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BASIC RESEARCH ON MUSIC PRESCRIPTIONS - SECOND EXPERIMENT WITH CLASSICAL MUSIC

Hirotoshi Hishida
Kogakuin University
Tokyo, Japan

Shigehiro Hashimoto
Kogakuin University
Tokyo, Japan

Kaito Saeki
Kogakuin University
Tokyo, Japan

Hikaru Kouno
Kogakuin University
Tokyo, Japan

Keiko Hishida
Keiko's Music Room,
Kamakura Player's Association
Kamakura, Japan

ABSTRACT

The authors assume that the stress state can be expressed by a value, SMB, and are trying to develop a method to change the value in an appropriate direction by music. This paper compares the results of the music therapy experiment conducted in 2022 with those in 2020. Subjects are recruited and classified into four groups according to whether they know the pieces played and whether they like the music. Some subjects wear the pulse oximeter throughout the concert. Other methods are employed to measure the stress states of all subjects at the beginning, the intermission, and the end of the concert.

Based on the experiment, the possibility of prescribing classical music to patients is recognized. The same music has different effects on the subjects, depending on the type of music and the subject's characteristics such as gender and whether he/she likes the music. The effects also differ depending on the piano player. In other words, prescribing music would not be simply selecting songs according to the symptoms.

In the future, the music database will be grown up and the experimental methods using public concerts will be improved. Some of the stress measurement methods employed in this experiment may be combined to determine SMD.

Keywords: Concert, Piano, Stress, Pulse, Arterial oxygen saturation, POMS, Blood pressure, Muscle hardness.

NOMENCLATURE

SMB	total state of health in mind and body
HR [bpm]	heart rate (= heart rate in a healthy person)
SpO_2 [%]	arterial oxygen saturation
TMD	total mood disturbance obtained POMS-2

1. INTRODUCTION

People living in modern society have many sources of stress in the school environment, work environment, everyday life, and so on. In recent years, the coronavirus [1] and war [2] have also become sources of strong stress. Stress can cause all kinds of ill health. It is important to create an environment where stress can be reduced or eliminated in modern society, where everyone is under a lot of stress due to many factors. In the past, efforts to ensure health and safety were regarded as an occupational disease of workers [3]. It is said that such efforts should now be made for children's mental health [4].

We can see many studies on the effects of stress on health [4-6]. Trials are continuing to reveal if music [7] can be applied effectively, and research on music therapy, such as the use of music to induce sleep [8], is also active. On the other hand, there are various opinions about its effect [9]. Since the end of the 20th century, attempts have been made to prescribe music instead of drugs or medical treatments, but there are large individual differences and a systematic methodology has not yet been established. It is heard that many hospitals in Japan took on the challenge and stopped research and surveys in around 2010.

In our laboratory, the dangers of the sound [10,12] and the possibilities of its utilization [11,13] have been studied. The practical application of music prescription is also one of the purposes. One of the capital obstacles in the basic research on music therapy is that it is difficult to conduct experiments on a large number of subjects under the same conditions. The authors have conducted music therapy experiments several times in the past, made some assumptions, and are continuing to improve the experimental method. In this paper, the results of the music

therapy experiment conducted in 2022 are compared with those of the experiment conducted in 2020 [11].

2. METHODS

On June 30th, 2022, the latest music therapy experiment was conducted. The implementation method was essentially the same as that of the previous music therapy experiment conducted on December 5th, 2020. The following describes the contents of the experiment. However, the necessary databases, the measurement of the subjects' conditions, and the classification of the implementation methods of the music therapy experiment have been described in detail in previous literature [11,14], so only a brief explanation will be given here.

2.1 A hypothesis on the mechanism of music therapy

It is believed that there are various conditions that would hopefully be improved through music, but for the sake of simplicity, let us first assume that the overall health of a patient can be quantified as a scalar value, *SMB* (total state of health on mental and body). Similar to the human nervous system, it may be best to consider positive values as indicating an excited state and negative values as indicating a calm state. An excessive positive value of *SMB* means madness, and an excessive negative value means the cessation of life activity. That is, it is assumed that *SMB* is equal to 0 in the healthiest state. Sometimes a little sedation or agitation is good, but in normal times the most balanced state may be desirable.

FIGURE 1 schematically shows two examples of the effects of music. Here, patient 1 is depressed and Patient 2 is agitated. Music prescriptions are made so that their *SMB*s, P_1 and P_2, are both improved approaching 0. Under the premise that music can be quantified on the same *SMB* axis, the case of prescribing music A, B, and C corresponding to different *SMB* values, M_A, M_B, and M_C are taken into consideration. It would hopefully be that let them listen to music A, B, or C, and that their *SMB*s, P_1 and P_2, will be pulled towards the *SMB* values of that music, changing to $P_1(A)$, $P_2(A)$, and so on. The phenomena can be thought to be due to the fact that the patient and the music are in synchronization [15,16]. It seems that how far the patient's *SMB* can be pulled depends on the relationship, for example, the compatibility of the patient and the music. However, it has been qualitatively pointed out that when the *SMB*s of the patient and the music is greatly different, the patient shows a rejection reaction to the music, and the *SMB* is rather distant from that of the music.

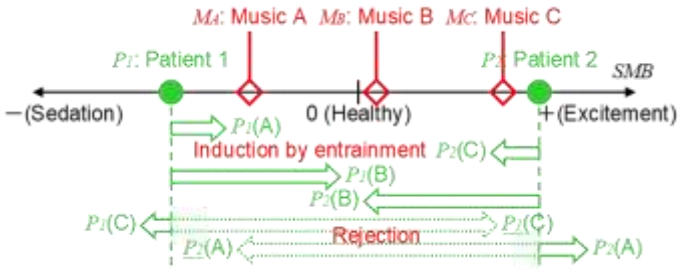


FIGURE 1: SCHEMATICAL EXPLANATION OF THE EFFECTS OF MUSIC

2.2 *SMB* value and the music database

In order to evaluate and use the above hypotheses, it is necessary to clarify in advance which values on the *SMB* axis correspond to the music and the patients. This method is currently under investigation and should be established by research. It is also not yet known how *SMB* should be calculated and what measurements should be taken for it.

At present, as a preliminary step to know what the patient's *SMB* value is, the method of measuring the pulse wave, blood pressure, etc., as described later, is adopted in our experiments. That is, in this experiment, the SMB value is provisionally approximated by the stress value. It was inferred that the stress that disturbs a healthy physical/mental condition is close to the SMB value, because it is the result of the normal functioning of the nervous control system. Of course, the factor that determines SMB is not only stress, but also individuality, that is, the background for music in life, physical constitution, eating habits, etc. can be considered. In the future, it will be necessary to propose a modification of SMB based on individuality, for example, by considering the results of this experiment in detail.

On the other hand, we are building a music database [12,13] to explore the equivalent *SMB* value of music. The database consists of at least musical scores and sound sources in WAVE format.

2.3 Program

At the latest concert on June 30 in 2022, in which the music therapy experimental was held, several pianists played classical piano pieces composed by Russian composers. This concert was open to the public, and scheduled to start at 18:30 at Shinjuku Residents Hall. The last pianist played all the pieces at the recital on December 5 in 2020 where the music therapy experiment was held.

