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Original Article

Comparing surface cerebral blood flow dynamics between straight walking and walking over obstacles

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Abstract. [Purpose] To discuss surface cerebral blood flow dynamics while walking over obstacles using a portable functional near-infrared spectroscopy (fNIRS) device. [Subjects and Methods] This study was designed as a non-independent 2-group comparative study that measured 2 tasks performed by 34 healthy adult males. Task 1 was straight walking and task 2 was walking over obstacles. The analysis target regions of portable fNIRS device were the left and right primary motor areas, the supplementary motor areas, and the left and right premotor areas. The analysis included comparisons within task (result of each task compared with resting standing) and the comparison between tasks (comparison of changing amount between tasks). [Results] In walking over obstacles, the surface cerebral blood flow dynamics of premotor area on both sides and supplementary motor areas were significantly increased. In addition, the task showed a significant difference in the premotor area on both sides as compared with straight walking. [Conclusion] The novelty of this study is that it was measured on flat ground, not on a treadmill. Walking over obstacles is thought to involve the premotor cortex because the task was performed based on visual information.

Key Words: fNIRS device, surface cerebral blood flow dynamics, walking over obstacles

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1. INTRODUCTION

In recent years, the concept of neurorehabilitation has attracted attention. It is defined as a problem-solving process in which the person who experiences a neurological impairment or loss of function acquires the knowledge, skills, and supports needed for their optimal physical, psychological, social, and economic functioning[1)].

In the walking function, in addition to research based on 3-dimensional motion analysis, neurological research has advanced in recent years. The structures of the central nervous system involved in gait include the cerebral cortex, basal ganglia, cerebellum, brain stem, and spinal cord extensively and hierarchically[2)]. A common locomotion control system in the vertebrate spinal cord is that central pattern generators produce motor patterns with appropriate timing. Each generator is affected by sensory feedback from the moving limb and is activated from the brainstem locomotor command regions[3)]. One important aspect of locomotor control is the ability of an animal to make anticipatory gait modifications to avoid obstacles, by stepping either around them or over them.

In a study of a walking model for decerebrate animals, Matsuyama reported that there are many inputs from the premotor cortex and the supplementary motor cortex in the cerebral cortex to the pontine medullary reticulum when avoiding obstacles[4)]. Drew also reported that some of the evidence suggests

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that the motor cortex is one of the principal structures involved in the control of such anticipatory gait modifications in cats, in particular when they are triggered by a visual signal[5].

In previous reports, many neurological studies of gait have targeted animals. In brain function measurement equipment for humans,positron emission tomography (PET), functional magnetic resonance tomography (fMRI) and the like were common. In these devices, it is necessary to fix the subject to the bed; therefore, it has been difficult to measure motions such as walking.

In recent years, the development of near-infrared spectroscopy (NIRS) has been applied to the medical field.

A technique for measuring brain activity based on the principle of coupling between cranial nerve activity and cerebral blood flow change is called functional NIRS (fNIRS). The fNIRS device emits near-infrared light from above the scalp into the skull, and measures near-infrared light that has passed through the brain and exited out from the skull. By this method, fNIRS measures the concentration of total hemoglobin (Hb), oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) in the capillaries of the cerebral cortex[6]. As an advantage, there are relatively few restrictions on the measurement environment, and it is possible to measure motion in the standing position, and it is easy to apply in the actual rehabilitation scene. On the downside, it is possible to measure the surface of the cerebral cortex, but difficult to measure deep in the brain. And it is also difficult to accurately measure instantaneous movement because of the measurement of hemoglobin concentration in the bloodstream.

In a report of brain activity while walking using fNIRS, Miyai reported that walking activities were bilaterally associated with increased levels of oxygenated and total hemoglobin in the medial primary sensorimotor cortices and the supplementary motor areas[7].

In the conventional fNIRS device, the code was connected between the device and the head folder. Therefore, in the measurement of brain activity while walking, a treadmill was used. Almost previous studies showed brain activity during treadmill walking. In recent years, a portable type of fNIRS device has been developed, and it has become possible to measure brain activity during normal walking in a wireless environment without using a treadmill. The characteristics of walking on a treadmill are that it is walking without moving in space, that the environment during walking is the same, and that it is walking at a set speed. Compared to actual walking, these are said to have similarities in muscle activity and floor reaction force. On the other hand, it cannot be said that they are the same in terms of brain activity. The reason is that the moving in space, environmental adaptation, and speed control during walking are controlled by each part of the brain[2]. In addition, difficult walking tasks cannot be performed on a treadmill.

We focused on walking over obstacles, which is frequently used in rehabilitation settings, and is commonly used for patients with Parkinson's disease. On the other hand, no report has been made using a portable fNIRS device in walking over obstacles. It was hypothesized that humans can also obtain the activity of the premotor and supplementary motor areas of the cerebral cortex like previous study of decerebrate animals. Therefore, the purpose of this study was to discuss the surface cerebral blood flow dynamics during walking over obstacles using a portable fNIRS device.

2. SUBJECTS AND METHODS

1. Subjects

The subjects were 34 healthy adult males (mean age 21.1 ± 0.9 years) with right dominant limbs with no history of neurological or psychiatric disorders. G*Power 3[8] was used to determine the sample size. The setting conditions were “Type of power analysis: A priori”, “Tail (s): two”, “Effect size: d: 0.5”, “α error prob: 0.05”, and “Power: 0.08”.

As a result, the total number of subjects was determined because the sample size required 34 people.

The choice of the dominant limb was the upper limb writing and the lower limb kicking a ball. Those who had exchanged dominant limbs in the past were excluded.

It is generalized that the dominant hemisphere of the brain in a right-handed person is the left brain and in a left-handed person is the right brain. Therefore, the difference in dominant hand may cause a difference

in the dominant hemisphere of the brain[9], so the subjects were right-handed. As a gender choice, the possibility of gender differences in the brain cannot be ruled out based on cognitive ability, behavioral characteristics, and corpus callosum thickness[10]. Therefore, in this study, the subjects were only men.

This study was approved by Teikyo Heisei University Ethics Committee (Approval No. 29-116). The subjects were informed of the research procedure in advance, and the measurement was started after obtaining written consent.

2. Methods

This study was designed as a non-independent 2-group comparative study. The subjects measured the surface cerebral blood flow dynamics using an fNIRS device during the two tasks. Task 1 is straight walking and task 2 is walking over obstacles.

For both tasks, fNIRS measurement protocol was performed in the following order: resting standing 20 seconds, task walking 20 seconds, resting standing 20 seconds. The break between the tasks was 5 minutes, and the subject waited in a sitting position. The order of task 1 and task 2 were randomized.

The measurement environment was a flat indoor straight corridor with a length of 55 m. During measurement, the environment was set only for the subject and the measurer. When walking over obstacles in Task 2, obstacles were prepared by stacking thick papers 5 mm thick, 6.7 cm long and 39 cm wide, and the distance between obstacles was 66cm (Fig. 1). This distance was based on the average stride of men in their 20s. Before the start of measurement, the subject waits in a resting standing position at the starting point. The verbal instruction during the measurement was only countdown from 5 seconds before the start of the task walking.

Fig. 1 The measurement environment

The verbal instruction of Task 1 was "Please walk straight at the usual walking speed. Stop when you are told to stop." The verbal instruction of Task 2 is "Please walk at the usual speed so as not to step on obstacles. Keep your head up and turn only your eyes downward." The fNIRS device can be noisy due to large movements of the head. Therefore, it is necessary to maintain walking in Task 2 while minimizing head movement. In consideration of the effect on brain activity, it was explained beforehand to each subject that he should not talk and should not move his head during measurement. In addition, in order to avoid excessive concentration during the task, the hand swing during walking is not instructed.

LIGHTNIRS manufactured by Shimadzu Corporation was used as a portable fNIRS device. Holders placed at 3-cm intervals in front, back, left, and right were placed from the forehead to the top of the subject's head. The analysis target regions were the left and right primary motor areas, the supplementary motor areas, and the left and right premotor areas. A total of 16 probes, 8 light transmitting probes (T1 to T8) and 8 light receiving probes (R1 to R8), were arranged in two sets of four columns and two rows. The measurement channels were 20. The Cz point in the international 10–20 method of electroencephalography (EEG) (the point where the bisecting point of the line connecting the nose root

and the occipital nodule and the bisecting point of the line connecting the right and left preauricular points) is used for the measurement. The position of channel 2, which is the midpoint between T3 and R5, was set to Cz.

