

RESEARCH ARTICLE

The Impact of Mathematics Class Right After Physical Education Class on Brain Activation in Children

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체육 수업 직후 수학 수업이 아동의 뇌 활성화에 미치는 영향

노민화¹ · 김경래^{2*} · 권석원³

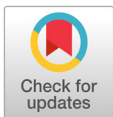
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ABSTRACT

The purpose of this study is to analyze the impact of mathematics class right after physical education class on brain activity patterns of elementary school students. For this study, among the 4th graders of G elementary school located in G-city, 20 students in the experimental group (M: 10, F: 10) and 13 students in the comparative group (M: 7, F: 6) were participated in an experiment for 8 weeks and then measured EEG. The data collected by the analysis of the activity patterns of the brain, SPSS / PC + Version 18.0 program sLORETA computational techniques were analyzed for the purpose of the data. The results are as follows. First, there was a significant difference in brain activity before and after the experiment in the same group after 8 weeks. Second, in the case of the experimental group, the activity was dominant in the gamma band (30-50 Hz) of the right brain, whereas the left brain showed negative activity in the alpha 2 band (10.5~13.0 Hz) and the beta 2 band (20~30 Hz). This results shows several similarities when compared to the noticeable characteristics of a functional lateralization at the right hemisphere belonging to gifted children in the creative thinking process.

Key words: Timing reconstruction curriculum, brain activation, physical education, mathematics, children



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Introduction

The recent curriculum has put emphasis on individualized curriculum or idiosyncratic curriculum that is based on the implementation of any curriculum initiative at the local, school, classroom and student level in parallel with national curricula. Through creative curriculum management with materials and equipment that capitalize on children's interests and needs, students can develop individualized goals and promote a variety of skills (Kim et al., 2021).

Curriculum typically refers to the knowledge or information that is going to be taught and the methods that are going to be utilized to teach that content something like that 'what, how, why, and when' in formal school institutions (Wong et al., 2014). Despite the world-trend towards the individualized curriculum, there is a relatively lack of interest and research on 'when' in comparison to a broad interest in 'educational contents, methods and goals' related to 'what, how and why'. Just as 'timing' is important in everyday life, it is necessary to recognize that 'when' is as important as 'why' and 'what' when managing a curriculum at school. Therefore, curriculum needs to offer a balanced and varied schedule that is flexible, yet consistent. With the aids of the brain image and results of the study in the brain science and neuroscience, teachers and educators approach closer to the answers that benefit learners in their ultimate success (Lee, 2019).

We now have a substantial understanding of the neural mechanisms of a timing system that is responsible for the generation and regulation of circadian rhythms. The construction of the human body includes components which are available to capable of rhythmic function. All human beings are born with many timing devices which play an important role in somatic processes as well as in mental and emotional operations (Bedrosian & Nelson, 2017). Human Biorhythms provide an internal clock that enables the coordination of rapid physiological processes and the precise timing of external events (Roenneberg & Merrow, 2016). The primary oscillators lie in the hypothalamus. In particular, the mammalian suprachiasmatic nucleus, a group of small neurons located in the basal part of the anterior hypothalamus, is mainly considered to be the critical element of the circadian timing system (Stenvers et al., 2019; Thosar et al., 2018).

The neuroscience researches that refer to above give indication that the physical, emotional and intellectual potential of human beings fluctuate periodically in the cycles. The answers to the ultimate questions of education such as 'What is the best way for students to learn?' and 'How far is human potential?' suggests strategies needed in classrooms and schools where students spend the most time in their daily lives. The answers to the ultimate questions of education such as 'What is the best way for students to learn' and 'How far is human potential?' suggests strategies needed in classrooms and schools where students spend the most time in their daily lives.

"How students learn best, what is, the answer to the ultimate question of the education of" human potential is somewhere to' suggests strategies students need in the classroom and spend the most time in the school day.

They suggest that designing a learning environment based on how the brain can learn naturally with not complicated but new educational paradigm. Timing reconstruction curriculum which take account of neural mechanisms of a timing system can rich opportunities for learning in the students' everyday routines and planned experience. As a result of it, students are capable of improvement of the better learning ability as well as maximizing the learning interest and achievement motivation (Jo & Kim, 2020; Shin, 2019).

Meanwhile, the beneficial effects of regular exercise and physical activity are evident. A growing number of studies support the idea that physical exercise might give rise to increased physical and mental health throughout life. They can exert a positive influence on multiple aspects of brain function and cognition to induce a cascade of molecular and cellular processes that support brain plasticity (Bernardo et al., 2016). Knaepen et al. (2010) showed Brain-derived neurotrophic factor (BDNF) could play a principal role that induces these mechanisms. Exercise and/or training would result in a higher BDNF synthesis following an acute exercise bout. Subsequently, more BDNF could be emitted into the blood circulation which may, in turn, be absorbed more efficiently by central and/or peripheral tissues where it could induce a cascade of neurotrophic and neuroprotective effects.