There are two main ways to conduct music therapy experiments. One is a method to measure the reaction to music in detail for one or a few subjects in a special measurement room such as a laboratory. The other is a method in which a large number of subjects participate in one concert and measure their reactions to music to the extent possible. In the latter method adopted this time, while it is possible to set the same experimental conditions for all subjects, there are various restrictions such as not being able to interrupt the concert and not being a nuisance to other general visitors. It was predicted that even the same piece of music would have different effects on the subjects if played by different performers. So, it was very lucky to have the chance to use the concert where the same pianist will play again this time as the previous time. In this present study, the authors would like to focus especially on Beethoven's music and Prokofiev's music performed by this pianist and consider the dependency on the pianist.

TABLE 1 shows the time schedule and the corresponding pianists of the program in the concert. The pieces played there

were given their number, A1 to B2-4. Piece A3, "Pictures at an Exhibition" is a suite consisting of 16 small pieces, but it was treated as one piece since each small piece is short.

2.4 Concert and the sounds

An experiment is not always allowed at a concert that is open to the public. In other words, authors cannot conveniently choose suitable concerts for experiments unless they create their own. However, this concert seemed to have quite an interesting program.

The piano used in the concert was a Steinway piano installed at the venue. As is often the case with Steinway pianos, the piano seemed to strongly serve its middle- and high-frequency sounds seemed to the audience. On the other hand, the pianists said that they could feel the piano sound rather weaker on stage, and for that reason, some playing put too much force into their performance, in which strong sounds, especially high notes, resounded in the audience. Based on the preliminary survey and impressions of the subjects, it is highly possible that the acoustic conditions in the hall depended heavily on the seating position. FIGURE 2 shows a planned view of the hall. Subjects sat in the seats from the rear to the right, colored green in FIGURE 2, and where it is thought that the acoustics were not good, so as not to disturb the general audience. However, there are generally some. audiences who prefer the seats on the right side where they can see the face of the pianist.

TABLE 1: TIME SCHEDULE AND CORRESPONDING PIANIST OF THE PROGRAM IN THE CONCERT

Music piece			Playing	
No.	Composer	Title	Pianist	Time
A1	Balakirev	The Lark	a	18:31:45
A2	Balakirev	Islamey	a	18:37:37
A3	Mussorgsky	Pictures at an Exhibition	b	18:49:13
Intermession				
B1-1	Rachmaninoff	Elegy Op.3-1	c	19:35:39
B1-2	Rachmaninoff	Prelude Op.3-2	c	19:41:22
B1-3	Rachmaninoff	Melody Op.3-3	c	19:45:49
B1-4	Rachmaninoff	Clown Op.3-4	c	19:50:17
B1-5	Rachmaninoff	Serenade Op.3-5	c	19:54:28
B2-1	Prokofiev	Sonata No.6, movement I	d	20:00:04
B2-2	Prokofiev	Sonata No.6, movement II	d	20:08:23
B2-3	Prokofiev	Sonata No.6, movement III	d	20:13:04
B2-4	Prokofiev	Sonata No.6, movement IV	d	20:19:58

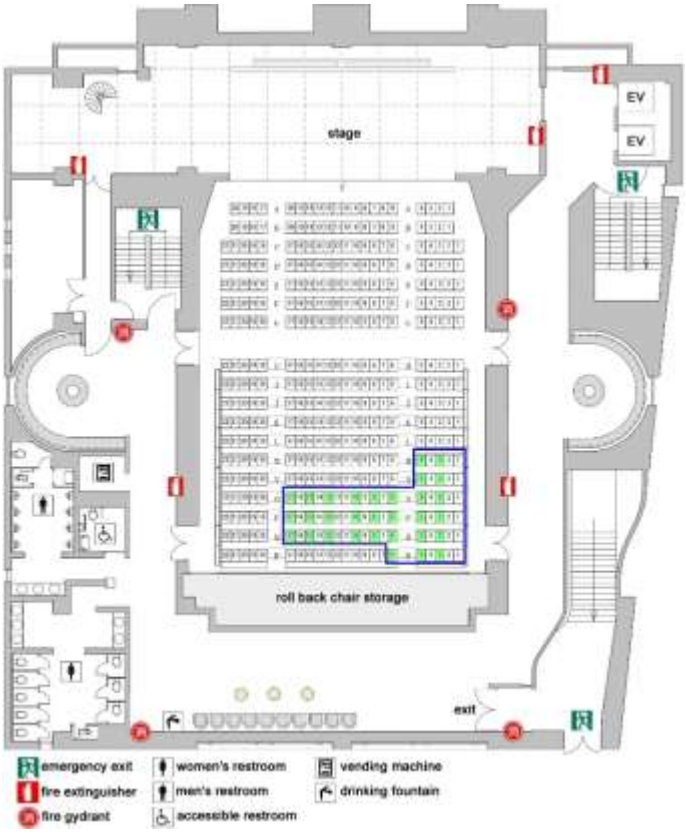


FIGURE 2: PLANNED VIEW OF THE HALL AND THE SEATS SUBJECTS SAT IN

2.5 Pieces and performances

There were four pianists, a, b, c, and d, all of whom were female. A brief description of each piece is given below.

It can be said that the Pieces A1 to B1-5 are so-called romantic music, using melodies and harmonies which are commonly accepted by those who have listened to the works of Bach, Mozart, Beethoven, Chopin, etc., or those who like recent pop music. These songs are familiar songs, which were composed to be simple and clear monophonic melody music, whose melody is easy to understand and romantic, and whose construction is not complicated. You may have heard them somewhere as BGM in recent years. It was expected that the stress of the subjects who listened to them would be reduced. However, any performances could not be perfect, and it is possible that subjects with more understanding of music felt more unsatisfactory.

Piece A1, “The Lark” is an overall slow and soothing song. Piece A2, "Islamay" has an exotic atmosphere, and is an overall lively and spectacular song. It's hard to understand just by listening, but Piece A2 in particular is a song that requires advanced performance techniques. Perhaps for this reason, pianists a and b seemed to focus too much on playing well technically to put out the forte (powerful) part too much and to be unable to fully express the beautiful piano (silent) part.

Pieces A3, the suite "The paintings at the exhibition" is famous in Japan, especially "the promenade" and the finale "La grande porte de Kyiv" are often used as BGM on TV. This suite can be said to never get tired of changing rhythms and scenes throughout. Since the impression of the pieces is fixed, the effect of the pieces may not depend much on the performance. On the other hand, the performance was aggressive, and some audience members may have felt intimidated.

Piece B1-1, "Elegy" is a heavy song with many ups and downs. Piece B1-2, "Prelude" is a famous song for skating fans, used as BGM for figure skating, and is a violent and dramatic song. Piece B1-3, "Melody" is a calm and beautiful song. Piece

B1-4, "Clown" is a pleasant song with a beautiful melody appearing in a lively atmosphere with vigorous movements. Piece B1-5, "Serenade" is a light piece on a waltz rhythm. Pianist c played according to the score without difficulty, but she may have insufficient depth and lacked cohesion.

Now, Pieces B2-1 to B2-4 may be surely special in this program. The composer made extensive use of dissonant chords and chromatic scales, as well as percussion-like playing techniques. The melody and harmony of the piece show a great deviation from those of conventional classical and romantic music, which generally gives listeners difficulty understanding. On the other hand, the form follows the sonata, classical form, and it may not be so difficult for a beginner or an amateur to understand in terms of overall cohesion and balance. The change in stresses of the subjects when listening to the sonata was quite interesting, and the authors predicted without any confidence that they wouldn't go down.