When inserting the fiber into each probe, it is necessary to prevent the near-infrared light from being blocked by the hair. Therefore, the hair was moved in the probe using an earpick and attached to the holder so that the tip of the fiber was in direct contact with the scalp. Before the measurement, it was confirmed that light transmission and reception were performed normally in the setting of the fNIRS device. After cerebral hemodynamics in all channels were stabilized, a zero reset was performed and the measurement was started.

Functional localization of the brain was set as follows: the left primary motor cortex was ch3, 6, 7; the right primary motor cortex was ch1, 4, 5; the left premotor cortex was ch10,13,17,20; the supplementary motor cortex was ch9,12,15,16,19; the right premotor cortex was ch8,11,14,18 (Fig. 2).

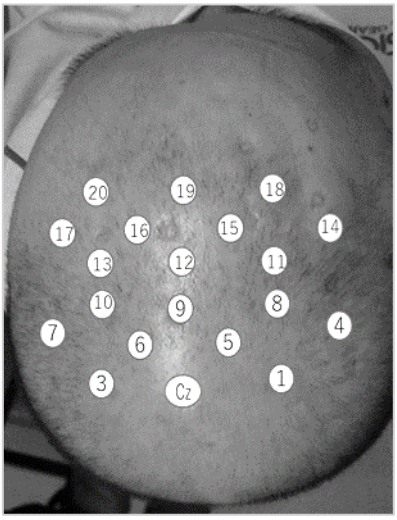

Fig. 2 Functional localization of the brain in this study was set as follows.
The left primary motor cortex: ch3,6,7
The right primary motor cortex: ch1,4,5
The left premotor cortex: ch10,13,17,20
The supplementary motor cortex: ch9,12,15,16,19
The right premotor cortex: ch8,11,14,18

The analyzes in this study included the comparisons within task (each result of straight walking and walking over obstacles compared to resting standing) and the comparison between tasks (comparison of changing amount between straight walking and walking over obstacles). In assessing the surface cerebral blood flow dynamics, oxy-Hb is said to best reflect brain activity associated with the task 6 Therefore, this study used oxy-Hb as an index of local brain cortical activity. Based on the obtained waveforms of results, the baseline correction was performed between resting standing (20 seconds) before and after the task. Since the fNIRS device cannot calculate the Hb concentration as an absolute value, the relative change from a certain baseline is used as an index. The oxy-Hb average value in the resting standing before tasks (20 seconds) was set to baseline. Then, the changing amount of the oxy-Hb value for the tasks (20 seconds) was calculated as an average value for each channel. Furthermore, the results of each channel were averaged for each functional localization group of brain. In the comparison within task, the oxy-Hb value was compared between resting standing and each walking task. In the comparison between the tasks, changes in oxygenated hemoglobin were compared between straight walking and walking over obstacles SPSS version22 made by IBM was used for both statistical analyses. For the test of normal distribution, Shapiro–Wilk's test was performed. After confirming that both results were normal distribution, a paired t-test was performed. The significance level was less than 5%.

3. RESULTS

The comparison within group for each walking task is shown in Table 1. Straight walking showed a significant increase in the supplementary motor area compared to resting standing. Walking over obstacles showed a significant increase in premotor area on both sides and supplementary motor area compared to resting standing. The comparison between groups is shown in Table 2. Walking over obstacles showed a significant increase in the premotor cortex on both sides compared to straight walking.

Table 1 The comparison within group

	Resting standing			Straight walking			p value
the right premotor cortex	-0.005	±	0.026	-0.002	±	0.027	0.11
the supplementary motor cortex	-0.008	±	0.035	0.012	±	0.024	0.02*
the left premotor cortex	-0.009	±	0.049	0.004	±	0.035	0.08
the right primary motor cortex	-0.003	±	0.011	0.000	±	0.012	0.13
the left primary motor cortex	-0.001	±	0.011	0.000	±	0.015	0.62

	Resting standing			Walking over obstacles			p value
the right premotor cortex	-0.001	±	0.012	0.026	±	0.039	0.00*
the supplementary motor cortex	-0.011	±	0.048	0.014	±	0.029	0.02*
the left premotor cortex	-0.008	±	0.062	0.024	±	0.023	0.00*
the right primary motor cortex	0.001	±	0.014	0.004	±	0.017	0.16
the left primary motor cortex	-0.002	±	0.008	0.001	±	0.013	0.17

NOTE. Values are represented as mean ± standard deviation

*:p<0.05

The unit of oxy-Hb are represented as mM・cm.

Table 2 The comparison between groups

	Straight walking			Walking over obstacles			p value
the right premotor cortex	0.003	±	0.012	0.027	±	0.043	0.00*
the supplementary motor cortex	0.020	±	0.048	0.025	±	0.063	0.20
the left premotor cortex	0.014	±	0.044	0.032	±	0.059	0.01*
the right primary motor cortex	0.003	±	0.011	0.003	±	0.012	0.98
the left primary motor cortex	0.001	±	0.013	0.003	±	0.012	0.46

NOTE. Values are represented as mean ± standard deviation

*:p<0.05

The unit of oxy-Hb are represented as mM・cm.

4. DISCUSSION

In this study, surface cerebral blood flow dynamics of the motor area during walking over obstacles were observed using a portable fNIRS device.

In brain function research using the fNIRS device, the measurement result may be affected by the setting of the task or the measurement environment. Therefore, it is necessary to carefully analyze data and set tasks[6]. Each subject has a different head size and different skull thickness. In addition, there is no clear anatomical or cytologic boundary between functional localization of the brain. Therefore, the measurement site of each channel of the fNIRS device is not exactly the same in all subjects. In other words, it is premised that the functional region of the brain set in this study is also the estimated position. Therefore, in this study, the difference in the numerical value of each channel was not mentioned, and the overall difference in each motor area of the frontal lobe was compared.

In the previous report[7] during walking on a treadmill using the fNIRS device, walking activities were bilaterally associated with increased levels of oxygenated and total hemoglobin in the medial primary sensorimotor cortices and the supplementary motor areas. In the report4 of walking over obstacles for decerebrate animals, there are many inputs from the premotor cortex and the supplementary motor cortex in the cerebral cortex to the pontine medullary reticulum when avoiding obstacles.

In the results of this study, neither straight walking nor Walking over obstacles showed a significant increase in the surface cerebral blood flow dynamics in the primary motor area. The primary motor area is involved in the representation of voluntary movement. The primary motor area is orderly arranged (in an inverted fashion) from the toe (at the top of the cerebral hemisphere) to mouth (at the bottom) along a fold in the cortex called the central sulcus[11]. The primary motor area integrates inputs from the higher motor cortex[12] (premotor area, supplementary motor area, and cingulate motor area) and parietal cortex[13] that are involved in voluntary motor programming, resulting in a final motor command. And it output this to the lower centers (brain stem and spinal cord). There are 2 possible reasons that the primary motor area did not show a significant increase in the results of this study. First, the lower limb region involved in walking is located deep in the primary motor cortex. The fNIRS device measures the surface cerebral blood flow dynamics. Therefore, even if the lower limb region of the primary motor cortex in the deep part was active, the activity may not have been measured. The other factor is considered to be control by central pattern generator (CPG), not control by primary motor area. CPG is a circuit that forms a rhythmic motor output pattern without an external rhythmic input. CPG is composed of excitatory neurons and inhibitory neurons. Excitatory neurons drive the rhythm itself, and inhibitory neurons form output timing and activity patterns[13]. In vertebrates, CPG during walking is localized in the spinal cord. The activity of these CPGs is controlled by the upper central nervous system and sensory inputs, forming functional movements[14]. In this study, the measurement environment was not walking on a treadmill, but walking on flat ground, which was close to everyday life. The walking over obstacles task was also the same obstacle at equal intervals, so there was a possibility that rhythmic walking would occur. For these reasons, the walking task in this study is an easy movement for the subjects, and it may be controlled by CPG.

On the other hand, the supplementary motor area was significantly improved in the comparison within group for both walking over obstacles and straight walking, and no difference was observed in the comparison between groups. Supplementary motor areas are cortical motor areas that occupy medial area of 6 area in the Brodmann brain map in the frontal lobe of the cerebral cortex 11. The supplementary motor area has a unique role in motor control that differs from the primary motor area[15, 16]. For example, the following functions have been clarified. The start of spontaneous exercise[17], choice of exercise sequence[18], cooperation with both hands[19], and so on. In this study, the task was started by counting for 5 seconds before the start of walking. Therefore, the reason that the blood flow in the supplementary motor area was significantly increased is considered to be mainly the influence of the start of spontaneous exercise[18] accompanying the start of walking. The activity of this supplementary motor area was the same as that of previous studies[7, 17].

