Effects of Moderate-Intensity Aerobic Exercise in Sportswear on Cardiac and Pulmonary Functions, Including Autonomic Nervous System

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Abstract

Today, most people prefer to wear sportswear while they are exercising. Wearing sportswear not only helps prevent injuries by applying gentle pressure to the muscles and resting muscle tremors, but also helps blood circulation by increasing the supply of oxygen to the muscles. Therefore, this study aimed to determine the improvement effects on the cardiopulmonary vascular system and autonomic nerve function depending on whether sportswear was worn during moderate-intensity exercise. A total of 39 healthy subjects in their 20s, including 18 females and 21 males, participated in the experiment. 9 females wore sportswear, while the other 9 did not; 10 males wore sportswear, while the other 11 did not. The subjects performed two types of exercise: the Master two-step tests were performed for 9 minutes, as well as 50 jumping jacks, 3 times a week for 4 weeks. Immediately after the exercise, subjects were allowed to rest comfortably for 10 minutes, and then electrocardiogram (ECG), pulmonary function, and autonomic nervous system (ANS) measurements were taken. Among the subjects, the group that did not wear sportswear (control group) had an average age of 22.5±1.05, weight of 64.7±23.87 (kg), height of 167.3±8.04 (cm); while the group wearing sportswear (experimental group) had an average age of 22.0±1.16, weight of 54.7±7.32 (kg), height of 161.4±8.46 (cm). The ECG results were statistically significant in the experimental group wearing sportswear, particularly in OCC and QRSD ($p<.001$, respectively). The within-subject effects were also statistically significant in OCC ($p=0.025$) and QRSD ($p=0.011$), indicating that the difference in the average vectors of measurement variables between both groups depending on whether sportswear was worn was caused by that between these two variables. For pulmonary function tests (PFT), the

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results of SVC (p=0.004), IRV (p<.001), FVC (p=.001), and MVV (p=.029) were statistically significant in the experimental group 10 min after exercise. In particular, the results of SVC are considered to be attributed to those of IRV, FVC, and MVV. In terms of changes in the autonomic nervous system, in the experimental group wearing sportswear, Beta waves, which are fast waves, showed a statistically decreasing trend, and Alpha waves, which are basic rhythm waves, showed a statistically increasing trend. Therefore, it is found that wearing sportswear during regular exercise had a positive effect on the control of the ANS, as well as cardiopulmonary function and the control of the parasympathetic nervous system.

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1. Introduction

Cardiovascular disease (CVD) is the leading cause of death throughout the world, with vascular endothelial dysfunction [1] and dysautonomia (or autonomic dysfunction) suggested as major mechanisms that increase the risk of CVD [2]. The occurrence of hypertension, heart failure, and CVD [3, 4, 5, 6] can be predicted based on vascular endothelial dysfunction, an early stage of arteriosclerosis. This dysfunction has been proposed as an important cardiovascular health index because it is closely related to the increase in early mortality from atherosclerosis. The autonomic nervous system (ANS) plays an important role in maintaining the homeostasis of the sympathetic and parasympathetic nervous systems (SNS and PSNS) in response to changes in the external environment. It has been reported that an increase in physical activity can help reduce the risk of heart disease and regulate the ANS [7]. Dysautonomia is known to worsen cardiac function and increase the risk of myocardial infarction and arrhythmia [8]. Regular aerobic exercise improves vascular and autonomic functions [7, 8 9]. In particular, the systemic and pulmonary circulation of blood is achieved through the contraction and relaxation of the myocardium by the heartbeat, through which oxygen and carbon dioxide are exchanged to supply the necessary oxygen to the tissues [10]. Changes in the respiration rate caused by exercise lead to changes in blood pressure and pulse rate (PR) [11]. These days, exercise enthusiasts tend to wear sportswear made of various materials to maximize the effects of exercise by efficiently controlling changes in body temperature and sweat secretion caused by exercise [12]. Compression tights not only help prevent injuries by applying gentle pressure to the muscles and resting muscle tremors, but also increase the supply of oxygen to the muscles, which speeds up blood circulation and increases the body's warm-up and recovery speed, thereby enhancing the effects of exercise [12]. Physical exercise helps reduce the prevalence of chronic degenerative diseases including hypertension, heart disease, diabetes, and arthritis. It was reported that those who exercise were directly related to a reduction in cholesterol and triglycerides, which are cardiovascular risk factors, HDL cholesterol control and decreased blood pressure, and the remission of non-insulin-dependent diabetes mellitus (Type II DM), compared to those who did not [13, 14, 15, 16]. In this study, the functions of the ANS, heart, and lung were evaluated on subjects wearing sportswear. Subjects in their 20s were divided into an experimental group and a control group depending on whether or not they wore sportswear. Two types of exercise were performed: the Master two-step test [17] and jumping jacks. An electrocardiogram (ECG) was performed to monitor changes in the circulatory system of the heart [18]. It recorded the electrical signals generated from the heart while electrodes were attached to certain spots on the body [18]. As exercise causes changes in the ANS, thereby leading to excitement in the SNS, the change in the waveform of the myocardium following exercise was determined by measuring the change in heart rate (HR). Immediately after the exercise, the subjects were allowed to rest for 10 minutes, and changes in the ECG, lung function, and autonomic nervous system were analyzed. As useful indices for evaluating the function of the heart, changes in the following were determined: HR interval to measure one cardiac cycle; T wave generated by repolarization of the heart; PR interval indicating the time from the onset of atrial depolarization to the onset of ventricular depolarization; corrected QT interval representing the time between the onset of ventricular depolarization and the end of ventricular repolarization [19]. Changes in pulmonary function following exercise were measured [20]. In particular, changes in the ANS were checked in order to determine changes in the SNS. Changes in the ANS were measured by attaching electroencephalography (EEG) electrodes to the left and right frontal poles, and pulse wave was also measured simultaneously. Therefore, this study is considered to be used as basic data for motor neurophysiological research.

