same kind of exercises were given to 7th to 9th graders, the lower graders showed higher intensity. In this survey elementary school boys were not on their toes effectively relaxed when they practice Judo. They just practice furiously. However, as the grade goes up, they gradually learn to cut the useless movement off and make good progress as a result. In Hisanaga's report[4] the same result was found in exercise intensity among high school and college students.

At the latter half of *uchikomi* (practice every *waza* as quick and accurately as possible) and at *randori* (*tachiwaza*), both elementary and junior high school boys reached around 90% $\dot{V}O_2$ max, which indicates the intensity of practice. However, at *newaza-randori* all of sudden the $\dot{V}O_2$ intake of both groups declined sharply. According to Judoists' opinion, *newaza* is a very hard exercise. It seems that the decline might be due to some disturbance during the practice by the radio transmitter to measure heart rate. The equipment was firmly fixed on the body, it must have been some disturbance to the subjects.

At *kakari-geiko* which is the final course of exercise, elementary school boys showed nearly 100% $\dot{V}O_2$ max, but junior high school boys did not even reach 90% $\dot{V}O_2$ max. The difference could be analyzed as follows; elementary school boys lost themselves during workout using all sorts of *waza*. On the other hand junior high school boys tried to see the movement of the opponent employing *waza*, and kept breath, for their exercises were always supposed to be the preparation to the tournament.

The difference of relative exercise intensity between 5th and 6th graders is shown in Fig. 6. Extremely closer data should be the proper result, judging from the rerult of heart beat response Fig. 3.

The difference of relative exercise intensity among the junior high school subjects is shown in Fig. 7. Unlike 5th and 6th graders, some large differences are seen in several items. Since 7th graders were very low in their exercise intensity in the first half of *uchikomi*, the difference between elementary and junior high school boys was explained by their skillfulness. However, in this case it is unable to use the same interpretation. In order to analyze the cause, we considered the formation of 8th grade subjects. In the 7th grade subjects, 5 members were chosen from the top-ranking junior high schools in Judo. In the case of 8th graders 3 members each were chosen from junior high schools to play off the final round at the Tokyo Tournament. Therefore, it is possible to consider that in the case of 7th graders, their exercises lacked tension. On the other hand, it was possible to consider that in the case of 8th graders they kept strong antagonism to each other and their training was blistering.

## I. SUMMARY

Paying attention to boy Judoists' respiro-circulatory function, we attempted to study the influence of Judo on the developing period. The daily workout intensity was shown as the relative intensity to maximum oxygen intake. The results are as follows;

1) It was found that the subjects in this survey (elementary and junior high school Judoists) had quite large physique.

2) There was no big difference of maximum oxyten intake between elementary school boys and the national average.

3) The maximum oxygen intake of junior high school boys was comparatively large.

4) The elementary school boys' workout intensity was high compared to junior high school boys. It seemed that the influence of mental excitement was much larger than the increase of cardiac output.

5) The workout intensity of junior high school boys was lower than that of elementary school boys. It was because of their skillfulness.

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