In walking over obstacles, the surface cerebral blood flow dynamics of premotor area on both sides and

supplementary motor areas were significantly increased. In addition, the task showed a significant difference in the premotor area on both sides as compared with straight walking. The premotor area is located anterior to the primary motor area, lateral to the supplemental motor area, and posterior to the prefrontal area[20]. The representative role of the premotor area is to perform a motion associated with visual information[21, 22] and to understand the motion content of others (mirror neurons)[23]. Walking over obstacles is thought to involve the premotor cortex because the task was performed based on visual information. The activity of this premotor area was the same as that of previous studies[21, 22].

The limitations of this research are the characteristics of the fNIRS device and the measurement environment.

There is the accuracy of the measurement area and the analysis method in the characteristics of the fNIRS device include. The fNIRS device cannot accurately identify the brain region to be measured from above the scalp. Therefore, it is necessary to use 3-D MRI measurement to confirm the relationship between the position of the sending / receiving fiber attached and the brain region. However, no additional confirmation has been made in this study. On the other hand, according to the 10–20 international method of EEG, it has been reported that the attachment site of each EEG electrode is close to the supposed brain region[24, 25]. For this reason, the transmission / reception fiber was installed on the basis of this 10–20 international method and measured in this study. In the analysis method of fNIRS data, there is no standard analysis method such as (SPM) statistical parametric map[26] which is often used for PET or fMRI data analysis. The analysis of fNIRS data has been performed by each facility or by several methods. Comparison of mean value between 2 groups was adopted in consideration of previous studies and the number of subjects[8] in this study. However, it is necessary to verify the validity of the fNIRS analysis method in the future.
In the measurement environment of this study, measurement task, location, and contents of verbal instructions were unified as much as possible. However, since it measures brain activity, it is difficult to limit the unification of thinking. Therefore, it cannot be denied that the results of this study may have affected the subject's thinking, such as motivation for the study.

This study was to measure the surface cerebral blood flow dynamics while walking over obstacles using a portable fNIRS device. The novelty of this study is that it was measured on flat ground, not on a treadmill. In walking over obstacles, the surface cerebral blood flow dynamics of premotor area on both sides and supplementary motor areas were significantly increased. In addition, the task showed a significant difference in the premotor area on both sides as compared with straight walking. Walking over obstacles is thought to involve the premotor cortex because the task was performed based on visual information.

The task of "crossing obstacles" is frequently performed in rehabilitation exercises for patients with neurological disorders, balance disorders and so on. From the results of this study, it is expected that it will be effective not only as a walking exercise for multiple tasks, but also as an exercise that activates the brain compared to normal walking.

Funding and Conflict of interest

The authors declare no conflicts of interest associated with this manuscript.

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Original Article

Relation Between Written Examination Scores After a CPR Seminar and CPR Implementation in an Emergency

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Abstract. [Purpose] For the purpose of exploring factors to raise the cardiopulmonary resuscitation (CPR) implementation rate by bystanders, the authors examined relations between written examination scores after a CPR seminar and CPR implementation in an emergency. [Participants and methods] A questionnaire survey and a written examination were conducted for seminar participants from 2012 through 2019. [Results] Significant correlations were shown between written examination scores and the items in the questionnaire "Being able to do CPR in an emergency" and "The need of spreading CPR and the use of automated external defibrillators in future". As for correlation between the answers for the question "Being able to do CPR in an emergency" and other survey items, and written examination scores, correlation was seen for all items though the correlation coefficient between the written examination scores was small. [Conclusion] Attendance of the seminar might have raised the participants' confidence on CPR while the relationship between knowledge and behaviors was weak, the authors presume.

Key Words: CPR seminar, written examination score, confidence on CPR implementation

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1. INTRODUCTION

The number of deaths caused by heart disorders increases year by year in Japan, and its ratio among all deaths reached 15.0% in 2019[1)]. Cooperation of citizen rescuers is essential to improve the survival rate from out-of-hospital cardiac arrest (OHCA). In order to improve survival rate after OHCA, it is important to recognize and report the cardiac arrest quickly and start cardiopulmonary resuscitation (CPR). In addition, it is essential to raise bystanders' motivation for rescue[2)]. In Japan, firefighting organization and Japanese Red Cross Society play a key role in actively spreading various basic life support (BLS) for citizens, and the number of BLS training participants is estimated to be around 2,300,000 people a year[3)]. The first aid treatment execution rate by bystander of 2019 reached 50.7%[4)]. Although the first aid treatment execution rate by bystander is increase, the social return rate of the patients with OHCA is as low as less than 20% even for witnessed cardiogenic cardiac arrest[4)]. The ideal effect of resuscitation education is that a person who has received the education is able to conduct high quality resuscitation in an actual resuscitation. In order to raise the high-quality CPR implementation rate by bystanders present

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at the scene of cardiac arrest, it is needed to spread BLS training systematically. After a 3-hour CPR seminar, we performed a questionnaire survey about the seminar contents and a written examination to identify their level of understanding the seminar contents for the seminar participants. Our past survey[5] revealed that the seminar attendance may lead to improvement in safety consciousness and competence for responding to crisis and education of respecting for life. These results correspond with the report by Osaka University of Education[6]. The accuracy rate of the post-seminar written examination that we conducted[7] was 82.4%. The accuracy rate was lightly high in the participants had undergone CPR training.

In our survey[5], for the question "I can do CPR in an emergency?", 57% answered "Yes", 42% answered "I don't know" and 0.5% answered "No", indicating that many of them had anxiety for implementation of CPR. The authors studied relations between written examination scores and questionnaire results to obtain information material that will be helpful for discussing what must be done to enable a bystander who encounters a person with a cardiac arrest out of the hospital to join the rescue activity positively.

2. PARTICIPANTS AND METHODS

The participants of this study were people who took the first aid treatment diffusion seminar "General Lifesaving Course I (3 hours)" performed by a private group FAST (First Aid Support Team) of Kobe International University during the period from May, 2012 to August, 2019. In this study, a questionnaire survey and a written examination were conducted right after the participants attended the seminar. The questionnaire and written examination were performed anonymously, and each result was corresponded by printing the questionnaire and written examination on the same paper. As an ethical consideration in this study, the purpose of the questionnaire survey and the written examination was explained both orally and in document, and submission of questionnaire answer sheets was regarded as acquisition of the participants' agreement for participation.

The contents of the questionnaire survey consisted of 6 items of basic attributes (gender, age, position, job experience, experience in CPR training, motivation for attendance) and 7 question items about attendance at the general lifesaving seminar. Answers for the question items about attendance at the general lifesaving seminar were based on five-point scale (Table 1). The written examination consisted of with 20 questions, each of which was given one point (maximum 20 points). The questions in the examination were widely chosen from the contents taught in the seminar, mainly CPR and automated external defibrillator (AED). The participants were asked to choose their answers from three alternatives.

Table 1. The questionnaire used in this survey

Questions	Answer
Impression of general lifesaving seminar of this time	1: Not good at all, 2: Not very good, 3: Neither, 4: Slightly good, 5: Very good
Seminar attendance will lead to improvement of safety consciousness	1: Not at all, 2: Not very much, 3: Neither, 4: Slightly, 5: Very much
Seminar attendance will lead to improvement of the competence for emergency response	
Seminar attendance will lead to respect for life	
I can do CPR in an emergency	
Need of acquiring a certificate of general lifesaving training	
Need of spreading usage of CPR and AED to residents (including students) in future	

CPR: cardiopulmonary resuscitation, AED: automated external defibrillator

In the statistical analysis, descriptive statistics were performed for the result of the questionnaire survey. Next, the participants were classified by department, job experience and experience in CPR training, and written examination scores were compared. The Mann-Whitney U test was used for comparison between groups. Further, we calculated Spearman's rank correlation coefficient so as to investigate relationships between answers for the question items about the general lifesaving seminar and written examination scores. Furthermore, in order to clarify factors affecting the confidence on CPR in an emergency, we calculated Spearman's rank correlation coefficient to obtain relationship between answers for the question item "I can do CPR in an emergency" and other survey items and written examination scores.

All statistical analyses were performed using an Excel statistical software package (BellCurve for Excel, Social Survey Research Information Co., Ltd., Tokyo, Japan), and the significance level was set at 5%.