2. Research Subjects & Methods

2.1. Research Subjects

This study was only conducted on those who wanted to participate in the experiment among students at D university in B region. A total of 39 healthy subjects in their 20s, including 18 females and 21 males, participated in the experiment. The physical characteristics of the participants are shown in Table 1. Of the females, 9 wore sportswear, the remaining 9 did not; for males, 10 wore it, and the remaining 11 did not. A baseline survey of the participants was conducted to ascertain their medical history of CVD, metabolic disease, musculoskeletal disease, and respiratory disease as well as training experience related to the respiratory muscles. Those who had undergone surgery within the last 6 months were restricted from participating in the study. In order to comply with research ethics largely based on the Declaration of Helsinki, 1) we considered the suspension of the trials when safety issues arise, and 2) measures were prepared for the protection of personal information of research participants [21]. After sufficiently explaining the research method and purpose to all participants, the consent of the subjects was obtained, and the experiment was conducted. The research equipment used in this study employs a non-invasive (skin electrode attachment) method, so there is no pain and hassle for the study subjects, and the authors of study scrutinized the safety evaluation certificate of the research equipment and then applied it to the study. Approval to conduct this study was also obtained from the Institutional Review Board (IRB) of Dong-Eui University.

Table 1. Physical characteristics of research subjects

	Age	Body weight(kg)	Height(cm)
A	22.5±1.05	64.7±23.87	167.3±8.04
B	22.0±1.16	54.7±7.32	161.4±8.46

A: control group not wearing sportswear; B: experimental group wearing it

2.2. Moderate-Intensity Aerobic Exercise & Experiment Schedule

The perceived intensity of exercise refers to the psychological or physical burden experienced according to the degree of effort to perform physical activity and exercise. When the perceived intensity at rest is defined as 1, and the maximum capacity one can perform or the highest intensity that one can handle as 10, moderate-intensity exercise refers to the degree to which increases from the average pulse rate of 60-100 beats to 30-50 beats (55-70% of the maximum HR) with a perceived intensity of 5-6 in a state of a slight shortness of breath. In this study, 50 jumping jacks and 9 minutes of the Master two-step test were conducted. The Master two-step test consisted of climbing up and down the stairs for 9 minutes 3 times a week. The two-step stairs designed by Master consisted of 2 steps with 22.5 cm (9 inches) high, 25 cm (10 inches) deep, and 60 cm (24 inches) wide per step [22]. The number of steps used in this study was 2, with each step 23cm high and 25cm wide. Climbing up and down the stairs was maintained at a constant speed by performing it three times in a row for 3 minutes each in accordance with the speed of the metronome. The number of ascents and descents according to the speed of the metronome was calculated using the following equation.