In educational point of view, exercise might not only help to improve their physical health, but might also improve their academic achievement or other cognitive performance measures (Álvarez-Bueno et al., 2017; Harveson et al., 2019). Especially, aerobic fitness (Marques et al., 2018) and BMI (Bae & Ryou, 2015) are generally associated with academic performance in reading and mathematics of elementary school children. Additionally, several studies have documented a beneficial relationship between physical activity cognition (Álvarez-Bueno et al., 2017). Therefore, these results explain why the school can not neglect various physical activities and physical education subjects.

This study is an attempt to provide teachers and educators with basic data involved the best learnable moment of the students and the significance of any relationship with the positive exercise research. Specifically, we conducted a detailed analysis of the relationship between timing reconstruction curriculum of physical education-mathematics and the brain activation among 4th grade students using EEG. We investigate that physical education class which is the favorite subject of elementary students might bring about improved concentration cognition at the brain area might affect problem-solving ability in the mathematics class which is the unfavorable subject of elementary students. It was hypothesized that physical education would be most associated with mathematics globally related to brain activation.

Methodology

Participants

The participants of present research were the 4th grader in G elementary school in G City, with a total of 33 subjects were included in the experimental group 20 (M: 10, F: 10) and the comparative group 13 (M: 7, F: 6). They were composed only students of right-hander through Edinburgh Handedness Inventory (Oldfield, 1971). All those subjects informed of detailed explanation for EEG, non-invasive features and experimental procedure ahead of performing measurement of brain wave were voluntary participants.

Table 1. Characteristics of participants

Items	Experimental group (20)		Control group (13)	
	Female (10)	Male (10)	Female (6)	Male (7)
Age	10	10	10	10

EG: Experimental Group, CG: Control Group

Measuring Tools and Methods

Creative EEG Measurement Tasks

In this research, we produced gifted-level problems related to the section of ‘mathematics’ in 4th grade, for example ‘Number and Operations, figure, measurement, probability and statistics’, which checked the validity of the problem from two mathematics doctoral students. The task was presented on computer screen as well as the rules of the task was explained through preliminary guideline and main task for EEG measurement in Fig. 1.

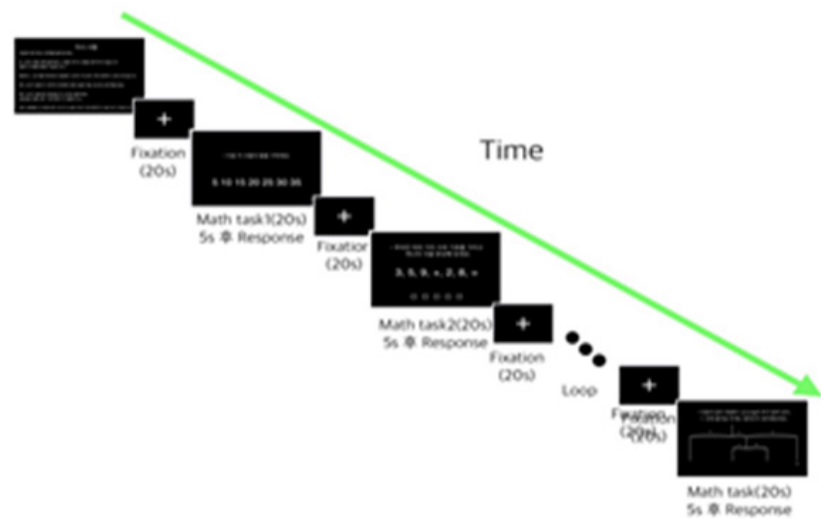


Fig. 1. Presented task paradigm

EEG Measurement Methods

We measured spontaneous background wave under eyes closed/open resting condition and made use of test subjects relevant to normal EEG range to identify. Additionally, we excluded any test subjects with abnormal brain wave from the study. The detailed design is shown in Table 2.