3. RESULTS

The number of participants who attended the seminar during the study period was 1,015. There were deficiencies such as unfilled items in 221, which were excluded from the participants. As a result, questionnaire results and the written examination results from 794 participants were applied to the analysis (response rate 78.2%). Therefore, we performed descriptive statistics for the results of the 794 participants and summarized the participants' basic attributes (Table 2) and results of the questionnaire survey and written examination (Table 3). The result reveled 90.7% of the participants of this study were 10-29 years old, indicating that a number of students were included (74.6%). In particular, it was revealed that students from Department of Rehabilitation, which is a medical department, accounted for a half of them. Further, as for gender configuration, males are included more than females as a characteristic. The rate of participants who had experienced CPR training was 70.8%, indicating that many of them had experienced CPR training. For motivation for participating in the seminar, 75% answered "I felt it needed" and "It was needed for my job (study)" together, indicating that there were many people who felt it necessary to participate in it.

The score of the written examination was an average of 17.2 ± 1.8 points. Classifying the participants by basic attributes and comparing the scores elucidated that the written examination scores were significantly higher in participants belonging to department of rehabilitation, those without job experience and those having experience in CPR training ($p < 0.01$ for all) (Table 4). Further, for relations of answer results for the question items about the general lifesaving seminar and written examination scores, significant correlation was seen between the written examination scores and the items "I can do CPR in an emergency" ($p = 0.012$), and "Need of spreading usage of CPR and AED to residents (including students) in future" ($p = 0.002$) (Table 5). Significant correlation was not recognized between other items and the written examination scores.

Correlation analysis for the answer "I can do CPR in an emergency" and answers for other items and the written examination scores revealed significant correlation in all items (Table 5). However, comparison of the correlation coefficient with other questionnaire survey items revealed that the correlation coefficient between the answer "I can do CPR in an emergency" and the written examination scores was even lower.

Table 2. Demographics characteristics of the participants (n = 794)

Characteristics	n (%)
Age (yrs.)	
10-29	720 (90.7)
30-49	32 (4.0)
50-69	37 (4.7)
Over 70	5 (0.6)
Gender	
Male	543 (68.4)
Female	251 (31.6)
Position	
Student	592 (74.6)
Department of economics	179 (22.5)
Department of rehabilitation	413 (52.0)
Other than student	202 (25.4)
Job experience	
Yes	188 (23.7)
No	606 (76.3)
Experience in CPR training	
Yes	562 (70.8)
No	232 (29.2)
Motivation for attending the seminar	
I was interested in it	78 (10.0)
I felt it needed	457 (57.6)
It was needed for my job (study)	148 (18.6)
I was recommended	56 (7.1)
Others	55 (7.0)

CPR: cardiopulmonary resuscitation

Table 3. The results of Questionnaire survey and written examination

	n (%), mean ± SD
Questionnaire survey	
Impression of general lifesaving seminar of this time	
Not good at all	8 (1.0)
Not very good	5 (0.6)
Neither	21 (2.6)
Slightly good	127 (16.0)
Very good	633 (79.7)
Seminar attendance will lead to improvement of safety consciousness	
Not at all	0 (0.0)
Not very much	2 (0.3)
Neither	15 (1.9)
Slightly	133 (16.8)
Very much	644 (81.1)
Seminar attendance will lead to improvement of the competence for emergency response	
Not at all	1 (0.1)
Not very much	1 (0.1)
Neither	20 (2.5)
Slightly	142 (17.9)
Very much	630 (79.3)
Seminar attendance will lead to respect for life	
Not at all	1 (0.1)
Not very much	4 (0.5)
Neither	24 (3.0)
Slightly	108 (13.6)
Very much	657 (82.7)
I can conduct CPR in an emergency	
Not at all	2 (0.3)
Not very much	11 (1.4)
Neither	105 (13.2)
Slightly	380 (47.9)
Very much	296 (37.3)
Need of acquiring a certificate of general lifesaving training	
Not at all	0 (0.0)
Not very much	7 (0.9)
Neither	43 (5.4)
Slightly	158 (19.9)
Very much	586 (73.8)
Need of spreading usage of CPR and AED to residents (including students) in future	
Not at all	1 (0.1)
Not very much	2 (0.3)
Neither	15 (1.9)
Slightly	128 (16.1)
Very much	648 (81.6)
Written examination score	17.2 ± 1.8

CPR: cardiopulmonary resuscitation, IQR: interquartile range, AED: automated external defibrillator

Table 4. Comparison of written examination score by basic attributes

	median (IQR)	p-value
Department		
Department of economics	17 (16－18)	< 0.001
Department of rehabilitation	18 (17－19)	
Job experience		
Yes	17 (16－18)	< 0.001
No	17 (16－18)	
Experience in CPR training		
Yes	18 (16－18)	< 0.001
No	17 (16－18)	

CPR: cardiopulmonary resuscitation, Mann–Whitney U test. IQR: interquartile range

Table 5. The results of correlation analyses

	Spearman ρ	p-value
Relationship with written examination score		
Impression of general lifesaving seminar of this time	0.05	0.150
Seminar attendance will lead to improvement of safety consciousness	0.03	0.419
Seminar attendance will lead to improvement of the competence for emergency response	0.03	0.350
Seminar attendance will lead to respect for life	0.04	0.286
Need of acquiring a certificate of general lifesaving training	0.05	0.192
I can conduct CPR in an emergency	0.09	0.012
Need of spreading usage of CPR and AED to residents (including students) in future	0.11	0.002
Relationship with the answer "I can do CPR in an emergency"		
Impression of general lifesaving seminar of this time	0.25	< 0.001
Seminar attendance will lead to improvement of safety consciousness	0.28	< 0.001
Seminar attendance will lead to improvement of the competence for emergency response	0.30	< 0.001
Seminar attendance will lead to respect for life	0.26	< 0.001
Need of acquiring a certificate of general lifesaving training	0.22	< 0.001
Need of spreading usage of CPR and AED to residents (including students) in future	0.26	< 0.001
Written examination score	0.09	0.012

CPR: cardiopulmonary resuscitation ， AED: automated external defibrillator

4. DISCUSSION

A half to two-thirds of the deaths due to acute myocardial infarction are cardiac arrest out of the hospital and therefore most of deaths due to heart disorders are sudden death out of the hospital. In order to improve the outcome of patients with cardiac arrest out of the hospital, it is necessary to functionalize lifesaving chain in the local effectively. Above all, early report, CPR and electronic shocks with AED by bystanders would be important[8]. The number of patients whom bystanders witnessed the time of cardiogenic cardiopulmonary arrest was 25,560 in 2019. The social return rate one month later is 9.0%, which is still low[4].

Although there are opinions that written examinations do not necessarily reflect skills of BLS, we presume that knowledge connected the confidence would enable bystanders who encounters a person with cardiac arrest out of the hospital to join rescue activity positively. Therefore, this study examined relations among participants' basic attributes, scale scores of the general lifesaving seminar attendance and written examination scores. In the relationship between the basic attributes and written examination scores, the scores were significantly high in students belonging to department of rehabilitation, those without the job experience and those having experience in CPR training, indicating that having medical knowledge and motivation for becoming a health care provider in the future may have influenced the scores. Furthermore, as Shindoh et al.[9,10] reported, it seems that what they had learned in the previous seminar influence the scores. As for the relationship between the scale scores of the general lifesaving seminar attendance and written examination scores, its correlation coefficient is extremely small although those who gave positive answers for "I can do CPR in an emergency" and "Need of spreading usage of CPR and AED to residents (including students) in future" tended to have higher scores. However, since the correlation coefficient with the written examination scores is small, it has been suggested that affirmative attitude for the seminar and recognition of the need of attending a seminar are not directly linked with acquisition of the associated knowledge.

As for the relation among confidence on conducting CPR in an emergency, other survey items and the written examination scores, significant correlation was recognized in all items. Further, since participants who believe that attendance at a seminar will lead to improvement of safety and crisis consciousness and respect for life have higher confidence on conducting CPR in an emergency, highness of the sense of purpose is the factor that influences the result of the CPR seminar. In this way, it is important to improve instructors' qualification and skills for holding a seminar, so that the seminar can raise the participants' sense of purpose. Implementation of CPR by bystanders is important for lifesaving yet "falling into panic", "concern about infection" and "no confidence on CPR" were obtained as factors of the rescuer side that make bystanders hesitate to join rescue. Moreover, factors of the patient side include "the patient is a strange person for a rescuer", "disarray", "seems to abuse medicinal substances", "bleeding" and "vomiting"[3]. Therefore, we consider that confidence on conducting CPR is a factor required to conduct CPR in emergency. The results of this study revealed that the participants showed high confidence after the seminar attendance, indicating that the attendance at the seminar might have raised their confidence on conducting CPR. This result agrees with the report of Sumitomo et al.[11], and seminar attendance lead to reduction of the participants' anxiety and improvement of their confidence on CPR, we infer.

