

Experiment of Music Therapy Conducted at a Classical Music Recital - Measurement of Saliva Amylase, Hand Sweat and Muscle Hardness -

Hirotooshi HISHIDA

Faculty of Engineering, Kogakuin University
1-24-2 Nishi-Shinjuku Shinjuku, Tokyo 163-8677, Japan

Riku KASAHARA

Graduate Student, Kogakuin University
1-24-2 Nishi-Shinjuku Shinjuku, Tokyo 163-8677, Japan

Keiko HISHIDA

Headquarter, Keiko's Music Room
2-37-7 Fueda Kamakura, Kanagawa 248-0027, Japan

Yoshihiro KOMATSU

Postgraduate Student, Kogakuin University
1-24-2 Nishi-Shinjuku Shinjuku, Tokyo 163-8677, Japan

Hina ETOH

Graduate Student, Kogakuin University
1-24-2 Nishi-Shinjuku Shinjuku, Tokyo 163-8677, Japan

Yasuhiro HISHIDA

Faculty of Science and Technology, Keio University
4-1-1 Hiyoshi Kouhoku Yokohama, Kanagawa 223-8521, Japan

Mitsuhiro HISHIDA

Yokohama plant tour, Nissan Motor Co., Ltd.
2 Takaramachi, Kanagawa, Yokohama, Kanagawa 220-8623, Japan

ABSTRACT

The effect of music on the mind and body is not yet known quantitatively. In our laboratory, the basic research has been conducting for the purpose of elucidating the mechanism and referring to specific methods of music therapy. In this paper, the measurement results of salivary amylase, hand sweat, and muscle hardness performed in the music therapy experiment, which was held in a public recital. There 3 measurements suggested that Beethoven's music had a positive effect on the mind and body.

In this experiment, pulse wave, blood pressure, and cardiac directivity were also measured. The results of these measurements will be discussed in detail in another paper. Compared with these measurements, the 3 kinds of measurements described in this paper are considered to require further improvement in usage and error evaluation.

Keywords: Actual concert, Music hall, Stress and relaxation, Beethoven's piano pieces.

1. INTRODUCTION

The authors consider that the principle of music therapy has not yet been elucidated and that no specific operational method has been established for its application to real problems. In our laboratory, experiment of music therapy has been continuing.

Although once every few years, experiments using an actual concert which is open to the public [2] has also been conducting. Then, subjects and experiment leaders participated in the Beethoven 250th Anniversary Recital held on December 5, 2020, and conducted music therapy experiments as the recital progressed [1].

At the experiment, 6 kinds of biometric information values were tried to be measured. In the other paper, the authors summarized the overall feeling, and reported and discussed the measurement results of pulse wave, blood pressure, and mental directivity. In the present paper, the measurement results of the remaining three types, namely salivary amylase, hand sweat, and muscle hardness will be reported and discussed. It also presents a record of detailed experimental implementation.

2. EXPERIMENTAL METHOD

Participated Recital

The specifications of the hall where the recital we attended was held are as follows;

Shape: It is a shoebox-shaped hall whose floor plan view is shown in Fig. 1. A shoe box type hall has shape of elongated one, such as rectangle or similar shape. The Großer Musikvereinssaal of the Wiener Musikverein (in Austria), Concertgebouw (in Netherlands), and The Symphony Hall in

Osaka (in Japan) are the examples.

Capacity: It has originally a capacity of 300 people, but as a part of measures to prevent infection with the new coronavirus SARS-Cov-2, the capacity was limited to 120 people on the day the experiment was conducted. It has a small foyer with mini kitchen as shown in Fig. 2.

Stage and Sound: The stage has the frontage of 14.15m and the depth of 6.4m with the echo wall with 2 doors on the right and left side. Reverberation of the entire hall is about 1.7sec. The pianist played a Steinway D-274 type piano. It may be that the reverberations overlapped excessively from the right and the left, which was probably because the number of visitors was limited.