Table 2. Development and design of EEG measurement

Items	Detailed Steps
Development of subject for EEG measurement	① Background EEG measurement ② Solving math problems on the computer screen ③ Voice reply ④ Amendment and supplementation through pilot test
EEG measurement design	① Explanation of measurement cautions and sticking EEG electrodes ② Measuring at rest condition ③ Measuring during solving mathematical problems ④ Electrode removal and scalp washing ⑤ EEG analysis

Table 3. Curriculum design

Items	Experimental group	Control group
Time table (Mon, Wed, Fri : 8 weeks)	Mon, Wed, Fri : PE-Mathematics	Mon: Korean-Mathematics Wed: Morals-Mathematics Fri: Society-Mathematics
Physical education con-tents	Competitive activity (Rugby-style games), Challenging activity (Mat exercises), Expressive activity (Rhythm activity), Leisure activi-ty (Traditional play)	
Mathematics education contents	Addition and subtraction of fractions, Bar graph, Mixed calculation	

In the third class of time table, the experimental group is divided into physical education, and the control group is composed of Korean, social and moral subjects concerning non-physical subject characteristics in general for 8 weeks. The differences in brain activity before and after the experiment were studied by applying one-shot case study and pretest-posttest nonequivalent control group design.

Data Analysis

The current search was intended to confirm difference of neural activation level in physical education-mathematics curriculum of experimental group and non-physical education- mathematics curriculum group. Group analysis was performed in compare with measured EEG data between individual resting condition and Mathematics task performance. We measured the evoked potential (EP) by using E-series EEG system and utilized E-series (Ver 3.4 Release) for the collection of EEG data. Location of EEG measurement was composed of 19 channels based on 10~20 electrode system which is international electrode displacement system. Analysis of nerve activation was made in 8 frequency bands through sLORETA(Standardized Low Resolution Brain Electromagnetic Tomography) technique. We estimated current density count in each voxel after dividing total brain into 6,239 voxels at 5 mm spatial resolution in sequence of computerized SPSS 18.0 program for Windows. In order to analyze to the variance of brain activation of pre and post experiment within same groups paired sample t-test was verified. On the contrary, the analysis of the variance of brain activation between two groups after the experiment was verified as independent sample t-test. The statistical significance for all analysis was set at $\alpha=.05$.

Results

Homogeneity Verification

EEG results were analyzed by independent sample t-test to confirm the homogeneity between the experimental group and the control group. We got 0.099 of the *P* value. In conclusion, there was no significant difference between the two groups in Table 4.

Table 4. Homogeneity verification

Variable	t (0.01)	t (0.05)	t (0.10)	Significance level
Two-Tailed	3.101	2.834	2.238	0.099

The Change of Brain Activation within Groups

The Change of Experimental Group

The experimental task indicates that the pre-placement of the physical education class accompanied by the sports activity and fitness before the mathematics class made effects of the cognitive activity of the students. Mean scores were positively correlated with EEG data ($p < .05$). Specifically, the gamma band activity emerged across the left and right brains, showing predominantly right brain activity in Table 5. Experimental group showed even higher synchronization of neuronal oscillation in total 396 voxels ($5 \times 5 \times 5$ mm) in Gamma band, with 10 left brain and 386 right brain in Table 6.

Table 5. The change of experimental group

Variable	t (0.01)	t (0.05)	t (0.10)	Significance level
Two-Tailed	1.911	1.803	1.747	0.002

Table 6. The results of experimental group brain activation

Maximum activation area		Broadmann area & side	Voxels	MNI coordinates			t-value
				X	Y	Z	
Frontal Lobe	Superior Frontal Gyrus	10R (9,11)	76	25	50	5	2.019*
	Middle Frontal Gyrus	10R (11,46,47)	93	40	40	10	2.016*
	Medial Frontal Gyrus	9R (10,11,32)	62	15	50	10	2.015*
	Inferior Frontal Gyrus	10R (11,13,45,46,47)	96	45	40	15	2.018*
	Orbital Frontal Gyrus	11R (47)	10	15	45	25	1.907
	Precentral Gyrus	44R	1	60	20	10	1.809
	Rectal Gyrus	11R	44	10	45	25	1.850
Temporal Lobe	Superior Temporal Gyrus	22R (38)	25	50	25	15	1.971
	Middle Temporal Gyrus	21R	2	55	10	30	1.821
Limbic Lobe	Anterior Cingulate Gyrus	10R (32)	24	20	45	10	2.017*
Sub-lobar	Extra-Nuclear	47R	1	35	20	0	1.831
	Insula	13R (45)	2	30	25	0	1.906