Method of calculating the number of ascents and descents according to the speed of the metronome

$Y = M \times 60/90 \times 5$,

where Y is the number of clicks of the metronome per minute;

M is the number of times for 90 seconds;

5 is the number of steps when ascending and descending 5 steps one way [22].

To meet the criteria for moderate-intensity exercise, a pulse wave meter was worn and jumping jacks were directly performed. When 50 jumping jacks were performed at a speed of 125bpm, the subjects' PR increased by 30-50 beats on average, which was confirmed to fall under the category of moderate-intensity exercise. In performing jumping jacks, the distance between legs apart was maintained at shoulder width, and the jumping height at about 10 cm. The method of implementation was as follows: first, as you jump lightly, spread both legs to about shoulder-width apart, and at the same time stretch both arms out in a circular motion and over your head, and bring them to the ears with the palms facing each other; second, 50 repetitions were continuously performed from the starting position.

2.3. Cardiopulmonary and Autonomic Nervous System

The subjects were allowed to rest for 10 minutes immediately after exercise, and then measurements were taken in the order of their ANS (measured for about 3 minutes), ECG, and pulmonary function. For ECG measurement, a cardiopulmonary function measuring device (Bionet Cardio Touch3000, Korea) was used. A standard 12-lead ECG was recorded at 25mm/sec with a gain setting of 10mm/mV. P wave, QRS complex, T wave, PQ segment, RR interval, PR interval, QRS interval, and QTc [23] were measured from bipolar lead II in recording the standard 12-lead ECG. Pulmonary functions were measured using a portable spirometer (Bionet CardioTouch3000, Korea), including slow vital capacity (SVC), inspiratory reserve volume (IRV), expiratory reserve volume (ERV), tidal volume (TV), forced vital capacity (FVC), and maximal voluntary volume (MVV) [24]. Changes in the ANS were measured by attaching EEG sensors to the left and right frontal poles (Fp1, Fp2) of the frontal lobe. A pulse wave sensor was attached to the tip of the right ring finger to measure the pulse wave signal in the peripheral blood vessels [25].

2.4. Statistical processing

The number of subjects in the experimental group wearing sportswear and the control group not wearing it were 18 and 21, respectively, and the experiment was repeated 4 times for the results of 12 sessions over 4 weeks. The number of measurement variables for each category of ECG, pulmonary function, and ANS was as follows: 8 (P wave, QRS complex, T wave, PQ segment, PR interval, one cardiac cycle (OCC), QRS deviation (QRSD), corrected QT (QTc)); 8 (SVC, ERV, IRV, expiratory capacity (EC), TV, functional residual capacity (FVC), forced expiratory flow (FEF), MVV); and 10 (left high beta wave (LHB), left middle beta wave (LMB), left low beta wave (LLB), left alpha wave (LA), left theta wave (LTh), right high beta wave (RHB), right middle beta wave (RMB), Right Low Beta wave (RLB), Right Alpha wave (RA), Right Theta wave (RTh)). These were processed using multivariate analysis techniques. For statistical significance, longitudinal data analysis was used through repeated measures. In this study, statistical analysis was performed using repeated measures multivariate analysis of variance (RM-MANOVA). Here, the RM-MANOVA approach was considered because it is suited for experimental design where the multiple groups of participants are being compared repeatedly (RM) on the multiple measures (MANOVA) of interest [26]. The analytic model (i.e., RM-MANOVA) was applied to all three modules divided according to the experimental design: ECG 10 min after exercise, PFT 10 min after exercise, ANS 10 min after exercise. All data were analyzed using SPSS Statistics Version 26.0.

3. Results & Discussion

The analysis results for the three modules were presented in the following order: electrocardiogram 10 min after exercise (ECG-10), pulmonary function tests 10 min after exercise (PFT-10), and autonomic nervous system 10 min after exercise (ANS-10). Analysis results of ECG-10 and PFT-10 modules are suggested in the order of multivariate F tests, tests of within-subject effects (including comparison results between repeated measures), tests of between-subjects effects, and profile plots. Those of the ANS-10 module were presented in the order of multivariate F tests, tests of between-subjects effects, and profile plots. The within-subject effects were to determine whether there was variability in the dependent variables according to repeated measures, and an interaction between the experimental or the control group and the repeated measures. The between-subjects effects represented the variability in dependent variables between the experimental and control groups.