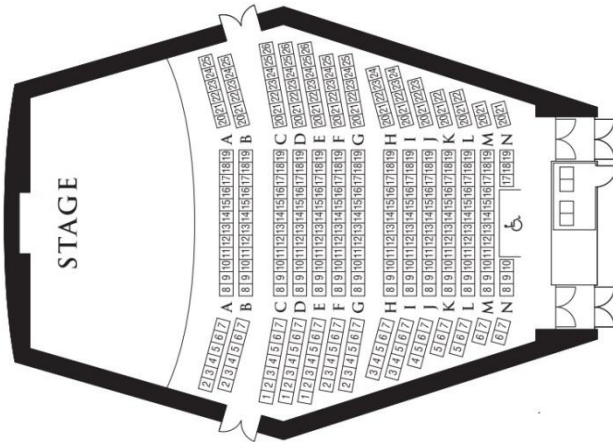


Fig. 1 : Floor plan view of hall with seat number [3].

Subjects

4 women and 24 men between the ages of 19 and 68 ran for the experiment as subjects. The 4 female subjects were asked to act together and therefore sit close to each other (D20, D22, E21, E23 in Fig. 1), one of whom became the experimental leader. One pulse oximeter which is a specified maintenance management medical device, one sphygmomanometer which is a home medical equipment, one saliva amylase measuring device explained below, and one muscle hardness tester explained below were lent to the 4 subjects, and the experiment leader carried out the management of measuring them.

They were classified into 4 groups according to whether they like classical music and whether they knew the pieces to be performed there. Bagatelle No. 25 WoO 59 "Für Elise", is a very famous piece in Japan, and Sonata No.8 Op.13 "Grande Sonate pathétique" is not a little known. On the other hand, Sonata No. 32 Op.111, Variations Op.34, 11 New Bagatelles Op.119 are not well known to the general public in Japan. The subject who knew more than 3 pieces in the recital program, is to belong to group a/b, and one who knew 2 or less is to belong group c/d. However, the 2 subjects who participated in the experiment on the verge could not be classified. The reason is that each subject was asked to listen to the first minute of the pieces and judge whether knew or not, and that they had no time to check. The subjects belonging to groups a/b were asked to attend a lecture on the pieces in the recital program one week before the experiment, and then listen to the pieces during the week until the day of the experiment.



Fig. 2 : View of measurement at foyer before recital started.

Table 1 : List of subjects.

Characteristics			Knew or not at experiment										like or not
No.	Sex	Age	S 20	V	S 8	Elise	B 1	B 2	B 3	B 7	S 32	class	class
1	Male	28										z	z
2	Male	30	knew	knew	knew	knew	not	not	not	not	knew	a/b	a/c
3	Male	23	not	not	not	knew	not	not	not	not	not	c/d	a/c
4	Male	24										z	z
5	Male	23	knew	knew	knew	knew	knew	knew	knew	knew	knew	a/b	b/d
6	Male	23	knew	not	knew	knew	knew	knew	not	not	not	a/b	a/c
7	Female	24	knew	not	knew	not	knew	knew	not	knew	not	a/b	b/d
8	Male	21	knew	knew	knew	knew	knew	knew	knew	knew	knew	a/b	a/c
9	Male	21	not	not	knew	knew	not	not	not	not	not	c/d	a/c
10	Male	22	not	not	knew	knew	not	not	not	not	not	c/d	b/d
11	Female	21	not	not	knew	knew	knew	not	not	not	not	a/b	a/c
12	Male	21	not	not	knew	knew	not	not	not	not	not	c/d	a/c
13	Male	20	knew	knew	knew	knew	knew	not	not	not	not	a/b	a/c
14	Male	20	knew	not	knew	knew	not	knew	not	not	not	a/b	b/d
15	Male	20	not	not	not	knew	not	not	not	not	not	c/d	b/d
16	Male	23	not	not	knew	knew	not	not	not	not	not	c/d	a/c
17	Male	21	not	not	not	knew	not	not	not	not	not	c/d	b/d
18	Male	22	knew	not	not	knew	not	not	not	not	not	c/d	b/d
19	Male	21	knew	knew	knew	knew	not	not	not	not	not	a/b	b/d
20	Male	23	not	not	knew	knew	not	not	not	not	knew	a/b	a/c
21	Male	22	not	not	not	knew	not	not	not	knew	not	c/d	a/c
22	Male	23	not	not	knew	knew	knew	not	not	not	not	a/b	a/c
23	Male	22	not	not	not	knew	not	not	not	not	not	c/d	a/c
24	Male	20	not	not	not	knew	not	not	not	not	not	c/d	a/c
25	Female	19	not	not	not	knew	not	not	not	not	not	c/d	a/c
26	Male	21	knew	knew	knew	knew	not	not	not	knew	knew	a/b	a/c
27	Female	24	knew	not	not	knew	not	not	not	not	not	c/d	a/c
28	Male	68	knew	not	knew	knew	not	not	not	knew	not	a/b	a/c