Piece B2-1, the 1st movement, and Piece B2-4, the 4th movement make you feel the disturbing sound and atmosphere. In addition, Piece B2-2, the 2nd movement shows the liveliness of the scherzo, and Piece B2-3, the 3rd movement has lyricism. The individuality of each movement stands out. The sonata has a variety of rhythms and tones throughout and is a lot of fun to listen to.

While most performers played this piece powerfully, the pianist d clearly distinguished the difference between forte parts and piano parts and performed comically. Not a few audience members would have felt the musicality of the performance, and would not have had the impression of being just picky.

2.6 Subjects

There were a total of 31 subjects: university students and general volunteers who applied for participation through open recruitment. In accordance with Kogakuin University's code of ethics, they received an explanation of the contents of the experiment in advance, agreed to participate in the experiment voluntarily, and signed a consent form. They have the right to stop participating in the experiment at any time.

TABLE 2 shows the list of the subjects. Here, Subject 29 refused to declare age. N and L indicate whether or not each subject knew the pieces which would be played in the concert. N indicates that the subject knew the name of the piece, and L indicates that she/he has heard the piece. Subjects described as "pulse" in the Group column were those who consented to the pulse measurement described below.

All subjects were classified into four groups. TABLE 3 shows the grouping method. Subjects were classified according to whether they liked the music and whether they knew the pieces in the program. Ideally, the number of subjects belonging to each group is expected to be approximately the same. In reality, people who do not like music do not voluntarily participate in music therapy experiments, so the number of subjects constituting Groups C and D is inevitably small. Fortunately, however, subjects whose pulse was measured, the measurement that matters most, were selected from all four groups. Just because they knew the name of the pieces doesn't mean they knew the pieces. Subjects 4, 5, 7, 11, 19, 22, 24, 25, and 26 only had some memory of listening to "Promenade" in Piece A3, the music suite "Pictures at an Exhibition". So, since it could not be said that they knew Piece A3, they were made to belong to Group B or D. Differences in results between groups are also discussed later.

TABLE 2: LIST OF SUBJECTS

Subjects				Which subjects know the piece or not								
No.	Sex	Age	Group	A1	A2	A3	B1-1	B1-2	B1-3	B1-4	B1-5	B2s
1	M	56	A			NL						NL
2	M	22	C			L						
3	M	21	C Pulse			L						
4	M	21	B			N						
5	F	21	B Pulse			N						
6	M	21	C			L						
7	M	22	D			N						
8	M	22	A			NL						
9	M	21	B									
10	M	25	A Pulse									N
11	M	22	D Pulse			N						
12	M	23	A			L						
13	M	22	A Pulse			L						
14	M	25	B									
15	F	23	D Pulse									
16	M	23	C			L						
17	M	24	A			L						
18	F	22	B			N						
19	M	19	B			NL						
20	F	42	B			N						
21	M	21	B									
22	F	21	B			NL						
23	F	40	A	NL		NL		NL				
24	M	21	B			NL						
25	M	21	B			NL						
26	M	22	B			NL						
27	F	21	B									
28	F	22	B									
29	F		A	NL	NL	NL		NL		NL		
30	F	19	A			NL	NL			N	N	
31	M	20	B									

TABLE 3: CHARACTERISTICS OF FOUR GROUPS

	Know the pieces	Do not know the pieces
Like music	A	B
Do not like music	C	D

2.7 Stress measurement

It is necessary to measure the subject's condition and obtain the *SMB* value. On the other hand, the authors do not yet know how to calculate it. In the present study, provisionally and primitively, stress value was discussed instead of *SMB*. Stress was measured in several ways and each result was discussed in its usefulness. While there are various definitions of stress [17], in this paper, stress is regarded as something like internal resistance that the body generates to protect itself from external stimuli, and it can be considered that the greater the stress, the greater the burden and influence on the body. This idea is almost equivalent to the definition of stress in mechanics.

In experiments conducted using public concerts, stress measurements should be non-invasive and straightforward. From

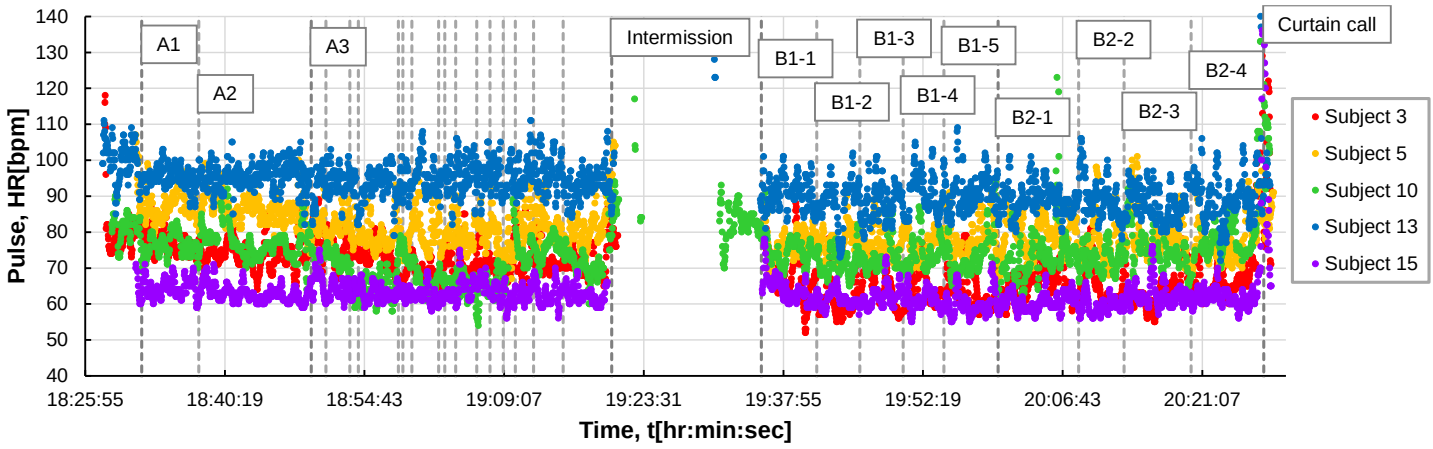
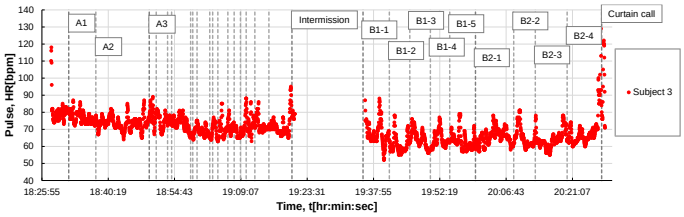
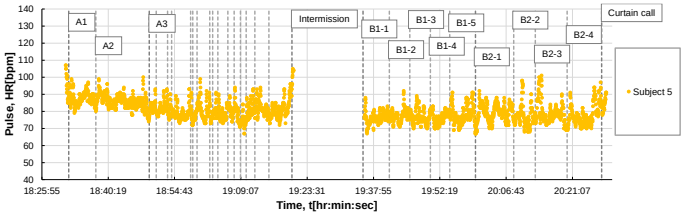


