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# Discussion on Tips of Exercise Using EMG

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***Abstract*—All types of physical exercise have various information that individual ability, environment and so on. Exercises have different meanings but look much the same. This is called the Individual Characteristic Principle. From this principle, it is thought that the same precision motions have internal difference. However, we want to completely do away with difference between these exercises because we have aesthesia. For example, likes and dislikes and learning the ropes. Because of this we thought that the common motion structures exist and so researched the possible existence of the common motion structures in the same accuracy isometric work.**

## I. Introduction

We set and do various exercises within our daily life. We do various tasks everyday. soccer, baseball, writing, walking, grabbing, and so on. To perform these tasks, the central nerve calculates motor command required to move muscles . Therefore, the status of the achievement of exercises have relationship with motor command. The features of motor command and its effect in motion accuracy have been widely studied. Some of the findings are as follows. Signal dependent noise exists in the motion command to each muscle from the central nervous system [1][2]. The dispersion of motion cannot be avoided because the noise causes the motion to disperse at the end of practice [3]. High accuracy motion is actualized by the raising impedance of the arm [4]. However, the difference in the motion commands in exercising the same precision has not been studied. We think that studying this will be very useful in learning about the best way to perform a task.

First, we use ”forward upward circling” as an example. Forward upward circling is when someone hangs from a horizontal bar before lifting his/her upper body above the bar and rolling over the bar back into the hanging position. Imagine two peaple who can perform forwarding upward circling well. Their forwarding upward circlings look much the same but are different. In addition, two forwarding upward circlings performed by the same person are different too. This is because all exercises include various information that individual ability, environment, and so on. Therefore, these different exercises look much the same. This is called the Individual Characteristic Principle[5]. From this principle, it is thought that the same precise motions have internal differences.

However, we want to completely throw out differences between these exercises. Because, people have likes and dislikes. People have learning the ropes. We can learn the motion of exercises, so we think common (or similar) motion structures exist. In other words, we think that dispersion of respective motion commands have width in exercises of the same precision.

Therefore, we make sure of the Individual Characteristic Principle. Moreover, we investigate possible existence of the common motion structures.

## II. Method

### A. Analysis

We used IOMCJ(Index of Over Muscle Co-contraction around the Joint) to investigate how to implement the exercises of with the same accuracy. It defined over output power for exercising. To obtain IOMCJ, we used two models: quasi-muscular tension and a joint model.

The first was used to estimate muscular tension. As a precondition, we assumed surface EMG to be directly proportional to muscular tension. We calculated the quasi-muscular tension using Second Order Low-Pass-Filter after moving average and full-wave rectification. It is sufficiently possible to describe the relationship between nervous impulse and muscular tension using Second Order Low-Pass-Filter. This was shown in a neurophysiological study [6]. In addition, Akazawa et al. muasured muscle tension from EMG using Second Order Low-Pass-Filter [7].

The second model was a skeletal muscle model consisting of one joint and two muscles. The means that the two muscles control movement of the joint. This time, we used these models and applied the biceps brachii and the triceps brachii and cubital joint to the skeletal muscle model. Then, we obtained the IOMCJ that was the difference between a cubital joint stiffness and a hand torque.

There, we set parameters for obtaining the IOMCJ. Computational expression of the hand torque $\tau$ is

$$\tau = a_e T_e - a_f T_f. \quad (1)$$

Computational expression of the cubital joint stiffness $S$ is

$$S = a_e T_e + a_f T_f. \quad (2)$$

The quasi-muscular tension of the biceps brachii was $T_e$. The quasi-muscular tension of the triceps brachii was $T_f$. $a_e$ and $a_f$ were constant. We estimated these constant numbers. Thereby, these constant numbers have several meanings that translate from range of EMG to muscular tension and morment arms of muscles. The parameters were estimated using pressure value and surface EMG. The method for estimating the parameters used the pressure value and the quasi-muscular tension. The parameters were set to tried to become close the pressure value with the quasi-muscular tension using the least-square method. In this case, several indefinite elements were removed. Muscles have contraction rates and muscle lengths. These elements impose for changing the EMG-musclar tension relationships. Another elements have similar effects. These include joint angle, angular speed, gravitational force and so on. Therefore, these changes were removed by the voluntary isometric contractions.