* $P < .05$

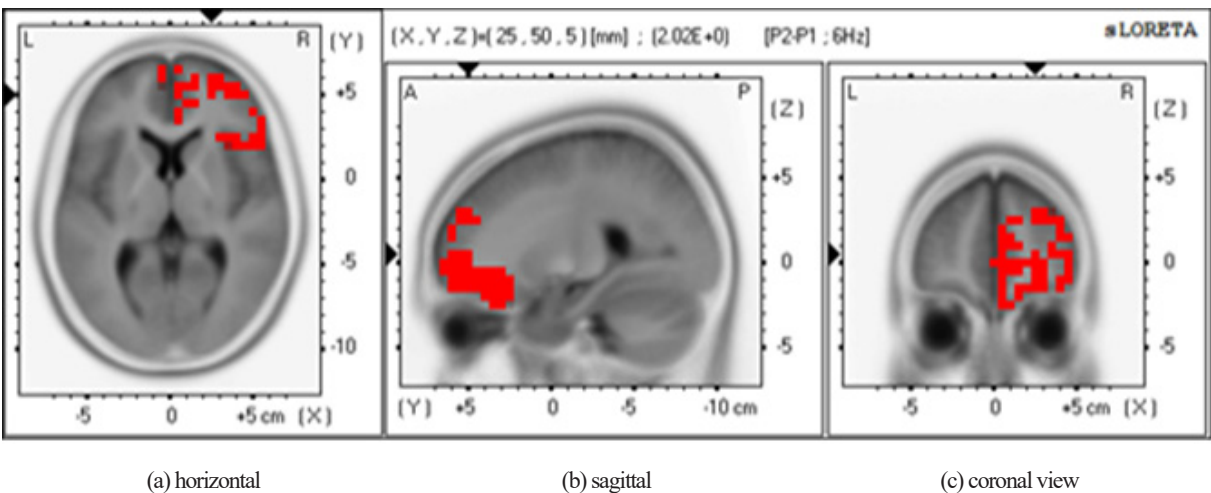


Fig. 2. Brain activation in experimental group during performing the task (Gamma range)

The area where activation of neural current source is the highest was right frontal lobe and main activation area being included in significant level was right the Superior Temporal Gyrus of the temporal lobe, Anterior Cingulate Gyrus of Limbic Lobe and Insula of Sub-lobar in Fig. 2. In case of activation of right temporal lobe, it is relevant to autobiographical memory or theory of mind (ToM). The recent prospective of study in association with ToM with has been documented that all of recognition of memory, identifying disposition of intention, predicting the future and ability of being able to command overall situation are created by works of similar brain networks, it could be realized that even before presenting a task, experimental group showed a strong disposition of trying to identify an intention of experimenter by reflecting episodic memory in their empirical system.

The Change of Control Group

Results of the correlation analyses of control group indicated positive correlation with performing the task ($p < .05$). A significant difference between the pre-post test in the control group that took the math class after the non physical education lesson such as Korean language, Society, and Morals were represented in the gamma band in left hemisphere unlike experimental group in Table 7 and Table 8.

As Fig. 3, the site where activated highly neural current source was left frontal lobe and the area where mainly activated was left the Superior Temporal Gyrus of the temporal lobe, Anterior Cingulate Gyrus of Limbic Lobe and Insula of Sub-lobar. In contrast, the number of voxels ($5 \times 5 \times 5$ mm) with active difference in the gamma band was totally 173 in the left brain, which is relatively narrow compared to the experimental group.

Table 7. The change of control group

Variable	t (0.01)	t (0.05)	t (0.10)	Significance level
Two-Tailed	2.411	2.242	2.105	0.004

Table 8. The results of control group brain activation

Maximum activation area		Broadmann area & side	Voxels	MNI coordinates			t-value
				X	Y	Z	
Frontal Lobe	Superior Frontal Gyrus	9L (10)	21	-20	50	25	2.437*
	Middle Frontal Gyrus	10L (11,46,47)	46	-20	60	25	2.398*
	Medial Frontal Gyrus	9L (32)	6	-20	40	20	2.457*
	Inferior Frontal Gyrus	10L (11,13,45,46,47)	73	-30	30	5	2.412*
	Orbital Frontal Gyrus	47L	1	-20	30	30	2.250*
	Sub Gyrus	10L	1	-40	45	0	2.280*
Temporal Lobe	Superior Temporal Gyrus	38L	13	-45	25	20	2.384*
Limbic Lobe	Anterior Cingulate Gy-rus	32L	5	-15	40	15	2.404*
Sub-lobar	Extra-Nuclear	47L (13)	2	-35	20	0	2.283*
	Insula	13L (45)	4	-30	25	0	2.389*