S for Sonata, V for Variations, B for Bagatelle.

z for classifying impossible.

Measurements

The measurements were taken with care not to disturb the general visitors of the recital. In the previous experiment carried out in an actual concert, subjects can occupy the back seat. However, they could not do this time because the hall is rather small and the number of visitors was limited. Male subjects were scattered in their favorite seats.

All subjects were measured in the foyer from 70 minutes to 30 minutes before the recital, because the staff of the recital organizer was preparing in the hall and could not enter. During

an intermission, female subjects measured at their own seats and male subjects outside the hall. Approximately 30 minutes after the recital was finished and the general visitors left the hall, the organizer allowed all subjects to take measurements at their own seats. Fig. 3 shows the view of the last measurement.



Fig. 3 : View of measurement in hall after recital finished.

3. SALIVA AMYLASE MEASUREMENT

Background

Amylase is regulated by the sympathetic nervous - adrenal medullary system [4], and several researchers [5] have hoped that α -amylase in salivary glands will be a stress marker [6]. Portable stress measuring device, COCORO METER, which is a specified maintenance management medical equipment and dry clinical chemistry analyzer for salivary amylase activity [7] is commercially available. In the experiment, all the subjects measured salivary amylase before and after the recital. They places a plastic tip coated with the reagent under the tongue and holds it for 30 seconds, and the amount of amylase is measured by inserting the chip into a measuring instrument.

Method

The female and male subjects shared 1 and 3 measuring instruments, respectively. Before inserting the measuring tip into the instrument, it is necessary to operate the tip a little. A dexterous subject can finish the operation in about 5sec, but some take over 30sec. It takes about 40sec from inserting the tip into the instrument to obtaining the result and removing the tip from the instrument. If the instrument displays "Unmeasurable", the measurement can successfully be done by restarting from the beginning in some cases, or cannot be realized due to unknown cause in other cases. The more subjects participate, the longer it takes, and the instrument makes small sound during it works. In the experiment, the authors gave up measuring during the 15-minute intermission, and the measurements were taken twice, before and after the recital.

Results

Table 2 lists the amount of amylase contained in the saliva of each subject, which was measured before and after the concert. All over, their saliva amylase decreased from 30.0 to 15.7 after the recital. 2 subjects could not measure after all. The standard deviation (S.D.) was as large as the mean, which claimed that there are large individual differences in the amount of amylase.

The time that the chip was contained in the mouth and the time that the chip was taken out of the mouth and then provided to the measuring instrument differed from subject to subject. The error evaluation of this measurement method should be done. On the other hand, the result that the coefficient of variation (C.V.) after the recital was smaller than that before, suggests the sedative effect of music, which is quite interested.

The change in the amount of amylase before and after the recital is shown in Fig. 4. Overall, the amount of amylase has decreased by 14.3. S.D. of the amount of change is 37.4, which is more than 2.5 times the mean value. The change significantly depends on a subject. Subject 12 showed measured value of 193 before the recital which is because he was very nervous or excited as presumed based on the other information. Excluding him, the mean value decreased from 23.5 to 15.4.