However, since the correlation coefficient between the confidence on conducting CPR in an emergency and the written examination scores is small, it is suggested that relationship between knowledge and behaviors is weak. Knowledge of CPR is an element that is essential for conducting high-quality CPR. At present, an optimum method to put knowledge into practice in an emergency has not been established. It is not easy to offer practical training and teach basic knowledge of CPR in three hours to common people without basic medical knowledge to enable them to conduct CPR in an emergency. However, in order to improve survival rates and social return rates for patients with OHCA it is required to acquire both knowledge and technique. Therefore, it is necessary to seek for ideal training to raise the implementation rate and quality of the CPR conducted by bystanders.

There are several limitations for this study. First, since we did not conduct a survey before seminar in

this study, we were not able to grasp directly the participants' change by the seminar. In the future, it is necessary to capture a change in the participant' consciousness by the seminar attendance through a questionnaire survey before and after a seminar. Secondly, individual differences were not detected sufficiently with the questionnaire scales used for this study. Development of a scale to capture the effects of a seminar subtly is required in future. Finally, since a half of the participants of this study were students who belonged to the medical department, it is possible that they already had knowledge of CPR and their consciousness about it was already high before the seminar. Therefore, there are limitations for applying the results of this study to general seminars. In the future, it is necessary to conduct a detailed analysis for every attribute of the participants and verify impacts of participants' attributes on the effect of the seminar.

Funding and Conflict of interest

The authors have declared that no competing interests exist.

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Original Article

Inter-rater reliability of the Test of Gross Motor Development Second Edition (TGMD-2) for Children with Down Syndrome : A Pilot study

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Abstract. [Purpose] The purpose of this study was to assess the Inter-rater reliability of the Test of Gross Motor Development Second Edition (TGMD-2) for Children with Down syndrome. [Participants and methods] This pilot reliability study involved 41 participants with Down syndrome from the School for Disabled Children, Yangon, Department of Social Welfare, Ministry of Social Welfare, Relief and Resettlement. All the participants were explained and demonstrated all 12 fundamental motor skills (FMS) of TGMD-2 before the assessment. All the participants were provided one test trial before starting the assessment and they had to perform each FMS twice. The rest period was provided between each FMS assessment. The performance of every child was videotaped for an accurate assessment of all performance criteria. The performance of the FMS of all participants was recorded in the study area by the principal researcher. Two pediatric physiotherapists (one well-experienced and one novice) assessed both locomotor and object control skills of the TGMD-2. The video recordings were watched and rated separately by the two raters for inter-rater reliability. The inter-rater reliability for locomotor and object control raw scores were calculated by intra-class correlation coefficients (ICC) and Cronbach's Alpha. [Results] Inter-rater reliability was excellent reliability for locomotor raw scores (ICC = 0.94) and object control raw scores (ICC = 0.94). Moreover, the inter-rater reliability of all individual FMS was high (ICC > 0.75), except run skill with moderate inter-rater reliability (ICC = 0.68). [Conclusion] The TGMD-2 is a satisfactory tool for assessing the FMS proficiency as well as highly inter-rater reliable tool for children with Down syndrome.

Key Words: Reliability, TGMD-2, Children with Down syndrome

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1. INTRODUCTION

Down syndrome (DS) is one of the most common genetic disorders caused by an extra copy of chromosome 21 which is also known as trisomy 21 [1-5]. The causes of DS were identified by Jerome Lejeune in the year 1959 and this syndrome was described by John Langdon Down in 1866, therefore it is named Down syndrome [6]. The estimated global incidence is around 0.1% in live births and it can also affect individuals of different races, ethnic groups, and socioeconomic classes [7-10].

There was a slight difference in the motor development of children with DS and typically developing children (TDC) [10, 11]. The developmental motor delay of children with DS has been associated with impairments such as low muscle tone, joint hypermobility, poor postural control, poor balance, and

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congenital heart disease and obesity [9, 11, 12, 13]. These characteristic impairments lead to the acquisition of fundamental motor skills (FMS) with compensatory movement patterns [14, 15].

The FMS are the building blocks for more complex movements that require the activation of muscles or muscle groups [16, 17]. It can be typically categorized as object control skills, locomotor skills, and stability skills (balance and twisting) [16-20]. Object control skills are transferring, catching, or propelling of objects such as throwing, catching, dribbling, kicking, underhand rolling, striking, and so on. Locomotor skills have such different movements to transport the body from one location to another as running, jumping, hopping, leaping, galloping, sliding, etc. [16, 18-20]. The proficiency of FMS is necessary to enhance the children's cognitive, social, and psychological development [20-23].

In order to provide detailed pieces of evidence for intervention plans, standardized FMS assessment methods for children with DS are necessary [24-26]. The FMS can be assessed by using standardized product-oriented or process-oriented approaches [16, 18, 20, 27]. Product-oriented assessments depend on time, distance, and/or frequency of successful performance of each skill. Process-oriented assessments are concerned with how the movement skills are performed. It can be said to be a valuable assessment in recognizing the content of impaired skill exactly [18]. Moreover, this assessment also evaluates the movement skills based on anticipated patterns at each stage of development [16, 18, 20, 27]. The standardized assessment tools can also be classified as norm-referenced and criterion-referenced type [20]. Norm-referenced types assess the quantity of performance and it has reference points that resultant from a reference group [20]. On the other hand, criterion-referenced types assess the quality and it has reference points that do not derive from a reference group [20].

One of the most commonly used standardized measures of the FMS assessment for children with or without disabilities is the Test of Gross Motor Development second edition (TGMD-2) [16-18, 20, 28-30]. It is a process-oriented as well as norm-referenced and criterion-referenced assessment tool [18]. This tool can be used to identify the individual FMS delay or not, develop instructional/ interventional programs, program evaluation, and research tools [18]. It has proved that this tool has excellent reliability [18]. The test includes two subtests: the locomotor skill subtest and the object control skill subtest. Each subtest is composed of six skills. The locomotor skill subtest involves run, gallop, hop, leap, jump, and slide. The object control subtest consists of striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll[18].

Several studies have documented for the FMS assessment of the TGMD-2 as cross-cultural studies in Brazil, China, Indonesia, Japan, Malaysia, Myanmar, and many other countries for TDC [31-36]. In the same way, many other studies have been conducted on the FMS assessment with the TGMD-2 for children with special needs such as autism spectrum disorder (ASD), cerebral palsy, intellectual disabilities (ID) and DS [37-40]. Furthermore, numerous studies have recognized the reliability of the TGMD-2 in TDC [41-47]. Moreover, studies for the reliability of the TGMD-2 were done in children with special needs such as Visual Impairment (VI) and ID [48-50]. All of these reliability studies have moderate to high reliability.

The TGMD-2 is widely used in clinical, educational, research settings because this tool has excellent psychometric properties and the norms values as well as it is easily applicable. Besides, the TGMD-2 is a reliable, valid, and well-standardized assessment tool to assess the FMS proficiency of children with and without disabilities in several countries [41-50]. However, results from the TGMD-2 may not be appropriate without proper verification through different cultures. Therefore, the reliability and validity should be explored in developing countries. Although there is evidence of the reliability of the TGMD-2 all over the world, the socioeconomic and cultural differences in children should be considered. Moreover, Rey and associates stated that there were few studies on the reliability of the TGMD-2 for children with VI, ASD, and ID, however, the reliability of the TGMD-2 for other special needs population was still required to examine [51]. Also, there is no study investigating the reliability of the TGMD-2 for the children with DS in Myanmar. Therefore, it is necessary to investigate the inter-rater reliability of the TGMD-2 for the children with DS in Myanmar.