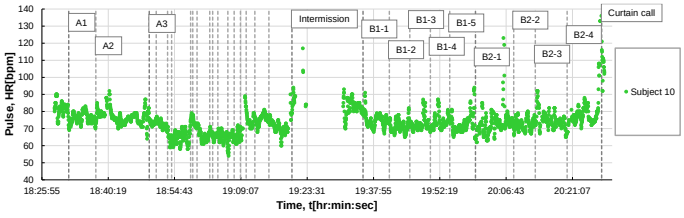
FIGURE 3: RESULTS OF PULSE MEASUREMENT FOR ALL SUBJECTS



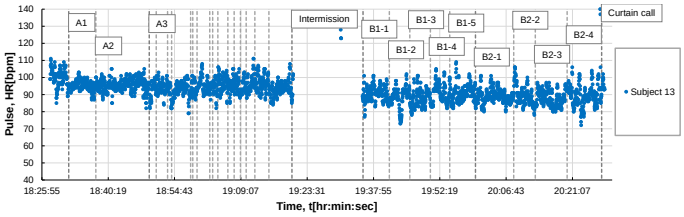
(a) Subject 3



(b) Subject 5

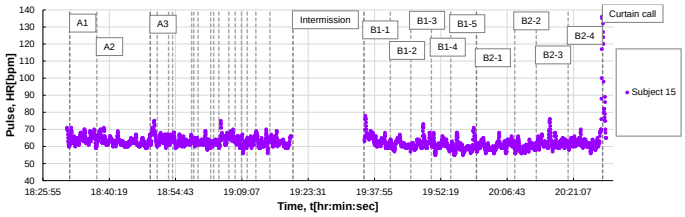


(c) Subject 10



(d) Subject 13

FIGURES 4 (a) to (e): RESULTS FOR EACH SUBJECT OF PULSE MEASUREMENT



(e) Subject 15

past research experience, it is known that the most effective and reliable stress measurement is pulse measurement. However, the pulse oximeter is a measurement device that should be given priority to medical sites during the corona crisis, so we have only 6 of them in our laboratory. The six subjects mentioned above wore the pulse oximeter from before the start of the concert to after the end of the concert. In addition, all subjects tried measuring blood pressure, POMS, and muscle stiffness before the concert, during breaks, and after the concert.

3. RESULTS AND DISCUSSION

3.1 Pulse measurements - individual

Six subjects attempted pulse measurements [18], and Subject 11 failed. FIGURES 3 and 4(a) to (e) show pulse measurement results for five subjects.

First, the obtained measurement results of five persons will be described. Overall, the pulse of the five subjects showed a downward trend, but in detail, each person showed a different response.

Subject 15, belonging to Group D, had the most specific reaction. It can be said that she showed almost no reaction to the music, as the fluctuations and changes in the pulse were quite small. On the other hand, it may be that she did not feel kinds of pain in the music because the fluctuation was small overall. However, looking at the details, it wasn't like there was no reaction at all. From the 10th small piece to the 13th small piece

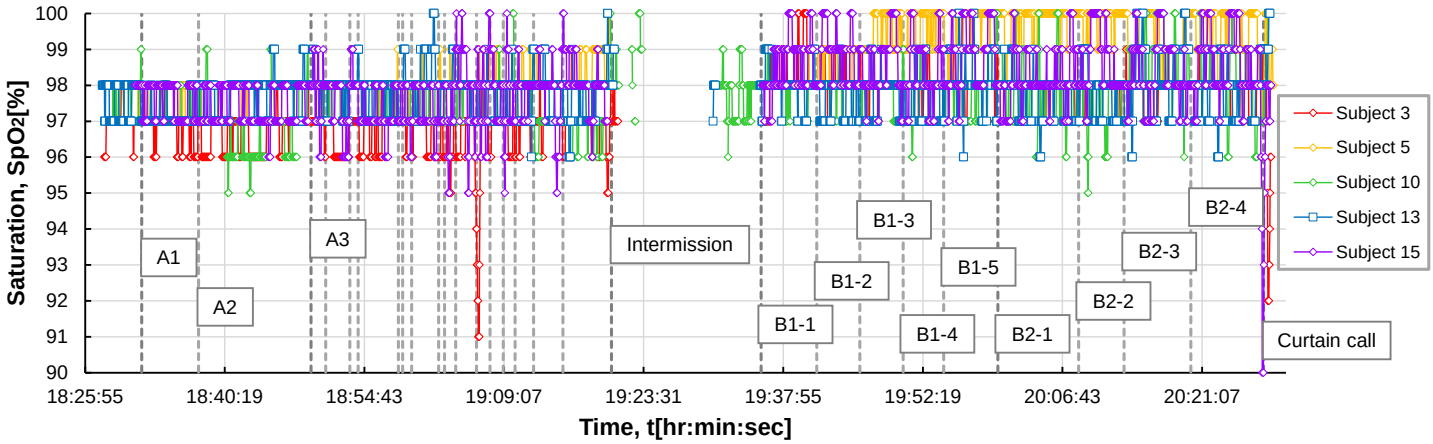


FIGURE 5: RESULTS OF PERCUTANEOUS ARTERIAL OXYGEN SATURATION FOR ALL SUBJECTS

of A3, the pulse wave increased once and recovered. Listening to Piece B1-1, it decreased with the largest change, followed by a relatively drastic change, taking the lowest value from Piece B1-5 to the start of Piece B2-2. Musically, it is possible that she responded to the relatively strong and long roll (repeated hits) seen in the 10th small piece to the 13th small piece of A3, the heaviness of B1-1, and the movement from B1-3 to B2-1. For a patient who neither knows nor likes music, music may be just a piece of auditory information with no further meaning. Nonetheless, we would like to investigate the cause of the minute localized reaction in the future and use it for the development of musical prescriptions.

Subject 13 belonging to Group A had a larger variation, but a smaller variation on his pulse history. Overall, heart rate tended to decrease slightly over time. However, during the performance of A3, the pulse rose until the semi-final piece and decreased from the semi-final piece. His pulse was lower during a performance of B2 which he did not know, than during the performance of A3 which he knew. It is speculated that the reason for the wide range of fluctuations is that he was impressed throughout the music.

Chinese Subject 10 belonging to Group A, on the contrary, had smaller fluctuations and larger changes. His heart rate dropped sharply after A3 started playing, which suggests the possibility of falling asleep. And the sleeping state seems to have disappeared just before the 14th small piece of B3. The pianist b played an aggressive forte, so his heart rate may have jumped as a result of being startled. He later testified that although it was too hot at that moment, he had no cognition of sleeping. During the performance of B2, which he knows, the pulse showed an upward trend.

The pulse of Subject 3 belonging to Group C and Subject 5 belonging to Group B both showed a downward trend during the performance of A1, A2, and A3. On the other hand, in the second half of the program, the pulse of Subject 5 was almost constant, while that of Subject 3 decreased significantly during the performance of B1-1 and slightly increased during B2. Subject 5 who liked music had larger local fluctuations, but the overall pulse was stable. The arterial oxygen saturation of Subject 3, as shown in FIGURE 5, sometimes decreased momentarily. It may be a constitutional problem that the pulse is not stable.

3.2 Pulse measurements - overview

No pulse changes common to all subjects were observed. On the other hand, although less clear than the results of previous experiments using Beethoven's works, the heart rate of all five subjects decreased, suggesting that listening to the Russian classical music used in the concert made the parasympathetic nervous system dominant. There may be some patients who have difficulty in prescribing music, but we can expect the possibility of prescribing classical music if appropriate music could be selected for the patient.