Table 2 : Values obtained by saliva amylase measurement.

Subject No.	Measurement value		
	before	after	aft.-bef.
1	28	4	-24
2	49	13	-36
3	17	15	-2
4			
5	60	11	-49
6	4	4	0
7	38	26	-12
8	18	6	-12
9	7	4	-3
10	9	6	-3
11	44	67	23
12	193	22	-171
13	12	13	1
14	36	7	-29
15	4	14	10
16	10	20	10
17	31	12	-19
18	33	9	-24
19	7	18	11
20	16	25	9
21	33	7	-26
22	64	19	-45
23	23	22	-1
24	4	4	0
25	7	38	31
26	16	8	-8
27	17	14	-3
28			
mean	30.0	15.7	-14.3
S.D.	37.4	13.4	37.4
C.V.	1.2	0.9	-2.6

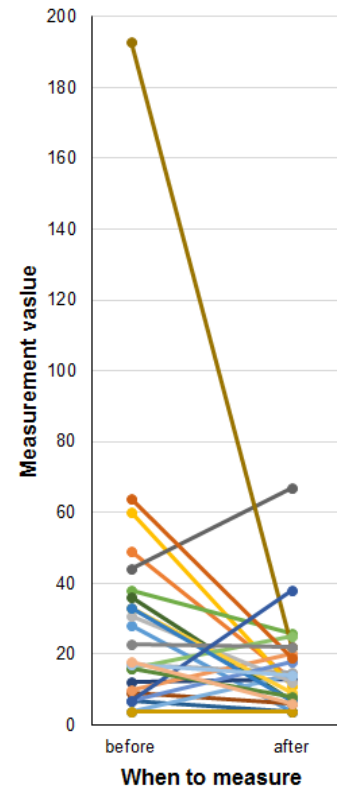


Fig. 4 : Each change of saliva amylase value.

Fig. 5 shows a histogram of the frequency distribution of the amount of change, where the class range is adopted 10. The frequency of the unchanged class (class value of 0) is the highest, and the frequency distribution is biased negatively. Considering the high possibility that stress is occurring during the measurement, the effect of music therapy was suggested.

4. HAND SWEAT MEASUREMENT

Mechanism and Method

2 types of sweat glands, eccrine glands and apocrine glands, have different sweating principles and sweat components. It is

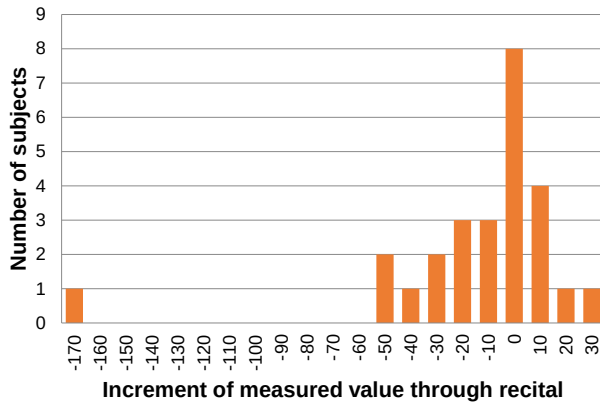


Fig. 5 : distribution of increment of saliva amylase value.

said that the mental sweating caused by mental stimuli such as tension due to stress occurs is scratched from both glands in limited areas of the armpits, palms, and soles by neural signals from the limbic system. While there are many things which are not understand yet, there are 2 types of stickers on the market that are coated with a drug which reacts to stress-induced hand sweat. In this experiment, the required number of these 2 types of stickers was distributed to all subjects, and measurement was attempted.

Results of the Long Term Sticker

The long term sticker reacts slowly and can measure the cumulative value of stress in chronological order based on the long term sticker. Under standard stress, the amount of hand sweat is about $2\text{mg}/\text{cm}^2$ per hour by the long term sheet. The concert took about 1 hour and 40 minutes, so the measurement corresponding to the standard amount of stress is about 3.6.