In summary, we estimated the IOMCJ to look for the method for implementing of the exercises with the same accuracy. We used the quasi-muscular tension and a joint model. The IOMCJ was the difference between a cubital joint stiffness and a hand torque.

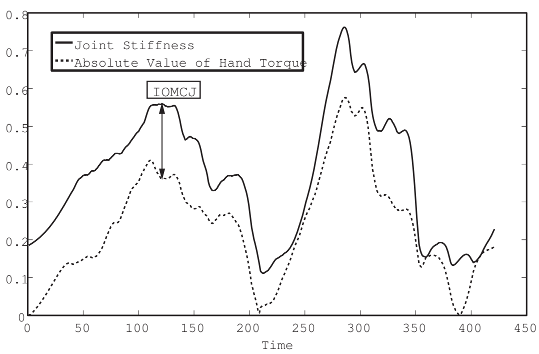


Fig. 1. IOMCJ(Index of Over Muscle Co-contraction around the Joint)

The joint stiffness is defined as follows. *The joint stiffness decreases as skill of exercises improves. It is be indicative of the pliability of the body [8].* However, this value has demerit. When motion strength differs, it cannot correspond because, in a lot of cases, there are times when motion strength changes. Moreover, the relationship between EMG and muscle tension is almost linear. Therefore, the joint stiffness depends on the size of exertion. Take golf, for example. A golf swing has impact motion, release motion, and so on. Impact motion involves greater exertion than release motion. Therefore, they are very difficult to compare. The minimum necessary joint stiffness is proportionate to hand torque in exercise. Figure 1 shows the joint stiffness, hand torque, and IOMCJ in this trial. This time, the minimum necessary joint stiffness and hand torque were equivalent. Herewith, IOMCJ does not depend on severity of force because it reject variable force. Therefore, IOMCJ can correspond when motion strength differs. Figure 2 shows a scatter chart of joint stiffness and IOMCJ to hand torque.

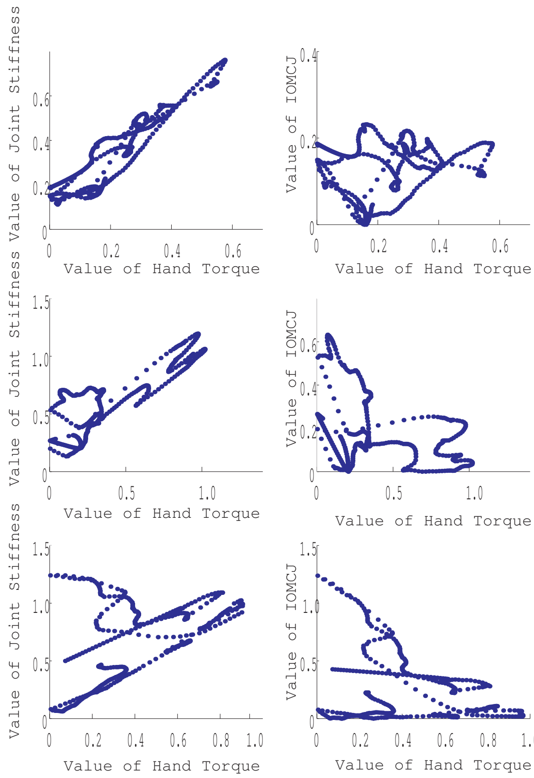


Fig. 2. Scatter chart of joint stiffness and IOMCJ to hand torque (left side pictures are sample of joint stiffness; right side pictures are sample IOMCJ)

## III. Experiment

### A. Experimental Environment

The trial subjects were 10 males between 20 and 25. They conducted the experimental trials with their dominant hand. Figure 3 is panoramic view of the experiment environment.