B2 is not normally comprehensible music compared to the last Beethoven's music. However, it did not increase stress for at least the five subjects. If listeners do not need to understand the music but just accept it based on their sensibility, it is considered that even music which is difficult to understand does not necessarily cause stress. Pianist d has a soft sound and overall musical composition. Fun and light playing of B2 by a pianist d may also be the reason why the subjects were able to suppress the occurrence of stress more. The knowledge that the impression of music changes greatly depending on the performance will be important when prescribing music.

For example, comparing the results of Subject 3 and Subject 15, it can be seen that knowing music may increase the fluctuation of the pulse. Listening to favorite or familiar music can be considered a good stimulant. It remains to be discussed and ascertained as to what the time history of the best pulse is, but it can be predicted that a certain amount of fluctuation will rather naturally occur by listening to music. It may be important that the final pulse after listening to music should be compared to that before listening to music, rather than fine changes in pulse while listening to music.

From FIGURE 5, it can be seen that the first half might be in an oxygen-deficient environment. It is impossible to find out the cause after the fact, but it would depend on ventilation conditions, temperature, humidity, and so on. It is also possible that lack of oxygen has a sleep effect, and it may be necessary to

TABLE 4: RESULTS OF POSM (RAW POINTS)

Subjects				At briefing session								Just before the concert started								During intermission								Just after the concert finished							
No.	Sex	Age	Group	AH	CB	DD	FI	TA	VA	F	TMD	AH	CB	DD	FI	TA	VA	F	TMD	AH	CB	DD	FI	TA	VA	F	TMD	AH	CB	DD	FI	TA	VA	F	TMD
1	M	56	A									5	15	1	10	11	31	13	11																
2	M	22	C									20	28	37	21	40	18	24	128																
3	M	21	C Pulse	11	14	0	11	2	9	11	29	6	3	0	10	2	3	4	18	20	5	0	16	2	5	4	38	1	0	0	5	2	7	5	1
4	M	21	B									13	20	16	11	26	24	18	62																
5	F	21	B Pulse									12	10	13	13	12	12	13	48									8	11	7	13	12	10	12	41
6	M	21	C	3	6	5	5	6	10	11	15	4	6	8	10	10	11	9	27	3	11	4	4	6	12	11	16	0	3	0	5	2	11	14	-1
7	M	22	D	8	5	5	7	7	18	15	14	5	9	5	5	9	17	18	16	6	12	7	11	13	17	17	32	4	5	5	8	5	17	12	10
8	M	22	A									4	5	6	6	5	10	12	16	4	1	2	2	2	9	12	2	1	3	1	4	2	13	7	-2
9	M	21	B	13	13	6	12	7	16	15	35	14	12	10	18	13	16	12	51	20	10	8	20	14	8	6	64	13	14	10	18	17	9	11	63
10	M	25	A Pulse									8	12	5	6	10	22	22	19									6	8	2	10	4	14	17	16
11	M	22	D Pulse	2	5	3	5	4	8	10	11	2	5	3	5	4	8	10	11									1	2	0	2	2	5	14	2
12	M	23	A	1	5	0	8	0	4	14	10	0	2	0	7	0	2	10	7									0	2	0	3	0	2	12	3
13	M	22	A Pulse	5	11	6	11	9	12	20	30	7	10	8	7	14	17	20	29	6	5	5	6	6	15	16	13	8	9	8	11	9	11	20	34
14	M	25	B									16	20	27	14	21	13	10	84																
15	F	23	D Pulse									7	32	18	15	32	23	20	81																
16	M	23	C	11	13	11	11	10	12	15	44	13	10	12	12	14	12	12	49	15	14	13	16	14	13	8	59								
17	M	24	A									4	15	23	20	25	18	16	69																
18	F	22	B									3	9	4	12	8	7	16	29									4	3	4	8	5	10	14	14
19	M	19	B									4	7	3	12	5	15	12	16									1	3	3	9	6	11	13	11
20	F	42	B	4	6	4	4	6	9	13	15	1	3	2	0	2	7	11	1	0	1	1	0	0	7	9	-5	0	2	0	2	0	6	8	-2
21	M	21	B	3	9	2	2	7	9	13	14	3	9	2	2	7	9	13	14	2	2	0	13	9	13	12	13	2	6	5	18	7	7	11	31
22	F	21	B									1	6	3	15	3	16	15	12									0	3	3	5	2	11	15	2
23	F	40	A	2	8	5	6	5	9	10	17	0	6	6	5	3	14	12	6									0	8	5	5	5	11	12	12
24	M	21	B	4	9	10	11	12	13	13	33	6	6	5	8	7	10	11	22	4	5	5	6	6	14	15	12	1	2	3	2	2	18	19	-8
25	M	21	B	10	14	10	14	13	10	10	51	3	8	5	12	6	11	8	23	0	3	1	5	4	6	6	7	0	5	1	6	5	10	10	7
26	M	22	B	0	0	2	2	1	9	12	4	0	0	0	0	3	10	10	-7	0	1	0	5	0	8	11	-2	0	1	0	6	0	5	13	2
27	F	21	B	0	4	2	4	7	13	12	4	0	3	1	5	6	10	14	5	0	4	3	3	5	9	12	6								
28	F	22	B	0	0	2	6	0	9	17	-1	0	0	3	0	0	9	18	-6	0	0	0	0	0	4	15	-4								
29	F		A									0	7	6	4	5	8	12	14									1	3	3	1	2	10	11	0
30	F	19	A	3	9	2	2	7	9	13	14	0	3	0	0	6	6	13	3	0	1	0	0	2	7	14	-4	0	2	0	0	1	7	14	-4
31	M	20	B	2	10	7	9	12	11	11	29	2	5	5	3	12	9	12	18	0	3	4	2	5	5	8	9	0	2	4	4	3	4	9	9
Means				4.6	7.8	4.6	7.2	6.4	10.6	13.1	20.4	5.3	9.2	7.6	8.6	10.4	12.8	13.5	28.3	5.0	4.9	3.3	6.8	5.5	9.5	11.0	16.0	2.3	4.4	2.9	6.6	4.2	9.5	12.4	11.0
Standard deviations				4.0	4.1	3.1	3.6	3.7	3.0	2.5	13.6	5.2	7.2	8.3	5.7	9.2	6.2	4.2	29.2	6.6	4.2	3.5	6.0	4.5	3.7	3.6	20.2	3.3	3.4	2.8	4.7	4.0	3.8	3.4	16.4
Coefficient of variations				0.9	0.5	0.7	0.5	0.6	0.3	0.2	0.7	1.0	0.8	1.1	0.7	0.9	0.5	0.3	1.0	1.3	0.9	1.0	0.9	0.8	0.4	0.3	1.3	1.4	0.8	1.0	0.7	0.9	0.4	0.3	1.5

investigate whether the downward trend in pulse seen in many subjects in the first half is an effect of music.

Overall, the reaction to the semi-final and final small pieces of A3 was unexpectedly small. Despite the fact that this piece is originally for a solo piano, the overall note arrangement is not very suitable for playing on the piano. At least in Japan, Ravel's orchestral version is more famous, and the piano version is rarely performed. Therefore, it is not easy to play the piece on the piano to impress the audience, and it felt like the pianist b played too powerfully and finally ran out of steam. However, for the purpose of reducing stress, it can be said that the piano version, which is not too exciting and is played in a subdued manner, is rather suitable.