8 subjects couldn't obtain the results. Some of them couldn't record because they didn't have time, and some others couldn't measure because the sheet was peeled off from their hand. The other 20 subjects could record the measurement results which show the time histories as shown in Fig.6. The results of only 5 subjects showed an increase in the numerical value, and the results of the other 15 subjects remained 0 and showed the same value. At the end of the recital, the stress levels of all the subjects were below the standard value of 3.6. The stress level of Subject 14 increased from 0 to 2 during an intermission. Except for his rise during an intermission, the cumulated stress rates of the other subjects never exceeded a standard cumulative stress rate of about $2\text{ mg}/\text{cm}^2$ for 1 hour. It can be said that the stress during the recital was generally less than usual.

Results of the Short Term Sticker

It reacts rapidly and can measure the cumulative value of stress received in 3 minutes. In the central circle window, this sticker displays the color which changes in response to the amount of sweating such as the continuous color from blue indicating "stressless", to red indicating "stressful". On the other hand, the continuous color pattern from blue to red is drawn around the central window. The subject can compare the color displayed on the central circle window with the color pattern to correspond the stress level to a numerical value of 1- to 4+. In this study, - and + were defined as ± 0.3 , respectively, and the color change was converted from 0.7 to 4.3.

The converted values obtained are shown in Table 2. The

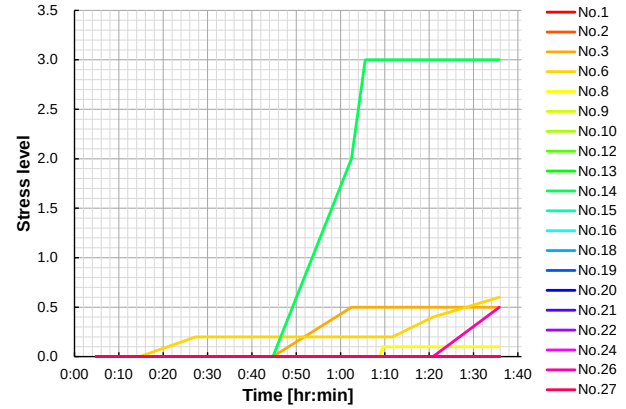


Fig. 6 : Results of stress level histories based on long term sticker.

Table 2 : Results of short term sticker.

Subject No.	Stress level at			Change of stress level between		
	before	intermission	after	int.-bef.	aft.-int.	aft.-bef.
1						
2						
3	4.0	4.0	3.3	0.0	-0.7	-0.7
4						
5	4.3	4.3	4.3	0.0	0.0	0.0
6						
7	2.0	1.0	1.0	-1.0	0.0	-1.0
8	4.0	3.7	3.3	-0.3	-0.4	-0.7
9	1.7	3.7	2.3	2.0	-1.4	0.6
10	0.7	1.7	1.7	1.0	0.0	1.0
11	3.7	2.3	2.0	-1.4	-0.3	-1.7
12						
13	2.7	2.7	3.3	0.0	0.6	0.6
14	3.7	3.7	4.3	0.0	0.6	0.6
15	1.3	3.3	3.3	2.0	0.0	2.0
16	2.3	2.3	2.7	0.0	0.4	0.4
17	1.3	3.3	3.3	2.0	0.0	2.0
18	1.0	2.0	1.0	1.0	-1.0	0.0
19						
20						
21	4.3	2.3	1.3	-2.0	-1.0	-3.0
22						
23						
24	2.3	2.3	3.0	0.0	0.7	0.7
25	2.0	2.0	2.0	0.0	0.0	0.0
26						
27	2.3	3.3	3.3	1.0	0.0	1.0
28						
mean	2.56	2.82	2.67	0.25	-0.15	0.11
S.D.	1.21	0.92	1.04	1.14	0.60	1.26
C.V.	0.47	0.33	0.39	4.53	-4.06	11.90