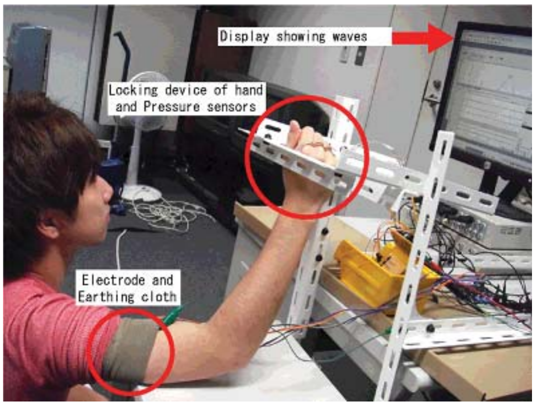


Fig. 3. Panoramic View of Experiment Environment

The trial subjects put their upper arm on the stand with the forearm pointing upwards. Moreover, their arm was restrained so they could make voluntary isometric contractions of the biceps brachii and the triceps brachii. The stand was adjusted for the height of the shoulder. Measuring data were surface EMG and pressure value. Surface EMG measured using bipolar surface electrodes and differential amplifiers. Sampling frequency was 4kHz. The electrodes were put on the surface of the biceps brachii and the triceps brachii. Moreover, we used earthing cloth to prevent externality noise. Obtaining a

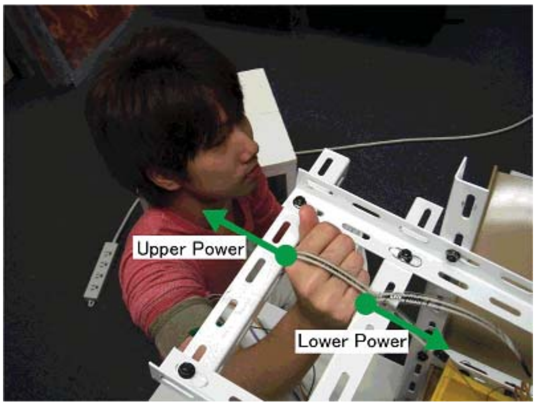


Fig. 4. Pressure Sensor and Power Direction

pressure value using pressure sensors(NITTA corp. FlexiForce) means showing power of the biceps brachii and the triceps brachii. Therefore, the sensors were set as shown in Fig.4. Trial subject put some muscle as ”upper power” or ”lower power”. An LCD monitor was put in front of trial subjects

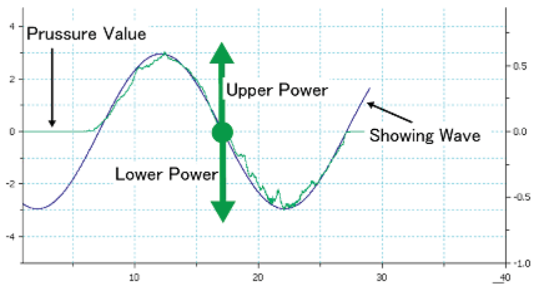


Fig. 5. Showing Screen

to show them graphs. The graphs displayed the sin waveing value and the subjects output value. The displaying value was sin wave. The output value was the pressure value. Its positive quantity means power of the biceps brachii(defined as ”upper power”). Its negative quantity means power of the triceps brachii(defined as ”lower power”). Figure 5 shows the display screen image.

### B. Task Setting

The task was to adjust the output value to the displayed sin wave. The sin wave value was 500mHz. This means 1 period lasted 2 seconds. The level of difficulty depended on the person. One trial lasted for 1 period of the displayed sin wave value. Each trial subject did 60 trials. These were done in 30-45 minutes because this is time for which concentration can be maintained. This movement is basic exercise. Usually, exercise is constructed put or let down in increments or keep going. Therefore, we used the desplayed sin wave that the exercise is basic movement.

We used coefficient of correlation between the pressure value and sin wave value to distinguish between success and failure. Its threshold value was set at 0.9. We defined that cases over the threshold value as successes. Then, we defined the successful tasks to have the same accuracy. The success rate was 55.7%(334 out of 10 $\times$ 60 trials). We investigated how to implement the exercises with the same accuracy. Therefore, we took notice of the successful tasks.

## IV. Experimental Results

### A. Definition

We investigated the possible of the existence of common motion structures. We describe these structures as quantity of degree of strength for common exercise. We defined the strength as the difference between stiffness and torque. This means IOMCJ. We researched the shifting IOMCJ. Therefore, we researched the difference in the motion structures by repeating exercise. That is, we researched analogy of the motion structures.