3.3 Pulse measurements – cause of failure

At the end of this section, the causes of measurement failure should be discussed.

The operation of the pulse oximeter, which is a simple procedure, was left to the subject by handing over a manual prepared in advance. The authors confirmed in advance that the equipment works properly. However, in the actual experiment, Subject 11 was unable to operate the pulse oximeter. One subject also served as a staff member in charge of pulse measurement, and he restarted the device several times and tried to use it without success. Other measurements, such as blood pressure, had to be taken, and as a result, the recovery was not made in time for the start of the concert, and measurements were abandoned.

When the staff calmly operated the device later, it started up easily. Although the cause could not be elucidated, the device was not out of order, and it was speculated that the subject had made a mistake in operation. When using electronic products, it may be necessary to understand the essential reasons for operating procedures. However, it is quite difficult to demand that much from the subjects.

Developing skilled staff is not easy, which is a problem every time an experiment using a public concert is conducted. Since pulse measurement is recognized as the most reliable measurement method, improvement proposals should be made in the future.

3.4 POMS

Profile of Mood States, POMS [19] was developed as a method to know various states of mind. In this experiment, POMS 2nd Edition, POMS-2 was implemented, which gives the following eight indicators; Anger - Hostility (AH), Confusion - Bewilderment (CB), Depression - Dejection (DD), Fatigue - Inertia (FI), Tension - Anxiety (TA), Vigor - Activity (VA), Friendliness (F), Total Mood Disturbance (TMD). While each indicator will be considered in detail in the next step, changes in each indicator were tracked this time without evaluating the absolute value of the indicator. By the way, it is proposed to convert raw points into T points in order to offset gender and age differences in each index value. But, considering that most of the subjects were in their twenties, the result of POMS-2 may be able to be discussed more simply based on raw points.

TABLE 4 lists the results. Subjects who wished to join from the concert hall had not performed POMS-2 at the preliminary briefing session. Some subjects could not answer all the questions of POMS-2 during the intermission and did not obtain the index values. The time until the venue was closed after the end of the concert was unexpectedly short, and some subjects could not answer all the questions after the concert to similarly fail to obtain the index values. This kind of lack of time is unavoidable as far as open concerts are used. When stress is relieved, the negative indicators AH, CB, DD, FI, and TA are

thought to decrease synchronously. Also, although VA is a positive index, activation is accompanied by good stress, so it is thought that VA changes in synchronization with stress as well. In addition, although the positive index F is said to be related to VA, it may be thought that it has little to do with the increase or decrease in stress. In other words, it is inferred that all indicators, including the TMD value that comprehensively considers these indicators, which is regarded as to be a rough indicator of mood disorders, have a positive correlation with stress. FIGURE 6 shows the distribution of the number of subjects with respect to the increment of raw points for each index value from before the concert to after the concert. All indices show approximately similar distributions. The majority of subjects decreased all indicators by participating in concerts. The decrease was more pronounced in the results of previous experiments with Beethoven's music. In other words, the results of POMS-2 showed the same trend as those of pulse measurement, indicating that the music performed in the present concert generally has a stress-relieving effect.

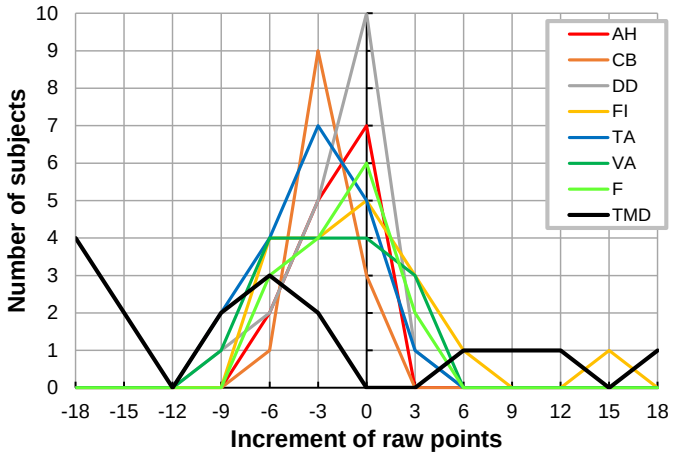


FIGURE 6: DISTRIBUTIONS OF THE NUMBER OF SUBJECTS WITH RESPECT TO INCREMENTS OF RAW POINTS DURING THE CONCERT

TABLE 5 lists the increments of the raw point of each index value for each subject, which is the base data for FIGURE 6. The subject dependence of index F was remarkably large, and the coefficient of variation was -35.5. On the other hand, the coefficient of variation of the index FI was -7.6, and the coefficient of variation of the other indices was less than -2.7, indicating little subject dependence. TABLE 5 also shows the average increment of each index for female subjects, male subjects, and subjects belonging to each group. Since the *SMB* index was simplified as a stress level, it seemed good to focus on the TMD, which indicates the overall psychological state. FIGURE 7 shows gender and group differences in TMD increments. Changes in TMD are quite different in females and males. There are also differences between groups. It is desirable that the number of subjects belonging to the group to be compared between should be the same as much as possible, but it would be extremely difficult to obtain subjects like that. In this experiment, the number of male subjects was about twice that of

TABLE 5: RESULTS OF POSM (INCREMENT)

Subjects				Increment during the concert							
No.	Sex	Age	Group	AH	CB	DD	FI	TA	VA	F	TMD
1	M	56	A								
2	M	22	C								
3	M	21	C Pulse	-5	-3	0	-5	0	4	1	-17
4	M	21	B								
5	F	21	B Pulse	-4	1	-6	0	0	-2	-1	-7
6	M	21	C	-4	-3	-8	-5	-8	0	5	-28
7	M	22	D	-1	-4	0	3	-4	0	-6	-6
8	M	22	A	-3	-2	-5	-2	-3	3	-5	-18
9	M	21	B	-1	2	0	0	4	-7	-1	12
10	M	25	A Pulse	-2	-4	-3	4	-6	-8	-5	-3
11	M	22	D Pulse	-1	-3	-3	-3	-2	-3	4	-9
12	M	23	A	0	0	0	-4	0	0	2	-4
13	M	22	A Pulse	1	-1	0	4	-5	-6	0	5
14	M	25	B								
15	F	23	D Pulse								
16	M	23	C								
17	M	24	A								
18	F	22	B	1	-6	0	-4	-3	3	-2	-15
19	M	19	B	-3	-4	0	-3	1	-4	1	-5
20	F	42	B	-1	-1	-2	2	-2	-1	-3	-3
21	M	21	B	-1	-3	3	16	0	-2	-2	17
22	F	21	B	-1	-3	0	-10	-1	-5	0	-10
23	F	40	A	0	2	-1	0	2	-3	0	6
24	M	21	B	-5	-4	-2	-6	-5	8	8	-30
25	M	21	B	-3	-3	-4	-6	-1	-1	2	-16
26	M	22	B	0	1	0	6	-3	-5	3	9
27	F	21	B								
28	F	22	B								
29	F		A	1	-4	-3	-3	-3	2	-1	-14
30	F	19	A	0	-1	0	0	-5	1	1	-7
31	M	20	B	-2	-3	-1	1	-9	-5	-3	-9
Means				-1.5	-2.1	-1.6	-0.7	-2.4	-1.4	-0.1	-6.9
Standard deviations				1.8	2.1	2.4	5.2	3.0	3.8	3.2	11.3
Coefficient of variations				-1.2	-1.0	-1.5	-7.6	-1.3	-2.7	-35.5	-1.6
Means		for Female		-0.25	-0.5	-0.5	0.5	-1.75	0	-0.5	-2.5
		for Male		-2	-1.92	-1.42	0.5	-2.83	-0.92	0.167	-6.75
		for Group A		-0.67	-1.33	-1.67	0.667	-4.33	-0.67	-1.33	-6.67
		for Group B		-1.44	-1.22	-0.67	1.444	-1.78	-1.44	0.444	-2.22
		for Group C		-3	-2	-2.67	-3.33	-2.67	1.333	2	-15
		for Group D		-1	-4	0	3	-4	0	-6	-6