* $P < .05$

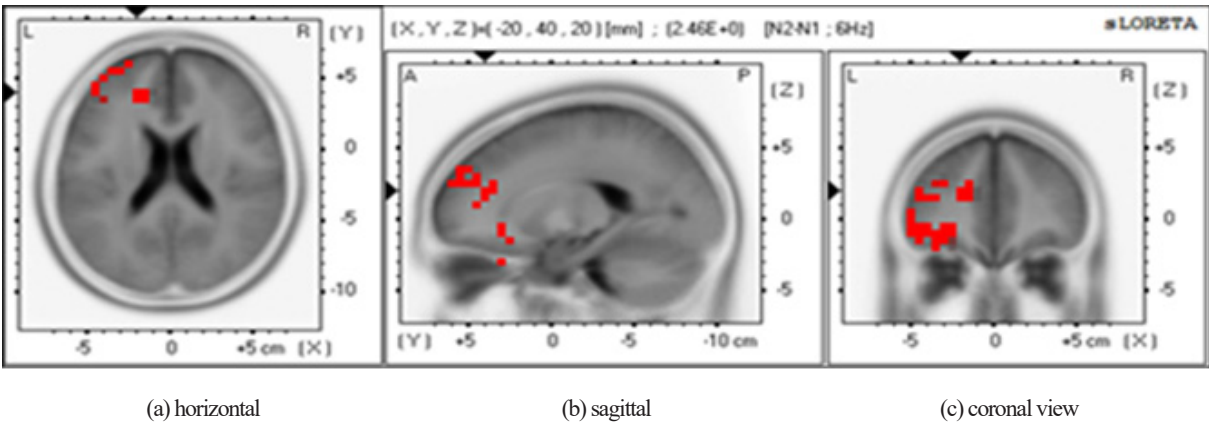


Fig. 3. Brain activation in control group during performing the task (Gamma range)

The Change of Brain Activation between Groups

As shown in the Table 9, the difference of brain activation between groups was positively correlated with the performing the task ($p<.001$). After 8 weeks of reconstruction of curriculum, the right brain activity of the experimental group was significantly higher than that of the control group in gamma bands (30 ~ 50 Hz). On the contrary to that, the left brain resulted in negative activity in the Alpha-2 (10.5-13 Hz) and Beta -2 (Beta 2; 20-30 Hz). The frequency-specific details of changes in brain activity in the PE-MATH group were as follows Table 10, 11 and 12.

Table 9. The difference between two groups after the experiment

Variable	t (0.01)	t (0.05)	t (0.10)	Significance level
Two-Tailed	2.019	1.397	1.282	0.001

Table 10. The difference of brain activation between groups (Alpha-2)

Maximum activation area		Broadmann area & side	Voxels	MNI coordinates			t-value
				X	Y	Z	
Frontal Lobe	Superior Frontal Gy-rus	10L (11,9,8)	140	-25	60	20	-2.020*
	Middle Frontal Gyrus	8L (9,10,11,46,47)	119	-25	60	15	-2.020*
	Medial Frontal Gyrus	10L (8,9,11,46,47)	126	-25	60	15	-2.020*
	Inferior Frontal Gyrus	10L (9,11,13,44,45,46,47)	151	-40	55	5	-2.000*
	Orbital Frontal Gyrus	11L (47)	24	-10	55	20	-1.860
	Precentral Gyrus	44L (6)	12	-60	15	10	-1.580
	Rectal Gyrus	11L	12	-5	55	25	-1.820
	Subcallosal Gyrus	11L	2	-10	25	10	-1.420
	Sub-Gyral	10L	2	-40	45	0	-1.960
Temporal Lobe	Superior Temporal Gyrus	38L (22)	47	-45	25	-20	-1.760
	Middle Temporal Gyrus	21L	8	-55	10	-25	1.530
Limbic Lobe	Anterior Cingulate Gyrus	32L	55	-20	45	10	-1.940
Sub-lobar	Extra-Nuclear	47L (13)	4	-35	20	0	-1.630
	Insula	13L (45)	19	-30	25	0	-1.720

* $P<.05$

The experimental group that a timetable was organized in physical-mathematical order was observed a low brain activity pattern in the alpha-2 band as well as in the areas of the left brain frontal lobe, the Superior Temporal Gyrus of the temporal lobe, Anterior Cingulate Gyrus of Limbic Lobe and Insula of Sub-lobar Table 10 and Fig. 4. Otherwise, the Middle Temporal Gyrus of the temporal lobe showed high brain activity in the left brain.