subjects measured with a sticker attached to the dominant hand on which they did not attach the long term sticker, before the recital started, during an intermission, and after the recital finished. 11 subjects couldn't obtain the results by the same reason as the Long Term Sticker. The difference in conversion values between each measurement showed a standard deviation (S.D.) which was significantly larger than the mean. The coefficient of variation (C.V.) means that the method for measuring the amount of sweating is unstable. In the measurement method, there are individual differences in color discrimination, and the collation of the color may be incorrect depending on the ambient light. Since the ambient light is

different at different measurement locations, it is highly possible that the three measurement conversion values cannot be compared directly. On average, the stress increased slightly after the recital compared to before it, but it is considered that the increase was not due to the effect of the performance but due to the stress caused by the task to do various other measurements^[1].

5. MUSCLE HARDNESS MEASUREMENT

Background

Symptoms in the early stages of stress include stiff shoulders, low back pain, eye strain, etc. This is because the action of the sympathetic nerve causes the muscle to become tense so that it can move immediately (muscle tonus). On the contrary, it is not always the case that the degree of stress can be estimated from that of muscle tension. In addition to stress (mental state), the causes of muscle tension include posture and central nervous system diseases.

In this experiment, we measured muscle hardness as a trial and examined whether it could be a method for measuring the degree of stress. The measuring instrument used was a muscular hardness tester, TDM-NA1 [8]. Although it is not a medical device, it is lightweight and easy to operate, and it is convenient for such an experimental meeting held by participating in an actual music concert. It can be measured by pressing the stylus perpendicular to the measurement point by the measurer himself or the measurement assistant by hand.

Method

It is considered that different muscles to be measured have different muscle hardness. In addition, even for the same muscle, if the measurement points are different, the muscle hardness may be measured at different values. It is considered that subjects should not change the measurement position during the experiment (It does not refuse to measure at multiple positions.) and all subjects should measure at the same position.

It is easy to measure if the subjects have something that can be used as a mark, for an example, it is effective to put a sticker on the measurement position. On the other hand, it is difficult to specify the measurement position when wearing clothes, so it is preferable that the skin is exposed at the measurement position.

In the experiment, the muscle hardness was measured at a place where it was easy to measure from the neck to the shoulder of the trapezius muscle. 4 testers were prepared, 1 was shared by 4 female subjects and the remaining 3 were by 24 male subjects.

Results

It differs from other measurement results in that S.D. is smaller than the mean. Although there are various problems in measurement method as mentioned below, it can be said that the muscle hardness measurement is more stable than others. Overall, muscle hardness decreased from 21.88 before the recital began to 17.85 after the recital finished. The mean of the difference in muscle hardness before and after the recital is -5.37. S.D. is 4.86 and smaller than the mean, which shows listening to the Beethoven's piano pieces played in the recital can be expected to have a relaxing effect.

There was a difference between the left and right, but it can be considered that it is due to the asymmetry of the original human

body and the daily activities such as how to sit. The detailed discussion will be done on the other studies.

Fig.3 : Result of muscle hardness measurement.

Subject No.	before recital			after recital			change (aft. -bef.)		
	right	left	mean	right	left	mean	right	left	mean
1	12	12	12.0	10	16	13.0	-2	4	1.0
2	9	8	8.5	12	9	10.5	4	0	2.0
3	16	20	18.0	22	13	17.5	2	-3	-0.5
4									
5	17	12	14.5	24	9	16.5	12	-8	2.0
6	20	16	18.0						
7	31	30	30.5	15	17	16.0	-15	-14	-14.5
8	31	28	29.5	20	18	19.0	-8	-13	-10.5
9	25	24	24.5	20	12	16.0	-4	-13	-8.5
10	21	21	21.0	14	15	14.5	-7	-6	-6.5
11	34	32	33.0	29	30	29.5	-3	-4	-3.5
12				17	17	17.0			
13				18	24	21.0			
14				30	37	33.5			
15				18	22	20.0			
16									
17	17	15	16.0	10	12	11.0	-5	-5	-5.0
18	24	33	28.5	23	21	22.0	-10	-3	-6.5
19	26	23	24.5	12	17	14.5	-11	-9	-10.0
20	23	33	28.0	20	16	18.0	-13	-7	-10.0
21	12	22	17.0	20	17	18.5	-2	5	1.5
22	23	21	22.0	15	14	14.5	-6	-9	-7.5
23	15	12	13.5	11	4	7.5	-1	-11	-6.0
24				20	19	19.5			
25	26	24	25.0	19	17	18.0	-5	-9	-7.0
26	26	28	27.0	24	10	17.0	-4	-16	-10.0
27	28	25	26.5	25	23	24.0	0	-5	-2.5
28									
mean	21.80	21.95	21.88	18.67	17.04	17.85	-4.11	-6.63	-5.37
S.D.	6.93	7.55	6.88	5.60	7.00	5.63	6.27	5.74	4.86
C.V.	0.32	0.34	0.31	0.30	0.41	0.32	-1.53	-0.87	-0.91