2. PARTICIPANTS AND METHODS

This pilot reliability study was conducted at the School for Disabled Children, Yangon, Department of Social Welfare, Ministry of Social Welfare, Relief and Resettlement, Myanmar. It is a preliminary study for reliability (inter-rater, intra-rater, and test-retest) and randomized controlled trial study for children with Down syndrome. Using the convenience sampling 41 children (30 boys, 11 girls; mean aged 9.87 ± 1.46 years) with Down syndrome diagnosed by pediatrician participated in this study. The inclusion criteria were (1) children who can follow two-step commands and demonstration and (2) children with DS who can demonstrate all 12 items of the FMS of the TGMD-2. The exclusion criteria were (1) children who have documented severe neurological or medical conditions (e.g. epilepsy, cerebral palsy, cardiopulmonary diseases, diabetes, uncontrolled asthma, hypothyroidism) (2) children with DS who have documented musculoskeletal problems which can interfere with their movements. Before collecting data, to consider the human value of participants, ethical approval for the study was obtained from the Institutional Review Board of the University of Medical Technology, Yangon. In addition, official permission was also obtained from the authorities of the study area. The principal, the teachers, parents/guardians of children, and all children with the eligibility criteria in the study area were invited to participate in this study. They were explained about the purpose, procedures, and safety measures of this study with verbal explanation and written explanation form. The written informed consent of all parents/guardians and verbal assent of all participants were taken.

The scoring and assessment procedures were done according to the TGMD-2 examiner manual. Each skill of the TGMD-2 was demonstrated by the researcher before assessment. The participants had to perform one practice trial that was not scored and two test trials that were scored for each skill. The performance of all 12 motor skills by each participant was video-recorded. The video recording of the TGMD-2 was done from the lateral and anterior views of the participants by the researcher. For locomotor skills assessment, the camera was fixed on the tripod to change the angle and direction of the camera for recording the entire performance of the FMS. For object control skills assessment, the camera was fixed in the best position to record the performance of the participant. The assessment of the TGMD-2 lasted for 10-20 minutes per participant.

The TGMD-2 evaluates 12 skills and the performance criteria were between 3 and 5 criteria according to each skill. Hop has five and leap has three performance criteria, and the rest have four criteria. Striking a stationary ball has five and catching has three performance criteria, and the rest has four criteria [18]. If the participant can perform the skill, he/she obtains a score of 1 and if he/she cannot perform the score is 0. The total criterion scores of performance criteria were summed to obtain a skill score. Six skill score was summed to obtain a subtest raw score and the maximum subtest raw score was 48 for locomotor and object control skills, respectively. Two raters (two pediatric physiotherapists) were responsible for scoring the TGMD-2. One rater was expert in administering and scoring of the TGMD-2 and that rater had more than five years' experience of using the TGMD-2 in children. The other rater was novice therapist for using the TGMD-2 although that rater had finished training for the TGMD-2 with very few children. They separately watched the same video recording to assess the performance of each participant.

To ensure the completeness and accuracy of the data, the data were thoroughly read, re-read and re-checked before analyzing the data. All individual FMS skills, raw scores of locomotor, and object control skills were calculated for the reliability testing. Normality was checked by using the Kolmogorov-Smirnov test. The inter-rater reliability was calculated by intra-class correlation coefficients (ICC) (two-way random, average measures, absolute agreement) and Cronbach's alpha. The inter-rater reliability refers to the agreement or consistency of scores between two or more raters who measure the same group of participants [52] and crucial element for assessing FMS skills proficiency of children [44]. In this study, the criteria for reliability coefficients were adopted from Protney and Watkin that consider ICCs < 0.50 poor reliability, from 0.50 to 0.75 moderate reliability, and > 0.75 high reliability [52]. The significance level was accepted as $p < 0.05$. Statistical analysis was performed using IBM Statistical Package for the Social Science (SPSS) software version (25.0) for Windows.

3. RESULTS

Table 1 shows the results of the mean values for all individual FMS, locomotor and object control raw scores by two raters, Cronbach's Alpha, ICCs, and p-value for the inter-rater reliability. The range of the ICC values was 0.76 to 0.96; therefore, high inter-rater reliability was seen for all FMS except the run.

Table 1. Results of inter-rater reliability test (Cronbach's Alpha and ICC)

Fundamental Motor Skills	Rater A	Rater B	Cronbach's Alpha	ICC	p-value
Run	4.98 ± 2.01	5.49 ± 1.48	0.70	0.68	<0.001
Gallop	1.29 ± 2.23	1.46 ± 2.37	0.86	0.86	<0.001
Hop	2.05 ± 3.06	2.12 ± 2.97	0.96	0.96	<0.001
Leap	1.83 ± 2.13	2.32 ± 2.37	0.85	0.84	<0.001
Jump	2.22 ± 2.54	2.51 ± 2.55	0.90	0.90	<0.001
Slide	3.12 ± 2.66	2.98 ± 2.39	0.87	0.87	<0.001
Striking a stationary ball	4.68 ± 2.00	5.44 ± 2.11	0.87	0.84	<0.001
Stationary dribble	1.29 ± 2.02	1.56 ± 2.03	0.90	0.89	<0.001
Catch	2.63 ± 1.71	2.44 ± 1.59	0.87	0.87	<0.001
Kick	5.15 ± 2.46	5.24 ± 2.10	0.85	0.86	<0.001
Overhand throw	3.27 ± 2.28	3.61 ± 2.30	0.76	0.76	<0.001
Underhand roll	3.27 ± 2.35	3.49 ± 2.11	0.87	0.87	<0.001
LRS	15.49 ± 10.24	16.88 ± 9.05	0.94	0.93	<0.001
OCRS	20.29 ± 9.26	21.83 ± 7.83	0.95	0.94	<0.001

± : Mean ± SD, ICC: Intraclass correlation coefficient, LRS: Locomotor Raw Scores, OCRS: Object Control Raw Scores

4. DISCUSSION

The objective of this study was to determine the inter-rater reliability of the TGMD-2 for assessing FMS proficiency in children with Down syndrome in Myanmar. The inter-rater reliability for the TGMD-2 locomotor and object control raw scores was higher than 0.9, this value can be interpreted as excellent reliability between two raters. Cronbach's Alpha for all skills was above 0.75 except the run; therefore it indicates that the TGMD-2 is a reliable tool to assess the FMS proficiency of children with Down syndrome in Myanmar. The findings of this study showed that the inter-rater reliability was excellent or high when the TGMD-2 examiners were well trained.

In the current study, the inter-rater reliability ICC for locomotor and object control raw scores were 0.94 and 0.95 which signified high or excellent reliability [52]. The results of the current study were similar to previous studies that were conducted with different study populations such as TDC, children with VI and ID [42, 46, 48-50]. All of these studies had excellent inter-rater reliability [42, 46, 48-50].

These current study findings were consistent with other studies that were conducted for children with special needs such as VI and ID [48-50]. A similar finding was also found in the study of Houwen and associates for the children with VI in the Netherlands [48]. They had found that the inter-rater reliability for the locomotor subtest was 0.82 and the object control subtest was 0.93 [48]. The study of Simons and colleagues found that excellent inter-rater reliability with an agreement between two raters for both locomotor and object control subtest in Flemish children with ID [49]. In comparison, the study by Capio and associates reported that the inter-rater reliability for locomotor subtest and object control subtest was 0.99 for Filipino children with ID [50]. Therefore, their results are the same as the current study, which is high inter-rater reliability.

The result of the current study was a coincidence to the studies of Barnett and colleagues in Australia [42] and Aye et al. in Myanmar [46]. However, these studies were conducted in TDC. The inter-rater reliability was excellent for the object control subtest and ICC was 0.93 in Barnett and associates study [42]. Aye et al. stated that the inter-rater reliability for locomotor raw scores and object control raw scores were excellent or high [46]. In their study, the inter-rater reliability for locomotor raw scores and object control raw scores were 0.95 and 0.88 respectively in Myanmar TDC [46]. Therefore, the results of the current study were similar to the studies for TDC and all of the studies had excellent inter-rater reliability.

For the individual skills, the ICC values for almost all skills of the TGMD-2 between two raters were above 0.75 which represented high or excellent reliability. In this study, the highest inter-rater reliability was found for the hop (ICC = 0.96) and the lowest inter-rater reliability was found for the run (ICC = 0.70) in locomotor skills. For the individual object control skills of the current study, the highest inter-rater reliability for the dribble (ICC = 0.90) and the lowest for the overhand throw (ICC = 0.76) were found. Although there were the lowest among the 12 skills of the TGMD-2, the ICC value can be interpreted as moderate for the run and high reliability for the overhand throw [52]. In this study, two raters assessed the recorded same video separately one time. This might be due to raters' error [52]. The interpretation of each criterion score might be influenced by the two raters. The variation of the inter-rater reliability could be due to different detailed interpretations of each criterion score. For example, in the "run" skill, the second criterion "Brief period where both feet are off the ground" and the third criterion "Narrow foot placement landing on heel or toe (i.e., not flat footed)" might be interpreted differently [18]. Therefore, pre-assessment agreements between raters should be made before actual assessment to obtain accurate assessment scoring. Moreover, other previous studies also recommended training for scoring was necessary for novice raters to achieve precise scoring [42, 44, 51]. The findings of the current study were coincident with the results of Barnett and the association study for TDC in Australia [42]. However, Barnett et al. explored the inter-rater reliability only for object control skills and they had reported excellent inter-rater reliability. In their study, the highest inter-rater reliability was reported for the dribble (ICC = 0.94) and the lowest for the catch (ICC = 0.71) [42].