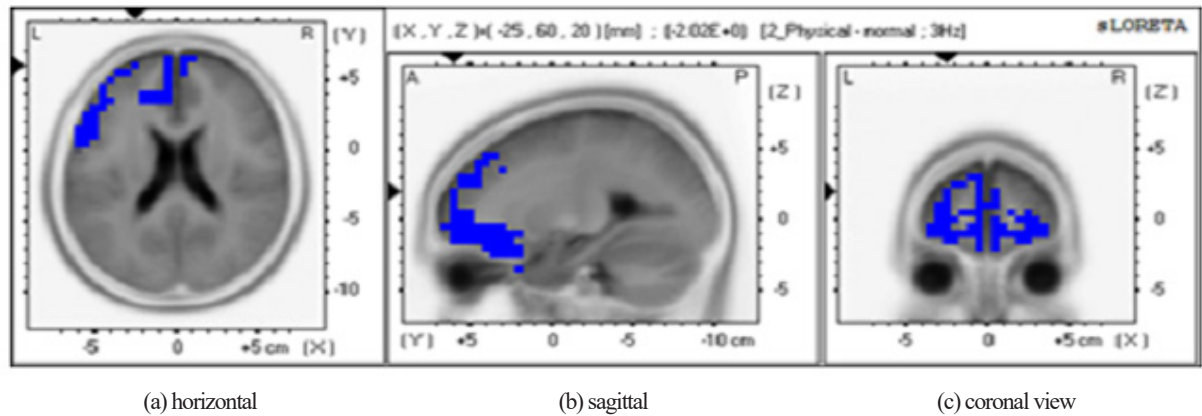


Fig. 4. The difference of brain activation between groups (Alpha-2)

The experimental group exhibited a low brain activity pattern in the Beta-2 band like the Alpha-2 synchronize in the areas of frontal lobe, the Superior Temporal Gyrus of the temporal lobe, Anterior Cingulate Gyrus of Limbic Lobe and Insula of Sub-lobar in the left hemisphere such as Table 11 and Fig. 5.

Table 11. The difference of brain activation between groups (Alpha-2)

Maximum activation area		Broadmann area & side	Voxels	MNI coordinates			t-value
				X	Y	Z	
Frontal Lobe	Superior Frontal Gyrus	10L (8,9,11)	70	-20	55	30	-2.019*
	Middle Frontal Gyrus	10L (6,8,9,11,46,47)	126	-25	50	25	-1.978*
	Medial Frontal Gyrus	9L (10,25,32)	48	-20	40	20	-1.979*
	Inferior Frontal Gyrus	46L (6,9,10,11,13,44,45,47)	172	-35	35	15	-1.840
	Orbital Frontal Gyrus	47L (11)	8	-20	30	-30	-1.680
	Precentral Gyrus	44L (4,6)	42	-60	15	10	-1.609
	Rectal Gyrus	11L	7	-10	35	-20	-1.484
	Subcallosal Gyrus	11L (13)	3	-10	25	-10	-1.458
	Sub-Gyrus	10L (9)	2	-40	45	0	-1.784
Temporal Lobe	Superior Temporal Gyrus	38L (22)	63	-45	25	-20	-1.795
	Middle Temporal Gyrus	21L	12	-50	10	-35	-1.579
Limbic Lobe	Anterior Cingulate Gyrus	32L (10,24)	32	-15	35	20	-1.912
	Cingulate Gyrus	32L	1	-10	30	30	-1.536
Sub-lobar	Extra-Nuclear	47R (13)	6	-35	20	0	-1.714
	Insula	45L (13)	26	-30	25	5	-1.804

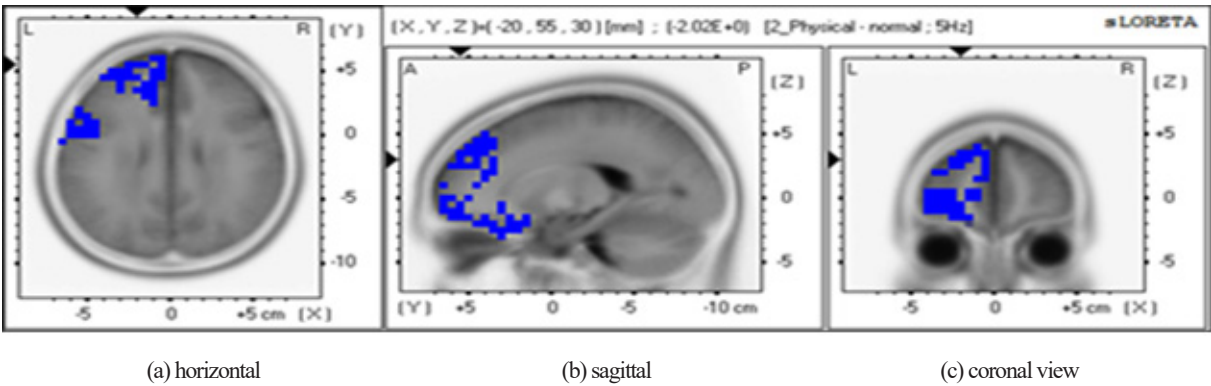


Fig. 5. The difference of brain activation between groups (Beta-2)

On the contrary, there was also centered on the right brain similarly to other frequency bands the difference in the gamma band such as Table 12 and Fig. 6. In the left hemisphere, activation of the brain region similar to that of the comparative group was observed, whereas the frontal lobe of the right hemisphere, the Superior Frontal Gyrus of the temporal lobe and the fusiform gyrus, the Anterior Cingulate Gyrus and Parahippocampal Gyrus of the limb lobe and the Insula of Sub-lobar.