### B. dispersion of IOMCJ

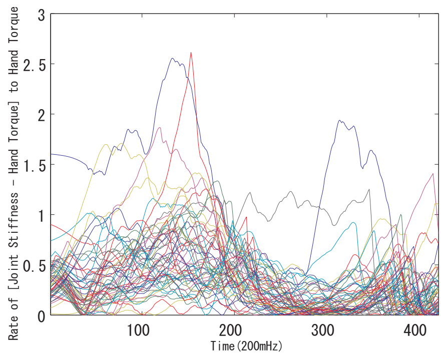


Fig. 6. IOMCJ of all trials(one trial subject)

Figure 6 shows IOMCJ of all trials (one trial subject). The IOMCJ have range is

Figure 7 shows the average joint stiffness and IOMCJ with errorbar using standard deviation. These values show different trends. Joint stiffness has two peaks. The line of joint stiffness is similar to the tendency of hand torque. That is, joint stiffness is affected by the size of hand torque. On the other hand, the phenomenon occurs in which the latter half is lower than joint stiffness in IOMCJ. We thought that this means that the subject gets a sense of exhaustion in the latter half. This information is difficult to see with joint stiffness. Therefore, we used IOMCJ, which is more visible information than joint stiffness.

dispersion of IOMCJ (the maximum value, the minimum value, and the difference between these values for 10 trial subjects) is listed in Table I. The data of all trial subjects is summarized as follows. The maximum value of IOMCJ ranges from 0.198 to 0.521. The minimum value of IOMCJ ranges

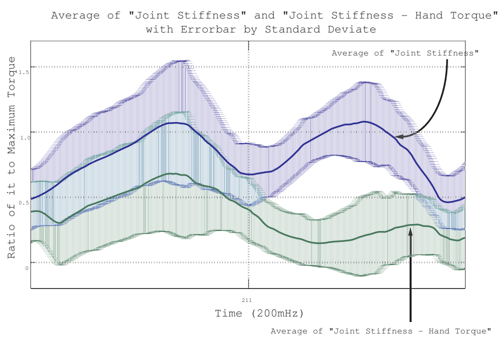


Fig. 7. Average joint stiffness and joint stiffness - hand torque(IOMCJ)" with errorbar using standard deviateion

TABLE I
RATE OF IOMCJ TO MAXIMUM VALUE OF HAND TORQUE (MAXIMUM, MINIMUM, AND DIFFERENCE BETWEEN THESE TWO VALUES FOR 10 TRIAL SUBJECTS)

| | A | B | C | D | E | |
|---|---|---|---|---|---|---|
| MAX | 0.398 | 0.521 | 0.257 | 0.198 | 0.239 | |
| MIN | 0.005 | 0.104 | 0.018 | 0.018 | 0.063 | |
| DIFF | 0.393 | 0.417 | 0.239 | 0.180 | 0.176 | |
| | F | G | H | I | J | Average |
| MAX | 0.348 | 0.328 | 0.328 | 0.437 | 0.490 | 0.354 |
| MIN | 0.072 | 0.030 | 0.059 | 0.016 | 0.174 | 0.051 |
| DIFF | 0.276 | 0.298 | 0.268 | 0.421 | 0.316 | 0.271 |

from 0.005 to 0.271. The difference between these values of IOMCJ ranges from 0.239 to 0.421.

### C. Comparison of the Trial Groups Using IOMCJ

We compared the trial group with other group using IOMCJ. We segmented all trials into 20 groups. Table II shows how the trial groups were segmented. The number of trial subjects was 10. We segmented experimental data for each trial subject into odd and even groups. The number of total segmented groups was 20 (10 people $\times$ 2 groups). The reason groups were divided like this was as follows. All trial data has many noises: proficiency, tiredness, ability to concentrate, and so on. Thus, we prevented these noises using this method of segmentation. After that, we calculated the dispersion and the average of these data with the respective groups. Then, we calculated the correlation of each group. Finally, we sorted the dispersion and the average of these data using the correlation of each data. Therefore, we found out the rank of the same personal data by using the correlation of each groups. Figure 8 shows ranking of the height of correlation to group of the same person in all groups. The probability where the data of the same person comes to 1 rank was 65%(Average of IOMCJ). Another was 61%(dispersion of IOMCJ).