Discussions

Several subjects repeated the measurement at several positions before the experiment. The results and impressions of the subjects are described as follows:

Arm: When a measuring point is provided on the arm, they can measure by themselves at almost the same position and from the same direction with the same force each time. It is presumed that the arm is a relatively stable and easy-to-measure part, and the error is hopefully small as a result. The elbow helps the subject identify the measuring position as a guide.

Leg: If a measuring point is provided on the foot, it is more difficult to identify than that on the arm. Since the legs are below the arms, the subjects cannot measure by themselves unless they bend their body, and as a result, they will be in an unreasonable posture and it will be hard to hold the measuring position during measurement. When they wear hard clothes on their feet, it is not always possible to measure outside.

Shoulder and Back: When a measuring point is provided on the shoulder or back, it is difficult to measure multiple times at the same position because the subjects cannot see it. The measurements will be significantly different if the measuring points are slightly off, which supports that the measurement error must be large. Compared to other motor systems, various muscles are complicatedly present around the neck, shoulders, and scapula. In addition, from the shoulder to

the back, the strain of the skeleton is likely to accumulate, and the coordinate value of the measuring position may shift during the experiment. It is difficult to measure at the same position through over the clothes, because there are few information that can be used as an exact guide. The muscle hardness values measured multiple times by multiple subjects at multiple measuring points were completely unstable.

The method adopted in the experiment depends on the strength of the force to push a muscle hardness tester. In order to measure with the same force, it is necessary to prepare a measurer or practice for each person. They hinder the simplification of the experiment, but they are not impossible. There will be an error in the measurement results depending on the presence and type of clothes. Thin clothes such as T-shirts do not cause large errors, and thick clothes such as trainers and knits cause obvious errors. Women are more likely to wear underwear in layers which may result in thicker clothing and less accurate measurements. In order to confirm the effectiveness of the muscle hardness tester, it will be necessary to first conduct a laboratory- level basic study.

6. CONCLUSIONS

A music therapy experiment was conducted using an actual recital. 6 types of biometric values were measured, all of which showed that Beethoven's music had a positive effect on the mind and body. The conclusions that can be drawn from the measurements of salivary amylase, hand sweat, and muscle hardness are listed as follows:

- 1) **Saliva amylase:** Overall, it suggested the effect of music. There were large individual differences. Since it takes time and various measurement conditions differ depending on subjects, it is essential to improve the measurement method and evaluate the error.
- 2) **Hand sweat:** The long term sticker, which is available in the dark environment during the performance, suggested a slight effect of music. On the other hand, the short term sticker, which showed an unstable result with an error in color discrimination, did not conclude the musical effect. Several subjects failed to measure. Careful consideration is required for the adoption of the measurement method, and its results may be limited to reference data.
- 3) **Muscle harness:** The best position to measure may be on the arm. Leg is not so suitable, and it cannot be done by the subject to measure on shoulder or back. In order to measure with the same force, it is necessary to prepare a measurer or practice each person. Thick clothes such as trainers and knits cause obvious errors.

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