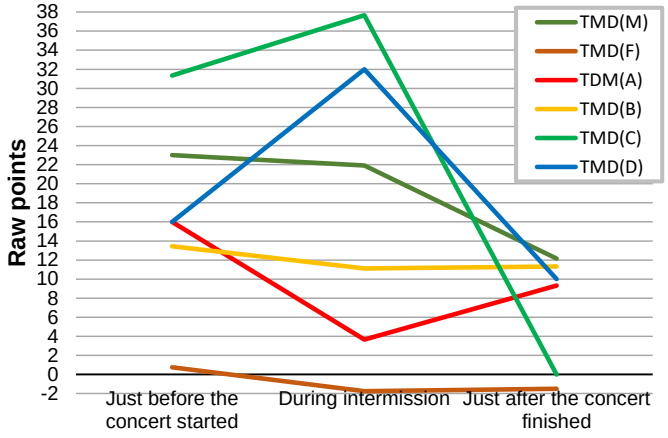


FIGURE 7: CHANGES IN THE MEANS OF TDM RAW POINTS DURING THE CONCERT

female subjects, and the number of subjects belonging to each group was also biased.

3.5 Blood pressure

It is generally known that blood pressure [20] changes greatly with a slight change in mood. Stress is one of the factors which raise blood pressure, but there are various other factors that raise blood pressure. Blood pressure measurement requires non-routine movements compared to pulse measurement or OMS. In addition, unlike pulse measurement and POMS, where measuring instruments and answering sheets are distributed to each person and there is no need to wait for a turn, just six sphygmomanometers are shared. There was a possibility that the subject felt stress when wearing the sphygmomanometer and that they thought various things during the waiting time until the sphygmomanometer comes around to me, which made their blood pressure change. Therefore, blood pressure values should be treated as reference information.

TABLE 6 lists the results of blood pressure (mmHg) measurements. The coefficient of variation is small, which supports that the variation between subjects is small. On the other hand, in the previous experiment, the coefficient of variation was larger. FIGURE 8 shows changes in blood pressure in average values for females, for males, and for each group. It can be seen that the blood pressure is slightly elevated overall. On the other hand, it dropped in the previous apparent changes were found between females and males or between groups. experiment. There were no significant changes, and no apparent

TABLE 6: RESULTS OF BLOOD PRESSURE MEASUREMENT

Subjects				Normal		Before concert		Intermission		After concert	
No.	Sex	Age	Group	systolic	diastolic	systolic	diastolic	systolic	diastolic	systolic	diastolic
1	M	56	A	149	97						
2	M	22	C								
3	M	21	C Pulse	112	67	122	81	124	74	140	73
4	M	21	B								
5	F	21	B Pulse	111	62	134	84				
6	M	21	C	121	77	130	82	137	78	135	78
7	M	22	D	131	61	115	61	114	64	123	63
8	M	22	A	117	77	116	65	98	58	128	84
9	M	21	B	121	65	149	73	135	70	125	70
10	M	25	A Pulse	150	98			136	87	130	99
11	M	22	D Pulse	120	81	112	69	101	63	122	78
12	M	23	A	110	79	112	73	111	73	112	72
13	M	22	A Pulse	109	74	119	86	121	85	111	79
14	M	25	B	112	76	123	82	110	78	109	74
15	F	23	D Pulse	93	71			104	70	116	84
16	M	23	C	120	65			118	77	118	84
17	M	24	A	126	78	124	84				
18	F	22	B	106	66			107	65	102	71
19	M	19	B	133	72	128	57	132	66	130	63
20	F	42	B	90	59	90	57	89	55	97	62
21	M	21	B	138	72	140	66	129	59	128	68
22	F	21	B	102	73			105	73	105	65
23	F	40	A	107	69	98	66	117	79	138	89
24	M	21	B	124	71	121	78	116	77	128	80
25	M	21	B	119	69	118	75	131	84	133	76
26	M	22	B	125	69	116	69	118	72	116	71
27	F	21	B	110	73	115	77	103	73	109	65
28	F	22	B	103	75	101	70	97	66	110	79
29	F		A	108	77	99	74	83	66	99	75
30	F	19	A	100	73	96	70	114	88	104	78
31	M	20	B	132	81	120	82	114	71	127	82
Means				117.2	73.3	117.3	73.1	114.0	72.0	119.0	75.5
Standard deviations				14.4	8.7	13.9	8.4	14.1	8.6	12.2	8.6
Coefficient of variations				0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.11

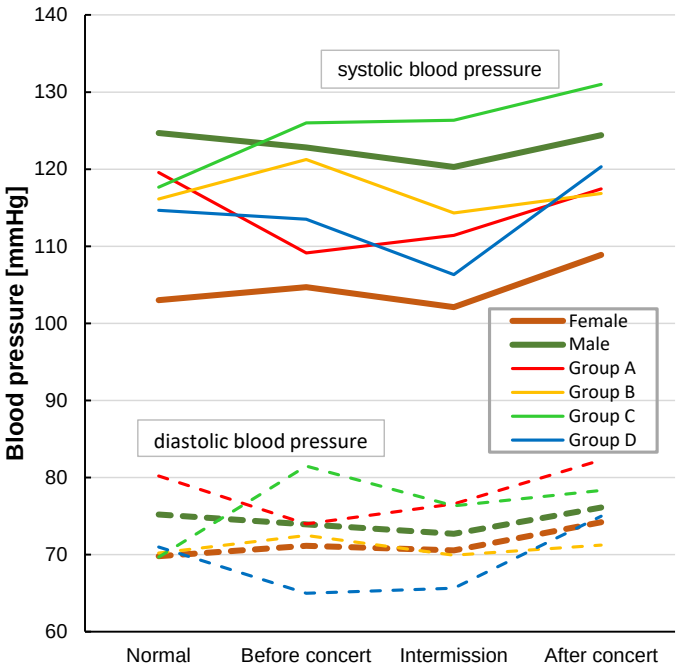


FIGURE 8: CHANGES IN THE MEANS OF BLOOD PRESSURES DURING THE CONCERT

changes were found between females and males or between groups.

3.6 Muscle hardness

Since the previous experiment, muscle hardness (kPa) measurements [21] have been attempted. Depending on where the probe is applied and how it is applied, muscle hardness measurement results will vary. In this experiment, four student subjects who had practiced measurement in advance were appointed as measurement staff, and they divided up all the subjects and measured them on that day. As yet, no conclusions have been drawn as to how effective muscle stiffness measurements are, while stress makes your muscles tense.