The limitation of the current study was, participants were only the children with Down syndrome from the School for Disabled Children, Yangon. Therefore, further different study areas are needed to find out the reliability of the TGMD-2 for children with Down syndrome in Myanmar. Moreover, other children with special needs should also be assessed to participate in order to explore the reliability of the TGMD-2 in Myanmar. In conclusion, the findings of this study support the sufficient inter-rater reliability of the TGMD-2 for examining the FMS proficiency of children with Down syndrome. Thus, it has been found out that the TGMD-2 is a suitable and satisfactory tool for assessing the FMS in this population in Myanmar.

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Original Article

Difference in Physical Activity Between Japanese Elderly People doing the Iki-Iki 100-year-old Gymnastics and Radio Gymnastics

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Abstract. [Purpose] In April 2020, the Ministry of Health, Labour and Welfare introduced the Iki-Iki 100-year-old gymnastics (100-year-old gymnastics), which can be performed at home during a state of emergency. The amount of physical activity (MET×min, PA) of 100-year-old gymnastics and radio gymnastics (RG) was measured and compared. [Participants and methods] The subjects were 7 elderly people living in Hiroshima. In August and September 2020, subjects wore an aero monitor and electrocardiogram to measure oxygen uptake and heart rate during gymnastics. [Results] The activity intensity of the first and second RG was 2.5 vs.3.1 METs, and the intensity of stepping, standing up from a chair, knee extension and hip abduction in the 100-year-old gymnastics was 1.7 to 1.9 METs.The amount of physical activity of 100-year-old gymnastics was higher than that of RG (p=0.03).The heart rate in RG was higher than that at rest. [Conclusion] The intensity was higher in RG (especially the second) and the amount of physical activity was higher in 100-year-old gymnastics. The heart rate during RG was high and it was possible to perform gymnastics at a moderate intensity. Adding both of these gymnastics to leisure and housework may help prevent activity decrease and muscle weakness while refraining from activities.

Key Words: state of emergency declaration, gymnastics, physical activity

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1.INTRODUCTION

COVID-19, which occurred in 2019, markedly impacted people's daily lives[1-3]. For one month from April 16, 2020, a state of emergency was issued to all prefectures, and people were forced to refrain from going out unless necessary to maintain their livelihoods[4]. The Ministry of Health, Labour and Welfare of Japan introduced "the Iki-Iki 100-year-old gymnastics" as a gymnastics video that can be followed at home in order to maintain physical function and activity while refraining from activities[5]. The Japan Sports Agency informed people about the points to keep in mind about sports, exercise, and exercise examples[6]. However, it was reported that refraining from activities due to a state of emergency causes a decrease in daily physical activity (activity intensity/time) [7-11]. As no exercise items to train core function have been reported, it is necessary to train the core by other methods[12]. In addition, it is unclear how much physical activity (especially activity intensity) 100-year-old gymnastics requires and which type of gymnastics counts as activity. Therefore, in this experiment, the first and second radio gymnastics (RG), which were created for the purpose of improving the physical strength and maintaining and improving the health of

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the Japanese people, was used as a comparison target, and the effectiveness of “the Iki-Iki 100-year-old gymnastics” was assessed by measuring the activity intensity, activity time, and physical activity amount.

2.PARTICIPANTS AND METHODS

The subjects were 7 elderly people (2 men, 5 women, age 76.8 ± 3.3 years old, height 155.5 ± 3.0 cm, weight 56.6 ± 9.8 kg) who live in Asakita Ward, Hiroshima City, Hiroshima Prefecture, and gather at a meeting place once a week for “the Iki-Iki 100-year-old gymnastics”. Participants were asked about the disease being treated and their medication status, and those with factors that may affect the measurement of activity intensity were excluded. This study was approved by the Hiroshima Cosmopolitan University Ethics Committee (2019004). Informed consent was received from all participants after explanation prior to participating in this study.

The intensity of the 100-year-old gymnastics and RG was measured once a week for all subjects between August and September 2020 when they gathered at the meetinghouse to perform them. In the experiment, in order to prevent COVID-19 infection, the measurement was performed on one subject per day by two measurers.

An aero monitor (AE-310S Nihon Kohden Co., Ltd.) was used to measure the intensity of each type of gymnastics. Oxygen uptake during gymnastics was measured by the breath-by-breath method by breath gas analysis. The obtained results were averaged by metabolic equivalents (hereinafter referred to as METs), which is the intensity of each type of gymnastics. The activity definition during gymnastics was 1.5 METs or more as physical activity[13, 14]. The METs during each type of gymnastics were calculated as the amount of physical activity by multiplying by the time (minutes). A multifunctional electrocardiograph (ECG-1550, Nihon Kohden Co., Ltd.) was used to measure the heart rate during gymnastics and the recorded heart rates during each type of gymnastics were averaged.

Commercially available software (SPSS ver.26 IBM) was used for the analysis. The mean ± SD is shown in Table 1 and the mean ± SE is shown in Figure 1. P-values less than 0.05 were considered significant.

3.RESULTS

As shown in Figure 1 and Table 1, both types of RG were considered physical activity (> 1.9 METs). Of the 12 movements in “the Iki-Iki 100-year-old gymnastics”, stepping, standing up from a chair, knee extension, and hip abduction were considered physical activity. As for the intensity of these four types of movements, that of hip abduction was significantly lower than that of the first RG ($p = 0.02$), and the other three types exhibited no difference ($p > 0.06$). Compared with the second RG, all four movements were low intensity ($p < 0.01$). The activity time of “the Iki-Iki 100-year-old gymnastics” was approximately 13 minutes and 20 seconds. The activity time of the four movements was approximately 17 seconds for stepping, 5 minutes and 5 seconds for standing up from a chair, 5 minutes and 22 seconds for stretching the knees, and 2 minutes and 36 seconds for hip abduction. The first and second RG were approximately 5 minutes and 48 seconds (first: 3 minutes and 5 seconds, second: 2 minutes and 43 seconds).

1. Amount of physical activity (Table 1)

As shown in Table 1, by calculating the amount of physical activity based on the activity intensity and time (minutes) of the movements, that of “the Iki-Iki 100-year-old gymnastics” was higher than that of RG (23.6 ± 3.6 vs.16.0 ± 2.6, $p < 0.01$). The amount of physical activity was greater in the “the Iki-Iki 100-year-old gymnastics” than in the first RG ($p = 0.01$). The amount of physical activity was lower during stepping and hip abduction than during the first RG ($p < 0.03$). Similarly, the physical activity of standing up from a chair and extending the knee was higher ($p < 0.01$) than that of the second RG, and the physical activity of the remaining two movements was lower ($p < 0.01$).

2. Heart rate (Table 1)

RG and standing up from a chair, stretching knees, and hip abduction in “the Iki-Iki 100-year-old gymnastics” increased the heart rate ($p < 0.03$). The heart rate during the four movements in “the Iki-Iki 100-year-old gymnastics” was lower than that during both RG ($p < 0.01$).