Table 12. The difference of brain activation between groups (Alpha-2)

Maximum activation area		Broadmann area & side	Voxels	MNI coordinates			t-value
				X	Y	Z	
Frontal Lobe	Superior Frontal Gyrus	8R (9,10)	18	15	45	50	1.413
	Middle Frontal Gyrus	6R (9)	20	30	0	50	1.403
	Medial Frontal Gyrus	9R (32)	10	20	40	20	1.421
	Inferior Frontal Gyrus	47R (13,44,45)	46	40	25	-10	1.398
	Precentral Gyrus	44R (6,43)	25	60	10	15	1.406
	Subcallosal Gyrus	34R	1	25	5	-15	1.420
Temporal Lobe	Superior Temporal Gyrus	22R (13,21,38)	98	60	-5	10	1.416
	Middle Temporal Gyrus	21R (38)	48	65	-5	-5	1.445
	Inferior Temporal Gyrus	20R (21)	10	45	-5	-40	1.419
	Fusiform Gyrus	20R	4	50	-5	-30	1.463
	Sub-Gyral	21R	1	40	-5	-10	1.456
	Inferior Frontal Gyrus	13	1	35	10	-15	1.867
Limbic Lobe	Anterior Cingulate Gyrus	32R	2	15	35	20	1.450
	Uncus	28R	1	30	5	-25	1.489
	Parahippocampal Gyrus	34R	1	30	5	-20	1.558
Sub-lobar	Extra-Nuclear	47R(13)	5	35	20	0	1.657
	Insula	13R(45)	50	30	25	0	1.420

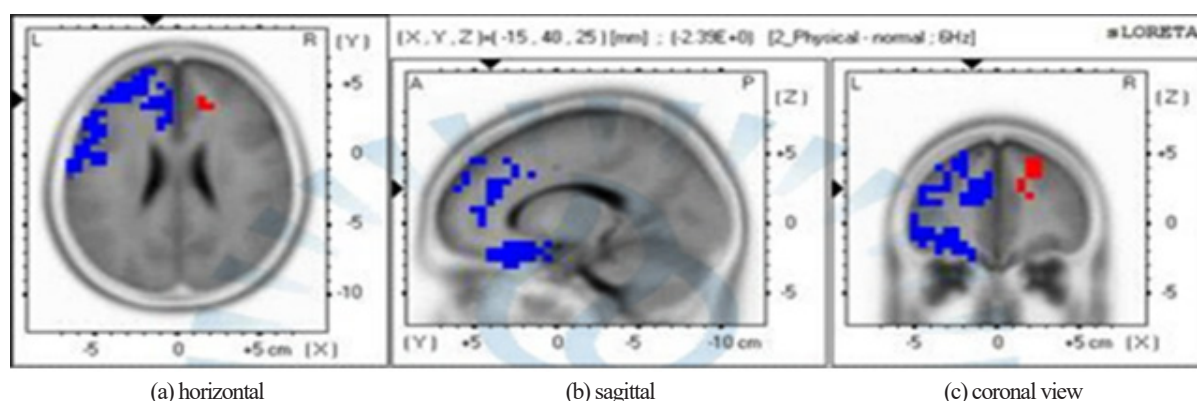


Fig. 6. The difference of brain activation between groups (Gamma range)

Discussion

The major finding of this study is that physical education was related to mathematics performance in forth-grade children on the basis of the notion that children who are physical activities are more likely to improve positive cognitive ability, in agreement with corroborating Cadenas-Sánchez et al. (2016) and Donnelly et al. (2016) study. When this general relationship was decomposed by Mathematics class and type of classes: Physical Education and Non-Physical Education, findings identified that performance on mathematics was related to Physical education. Specifically, the time reconstruction group of Physical education-math was positively active in the Gamma band in the right hemisphere, and Alpha-2 band and Beta-2 band were negatively active in the left one, whereas control group of Non Physical education-Mathematics was observed to given positive activation in the Gamma band in the left hemisphere. When physical education composed of physical activities and movements ends, the effect of exercise does not disappear, but it affects subsequent learning as well. If setting the "suitable time" of learning taken into consideration of the cognitive and biochemical changes as well as biorhythm of the students in the school, it will enhance the interest and achievement of students' learning.