TABLE 7 lists changes in muscle hardness for each subject. The subjects had two measurement points: the border between the neck and shoulder on the left trapezius muscle and the border on the right trapezius muscle. Measurement was carried out once each measurement point and the mean value was calculated. The coefficient of variation was 1 or less at any measurement time, which suggests that individual differences were extremely small. On the other hand, looking at the difference between the start and end of the concert, for example, the coefficient of variation of the difference of the mean value was 1.75, a little larger.

FIGURE 8 shows the changes in left and right average muscle hardness for each group. Groups C and D showed a tendency for muscle hardness to increase during the concerts. It may be the possibility that stress was caused by listening to disliked music. Although it is not possible to isolate the influence of Piece B2 alone, it can be said that the expectation that Piece

B2 increases stress has been overturned. No significant gender differences were seen.

3.7 Overview

It was shown that classical piano music may be able to be prescribed to the patient not only Beethoven's music but also Russian romantic and modern music whose melody, harmony, and chords are very different from those of classical music. Of course, individual differences cannot be ignored. On the other hand, there is a possibility that the effects may differ between females and males, and it was expected that music prescriptions for patients who dislike music would be difficult. As in the previous experiment, the present experiment showed that the piano solo, whose timbre is less assertive, seems to be able to prescribe more music than expected.

Several issues in conducting experiments using concerts which are open to the public were found this time. Despite the merit of being able to take multiple measurements on multiple subjects under the same conditions, some subjects did not participate in the preliminary briefing or failed to take the measurements. It can be said that it is a difficult problem to solve due to the nature of the experiment, which uses a public concert and asks volunteer subjects for a limited time. If everyone obtained all the planned data, the experiment might have shown more. The authors will continue to improve our experimental methods. Ideally, our laboratory would plan and manage concerts and conduct experiments there, but this would also require considerable funds, time, and effort. In the future, while focusing on experiments using actual open concerts, the authors are also going to conduct an experiment in which each subject listened carefully to music in the laboratory. And music other than classical music and music other than piano solos would like to be confirmed its effect of.

Several stress measurement methods were adopted. Each measurement method yielded a certain stress value based on its own principles and mechanisms. It can be said that these methods evaluate the effects of different types of stress and music. In defining *SMB* in the future, it may be necessary to use several measurement methods together. The music database is to be enriched, such as being added the pieces played at this concert, to discover indicators for music prescription.

Music therapy is established by positioning both the patient and the music on a certain *SMB* axis. In the present experiments suggested the possibility that the stress value could be used as an approximation of the *SMB* value in patients. On the other hand, the objective physical property obtained by analyzing music is the spectrum. Energy for each frequency band can be calculated from the spectrum, and Energy will generate stress in the organism. Of course, various other factors such as time signature (beat), rhythm, velocity, instruments employed, etc. are considered to govern the *SBM* value of music. In the future, music therapy research should be conducted from both the standpoint of measuring subjects who listened to music and that of music analysis, in order to pursue a unified *SMB* value. While the destruction of objects through energy, *SMB* value, which can be said to be a parameter of human destruction, may be close to the energy [J].

TABLE 7: RESULTS OF MUSCLE HARDNESS MEASUREMENT

Subjects				Normal			Before concert			Intermission			After concert		
No.	Sex	Age	Group	L	R	Mean	L	R	Mean	L	R	Mean	L	R	Mean
1	M	56	A	29	27	28				26	28	27			
2	M	22	C												
3	M	21	C Pulse	27	22	24.5	22	27	24.5	24	27	25.5	30	28	29
4	M	21	B	30	25	27.5									
5	F	21	B Pulse	20	20	20				16	18	17	15	18	16.5
6	M	21	C	24	28	26	24	22	23	24	21	22.5	14	35	24.5
7	M	22	D	21	28	24.5	24		12	18	30	24	31	20	25.5
8	M	22	A	13	27	20	27	26	26.5	23	21	22	30	33	31.5
9	M	21	B	17	18	17.5	25	26	25.5	27	31	29	14	22	18
10	M	25	A Pulse	19	25	22	19	25	22	23	27	25	13	21	17
11	M	22	D Pulse	28	24	26	17	17	17	18	15	16.5	20	20	20
12	M	23	A	15	19	17				19	18	18.5	11	12	11.5
13	M	22	A Pulse	24	20	22				22	22	22	23	18	20.5
14	M	25	B				26	27	26.5	14	11	12.5	21	19	20
15	F	23	D Pulse	23	25	24				23	17	20	18	15	16.5
16	M	23	C	22	29	25.5				23	19	21	27	18	22.5
17	M	24	A	23	24	23.5									
18	F	22	B	25	18	21.5				21	15	18	20	17	18.5
19	M	19	B	21	21	21	22	17	19.5				20	13	16.5
20	F	42	B	20	21	20.5	15	25	20	20	17	18.5	18	12	15
21	M	21	B	18	24	21				24	22	23	23	23	23
22	F	21	B	13	21	17				20	15	17.5	17	20	18.5
23	F	40	A	21	23	22	20	23	21.5	25	15	20	18	20	19
24	M	21	B	16	19	17.5				29	17	23	22	10	16
25	M	21	B	18	25	21.5				12	28	20	19	13	16
26	M	22	B	25	21	23				18	19	18.5	20	14	17
27	F	21	B	19	17	18	12	18	15				12	15	13.5
28	F	22	B	15	15	15	21	18	19.5	17	22	19.5	21	20	20.5
29	F		A	23	24	23.5	23	18	20.5	20	19	19.5	13	20	16.5
30	F	19	A	28	32	30							21	29	25
31	M	20	B	23	23	23	27	26	26.5	30	30	30	18	26	22
Means				21.4	22.9	22.2	21.6	22.5	21.3	21.4	21.0	21.2	19.6	19.7	19.6
Standard deviations				4.6	3.9	3.5	4.2	3.9	4.2	4.3	5.5	4.0	5.3	6.1	4.5
Coefficient of variations				0.21	0.17	0.16	0.20	0.17	0.20	0.20	0.26	0.19	0.27	0.31	0.23

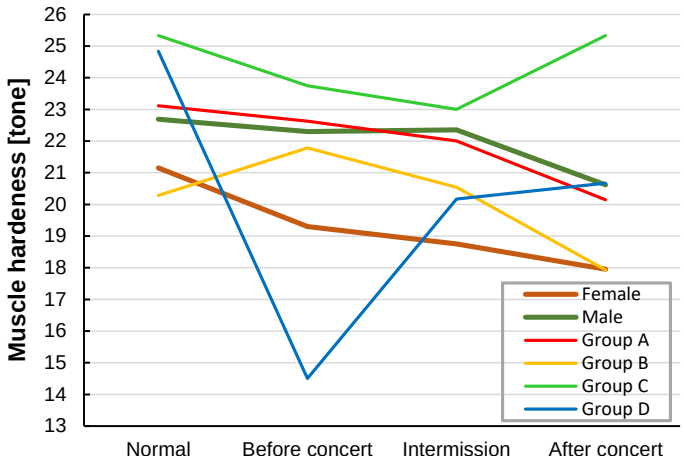


FIGURE 9: CHANGES IN THE MUSCLE HARDNESSES DURING THE CONCERT

4. CONCLUSION

A music therapy experiment was conducted using concerts open to the public. Classical music can expectedly be prescribed. The same music had different effects on the subject. Its effect also depends on the performer, the playing method, and so on.

Music analysis will also be performed in parallel, and an attempt will be made to identify the SMB value.

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