TABLE II
HOW GROUPS WERE SEGMENTED

| Number of group | 1 | 2 | 3 | 4 | | 19 | 20 |
|---|---|---|---|---|---|---|---|
| Subjects | A | | B | | ... | J | |
| Segment | odd | even | odd | even | | odd | even |

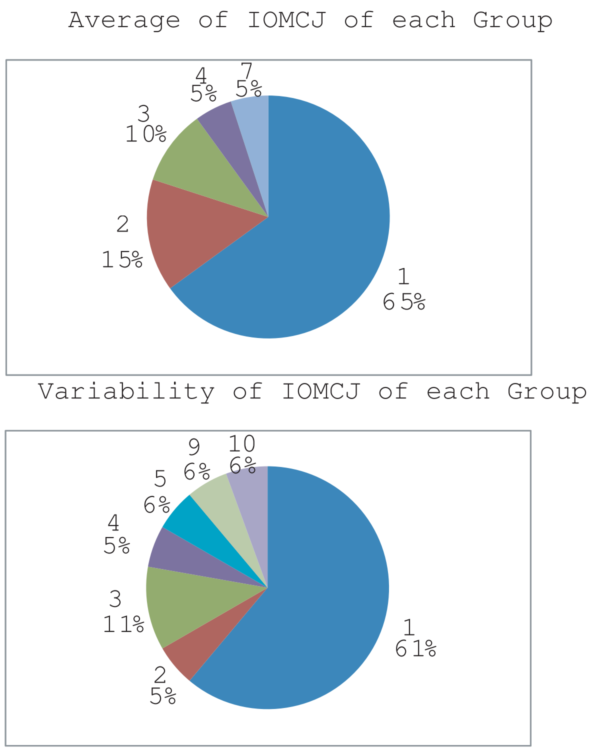


Fig. 8. Ranking of the height of correlation to group of the same person in all groups

## V. DISCUSSION

### A. Individual Characteristic Principle

We verified if Individual Characteristic Principle truly appears, when it appears, and how is appear.

We compared the data that is judged to have the same accuracy with exterior index (coefficient of correlation between the pressure value and displaying value). As a result, the difference appeared that could not be measured with an external index. The difference appeared as dispersion of IOMCJ. Unlike the largest torque, when it is the person whose dispersion of IOMCJ is largest, the value of around 50% appeared. In addition, even the average dispersion of IOMCJ for all subjects was approximately 35%. In other words, over half the force exerted on exercise was unnecessary. Because of this, it was verified that the big internal difference exists in doing motion of the same precision. When it is simple motion and being the single joint, this kind of result appeared. Therefore, we think that further big internal differences may appear, if the motion has a higher degree of freedom. In daily life, we think that these phenomenon are differences in skill. We can show power efficiently if we decrease the unnecessary power. In other words, the big difference of largest showing power, fatigue condition, and so on appears if the people have similar muscular strength, physique, and so on.

### B. Resemblance of the Motion Structures

We found out motion structures resemble each other. This phenomenon appeared both in average value and variation. Therefore, first, in identical people, we can see resemblance in the IOMCJ flow. That is, the average IOMCJ may have strain points and exhaustion points that resemble each other. Second, in identical people, we can see resemblance in the IOMCJ variation. That is, the variation of IOMCJ may have fixed points and dispersed points that resemble each other as inserting the power.

## VI. Conclusions

Individual Characteristic Principle indicated the existence of difference in the same accuracy. We confirmed this principle using IOMCJ. IOMCJ has dispersion to maximum torque. It tops about 50We thought that the common motion structures existed because the phenomenon includes strong points and knacks. We verified the possible existence of common motion structures. With that, we confirmed as follows. We learnt that trial of the same person have more phenomenon of exercise than those of other people. Then, we thought that the analogy was knack and habit corresponding. This go-round, we researched very simple motion, and the analogy in the same person. After this, we research the features of motion common to many people. In the future, we will try more complicated motion. Then, we study motions that more similar to the motions in daily life.

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