Most of all, brain activity of experimental group revealed prominently in the gamma band of the right brain in comparison with gamma band of left brain in the control group. These findings are of interest for several reasons. In addition to the differences in activity of the cerebral hemispheres, which were clearly revealed in the left and right brains between experimental group and control group, the prominent phenomenon was that in the experimental group in which physical education-mathematics class was conducted, the right precentral gyrus (BA 44), Rectal Gyrus (BA 11), and Middle Temporal Gyrus (BA 21) activities. However, this is not the case for the control group that taught physical education after non-physical education class.

The left brain does a lineal type of processing, a sequential type, while the right brain reveals a global process. Based on the association between the right hemispheric structures with increasing gamma activity when performing tasks requiring a high level of cognitive function, the physical education lessons with physical activity can be classified

insight, intuitive and, analogical thinking. It suggests the brain change to the higher order with the view (Szulc-Lerch et al., 2018). Therefore, it presents the possibility as a training and a method for raising students' intuitive thoughts beyond logical thinking through language. In addition, this tendency is similar to the lateralization of the right hemisphere, which is one of the representative characteristics of the intellectually gifted children's creative thinking process. Students with high intellectual ability showed the increasing level of right hemisphere involvement during cognitive processing (Wei et al., 2020; Zhang et al., 2015). Therefore, it is expected that exercise and physical activity will promote the possibility of giftedness and learning efficiency of general children.

The difference in the number of frontal lobe voxels seen in the experimental group and the control group is about twice that in the physical education class with physical activity. This result might be correlated with Physical education along with physical activity activate the brain more rapidly by stimulating the frontal area of the unactivated brain (F2, F4). Countless associations between mind and body have been documented, and there are reasons to justify physical activity could assist learning (Thosar et al., 2018) Regardless of age, fitness training has been demonstrated to have robust but selective benefits for cognition, with the largest fitness-induced benefits occurring for executive-control processes (Memarmoghaddam et al., 2016).

It is easy to choose expanding the academic class time to develop academic achievement. However, academic performance is not proportional to study time such as math or reading in school. Time spent in physical education does not hinder academic achievement and may even arise an improvement (Álvarez-Bueno et al., 2017). In the case of low-income students, the students who have high momentum attain high grades rather than those who do not have enough momentum (Ratey, 2010). In order to eliminate hierarchical inequalities, education has to find breakthroughs. Although it is difficult to intentionally manipulate the income level of households, low-income students are more likely to increase their grades by increasing their exercise. There seems to be wide agreement with regular physical activity benefits the brains and bodies of school-aged children.

Physical activity in school life enhances concentration in the classroom and performs appropriate actions (Choi et al., 2019; Lee et al., 2019). Thus, active physical activity is important in physical education classes because it provides students with benefits in health, academic achievement, attitudes, and classroom behavior (Watson et al., 2017). Based on such research, we argue that schools need to stop eliminating physical-education programs to make an emphasis on academics and instead to reform the traditional curriculum pattern that employs a wide range of play involving strenuous physical activity for every student. We justify exercise and physical education programs. Physical education and exercise become available for contribution to intellectual development, then they would gain credibility and be justified in Curriculum. This is certainly not the single model for quality curriculum. However, it does suggest the key elements of effective school curriculum reform.

Conclusion

This study is to investigate the impact of mathematics class right after physical education class on the brain activity patterns of elementary school students. For this study, among the 4th graders of G elementary school located in G-city, 20 students in the experimental group (M: 10, F: 10) and 13 students in the comparative group (M: 7, F: 6) were participated in an experiment for 8 weeks and then measured EEG. The results are as follows. First, there was a significant difference in brain activity before and after the experiment in the same group after 8 weeks. Second, in the case of the experimental group, the activity was dominant in the gamma band (30-50 Hz) of the right brain, whereas the left brain showed negative activity in the alpha 2 band (10.5~13 Hz) and the beta 2 band (20~30 Hz). This results show several similarities when compared to the noticeable characteristics of a functional lateralization at the right hemisphere belonging to gifted children in the creative thinking process.

Based on such research, we argue that schools need to stop eliminating physical education programs to make an emphasis on academics and instead to reform the traditional curriculum pattern that employs a wide range of play involving strenuous physical activity for every student. We justify exercise and physical education programs. Physical education and exercise become available for contribution to intellectual development, then they would gain credibility and be justified in Curriculum.

They suggest that designing a learning environment based on how the brain can learn naturally with not complicated but new educational paradigm. Timing reconstruction curriculum which take account of neural mechanisms of a timing system can rich opportunities for learning in the students' everyday routines and planned experience.

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