Table 1 Time, heart rate, Intensity and amount of physical activity of the Iki-Iki 100-year-old gymnastics and radio gymnastic

* significant difference compared to radio gymnastic first;

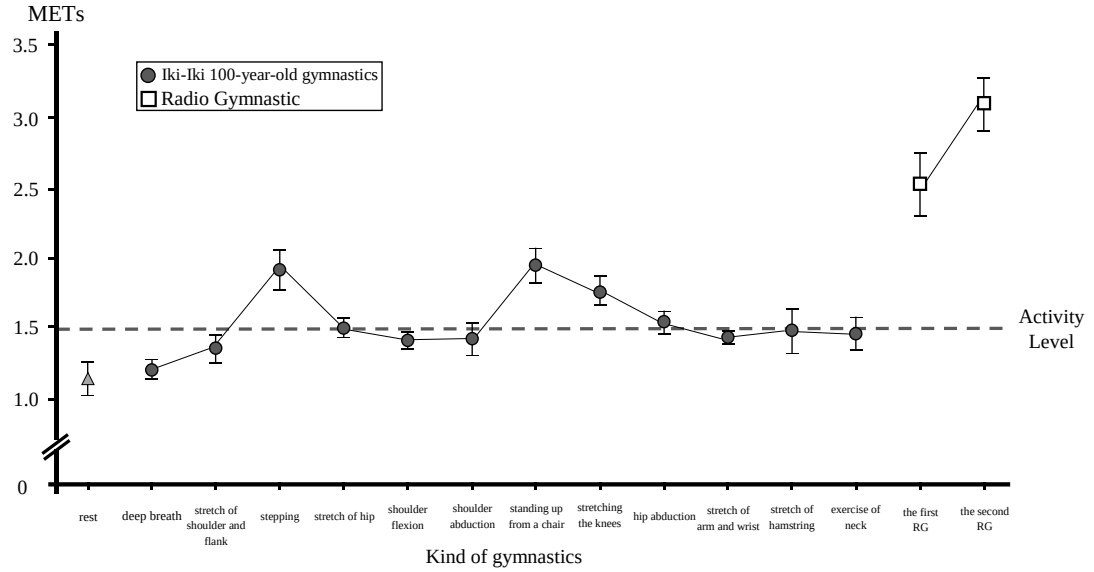
Detail of gymnastics	Rest	The Iki-Iki 100-year-old gymnastics				Radio gymnastic	
		Stepping	Standing up from a chair	Knee extension	Hip abduction	First	Second
Exercise time (min : sec)		00:17	05:05	05:22	02:36	03:05	02:43
Heart rate (bpm)	70.4±3.4	71.6±3.2*†	75.8±3.2*†	74.0±2.5*†	75.2±2.9*†	91.4±82	94.8±8.7
Intensity (METs)	1.1±0.4	1.9±0.6†	1.9±0.3*†	1.7±0.3*†	1.5±0.2*†	2.5±0.6	3.1±0.5
Amount of PA		0.5±0.2*†	9.7±1.6*†	9.3±1.4†	4.0±0.5*†	7.7±1.9	8.3±1.3
Amount of PA of each exercise			23.6±3.6‡			16.0±2.6	

† significant difference compared to radio gymnastic second;

‡ significant difference compared to radio gymnastic.PA, physical activity;

METs, metabolic equivalents; bpm, beat per minute;

The unit of amount of PA is METs×min.



Of the 12 types of the 100year-old gymnastics, 4 types (stepping, standing up from a chair, knee extension and hip abduction were activities. all radio gymnastics were active. Activity METs is more than 1.5 METs. METs, metabolic equivalents; RG, Radio Gymnastics

Figure 1 Intensity of gymnastics

4.DISCUSSION

In this study, the activity intensity of "the Iki-Iki 100-year-old gymnastics" and RG was measured in healthy elderly people, and the amount of physical activity was calculated as the product of the activity intensity and time. As a result, although the activity intensity was high in RG, the activity time was longer and the amount of physical activity was greater in "the Iki-Iki 100-year-old gymnastics".

The American Heart Association (AHA) recommends 500 METs × min/week of activity or 150 minutes or more/week of moderate intensity gymnastics as daily physical activity to maintain and improve athletic performance and cardiovascular function[15-17]. In Japan, the Ministry of Health, Labour and Welfare recommends that people aged 65 and over perform 10 METs/hour/week, 40 minutes or more every day, regardless of intensity in the physical activity standard 2006 and 2013 for health promotion (hereinafter: domestic activity standard)[18,19]. Compared with that recommended by the AHA (500 METs × min/week), the amount of physical activity by the weekly "the Iki-Iki 100-year-old gymnastics" and RG currently performed by the elderly is insufficient (> 4.7%). When performed daily, it is possible to perform 33.4% and 22.4% of the recommended amount of physical activity by "the Iki-Iki 100-year-old gymnastics" and RG, respectively. By performing both types of gymnastics daily, it is possible to achieve 55.4% of the recommended amount of physical activity. Moderate intensity (3 METs or more) according to AHA was satisfied only by the second RG, but the time for one session was short and it was necessary to include many other activities. On the other hand, even if both types of gymnastics are performed once a week, the amount of physical activity (10 METs/hour/week) is insufficient based on the domestic activity standard (> 2.7%). "The Iki-Iki 100-year-old gymnastics" required 0.4 METs/hour/time and RG required 0.3 METs/hour/time. Both of these types of gymnastics can be performed daily at 2.7 METs/hour (27.3%). Although the recommended activity time was 40 minutes/day, that for "the Iki-Iki 100-year-old gymnastics" was 33.2% and that for RG was 14.5%. By performing both types of gymnastics together, it is possible to reach 47.8% of the recommended time per day. Suzuki et al. reported a strong correlation between physical activity and subjective well-being[20]. Yamada et al. reported that the physical activity time in the elderly decreased significantly in April 2020 compared with January 2020[21]. By increasing daily gymnastics, leisure time, housework exercise, and activity time, it may be possible to prevent the exacerbation of heart failure, major adverse cardiac events (MACE), and declining quality of life during self-restraint.

The average maximum heart rate (208- (0.7, age)) calculated from the subject's age according to the AMERICAN COLLEGE of SPORTS MEDICINE (hereinafter referred to as ACSM) was 154.2 beats per minute[22]. As a result of calculating the moderate intensity level (55 to 69% from the maximum heart rate) recommended in the gymnastics guidelines, 84.8 to 106.4 was determined as the target heart rate. The heart rate of the subjects during each type of gymnastics was 91.4 for the first RG and 94.8 for the second RG, which reflected a moderate intensity level. However, the total gymnastics time was as short as 6 minutes. The ACSM recommends 75 minutes of gymnastics per week at a moderate intensity level for people over 65 years of age. Thus, but in addition to both daily radio gymnastics, approximately 5 minutes of moderate-intensity gymnastics is required every day. The physical activity standard of the Ministry of Health, Labour and Welfare does not specify the activity intensity for people aged 65 and over, and it is set at 10 METs/hour/week for 40 minutes every day[19]. Therefore, in addition to daily 100-year-old gymnastics and both RG (approximately 19 minutes), approximately 20 minutes of activity is required every day. In conclusion, the time for performing "the Iki-Iki 100-year-old gymnastics" was longer, but activity intensity was higher in RG (especially the second) . The heart rate during RG was high and it was possible to perform at a moderate intensity level. Furthermore, performing both types of gymnastics daily fulfills 27.3% of the amount of physical activity required per day and 47.8% of the activity time. By supplementing the remaining required amount of physical activity with daily leisure activities, housework activities, gymnastics, etc., it is possible to meet the required amount of physical activity. It can be recommended as a type of voluntary training at home in order to maintain self-restraint and prevent falls.

In conclusion, the activity time required for "the Iki-Iki 100-year-old gymnastics" was longer and the amount of physical activity was larger than that of RG. On the other hand, the intensity of exercise was

higher in RG (especially the second) and the heart rate during the exercise increased to the level recommended by the ACSM, and it was possible to perform medium-intensity activity. If only the first or second RG is performed, the amount of physical activity will be reduced; therefore, it is better to perform both exercises. However, when performing “the Iki-Iki 100-year-old gymnastics” or RG, the amount of physical activity per exercise did not reach the target amount in Japan and the United States (≤ 4.7%). By performing both “the Iki-Iki 100-year-old gymnastics” and RG every day, 27.3% of the recommended daily physical activity and 47.8% of the recommended activity time in Japan can be performed. If only life-maintaining activities can be performed due to long-term outing restrictions, it may be possible to prevent a decrease in physical activity, MACE, and heart failure by adding both “the Iki-Iki 100-year-old gymnastics” and RG to daily leisure and housework activities. We are planning to create our original gymnastics to supplement “the Iki-Iki 100-year-old gymnastics” (low intensity) and radio calisthenics (medium intensity) according to the physical function of the subject.

This study has some limitations. Due to the small number of subjects,the impact of changes may be significant. In addition, there were many items with simple measurements, and biomarker tests (hemoglobin, etc.) and cardiac function tests that may affect the measurement results were not performed. The maximum gymnastics stress test, which was reported to be an independent predictor of life prognosis, was also not conducted.

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The authors have declared that no competing interests exist.

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