3.1. Electrocardiogram 10 Min After Exercise (ECG-10)

The results of multivariate F tests are summarized in Table 2. There was a significant difference between the mean vectors of all 8 variables depending on whether sportswear was worn ($F(8, 30) = 3.496$, $p = 0.006$). The variation of 8 variables according to repeated measures was significant ($F(24,14) = 6.555$, $p < .001$). Since the variation over time between both groups depending on whether sportswear was worn was not significant, there were no interaction effects between repeated measures and both groups. That is, the variation over time between the two groups depending on whether sportswear was worn was found to be similar.

Table 2. Multivariate F tests of effects between- and within-subjects for ECG-10

Effect		Value**	F	Hypothesis df	Error df	p-value
Between-subjects (groups)		0.482	3.496	8	30	0.006
Within-subjects	rep*	0.918	6.555	24	14	0
	rep*group	0.57	0.774	24	14	0.719

* rep: repetition
** value: based on Wilk's lambda

The results of tests of within-subject effects are as follows. By conducting Mauchly's Test of Sphericity, it was found that QRS, PR, QRSD, and QTc did not meet the sphericity assumption. The variables were corrected for degrees of freedom using methods such as Greenhouse-Geisser, Huynh-Feldt, and Lower-bound, and the final results are presented in Table 3 below; as there were no interaction effects, only those related to repeated measures among within-subject effects are presented.

Table 3. Univariate F tests of within-subject effects for ECG-10

Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
P wave	498.352	3	166.117	.490	.690
QRS complex*	563.858	1.701	331.426	.563	.545
T wave	986.813	3	328.938	.278	.842
PQ segment	1330.647	3	443.549	.871	.458
PR interval *	1644.500	2.092	786.256	2.560	.081
OCC	122149.403	3	40716.468	6.614	.000
QRSD*	3944.071	2.135	1847.706	15.812	.000
QTC*	2711.077	1.368	1981.518	1.798	.185

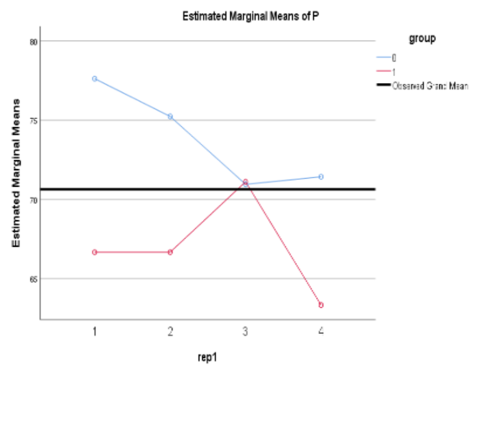
* Measures that do not meet the sphericity assumption. We just present the Greenhouse-Geisser correction method. However, alongside the Greenhouse-Geisser method, Huynh-Feldt, Lower-bound corrections are also checked. Unless otherwise stated, three methods indicate the same significance flag. Abbreviation: OCC (one cardiac cycle); QRSD (QRS deviation); QTc (corrected QT)

Based on the analysis, the variation according to repeated measures was statistically significant in OCC and QRSD ($p<.001$, respectively). The variation in OCC during moderate-intensity exercise is considered to be caused by changes in ventricular function. A contrast analysis between repeated measures showed significant differences between the second and third measures, and between third and fourth measures for QRSD, while no significant difference was found between time points of measures for OCC. For QRSD, which represented the time from the onset of the P wave to the onset of the QRS complex, it is judged that moderate-intensity exercise affected the depolarization times of the atria and ventricles.

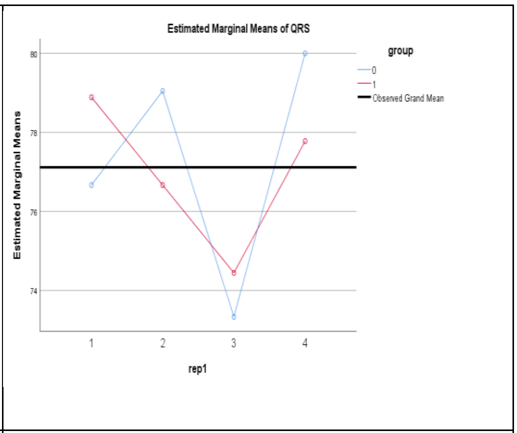
The results of tests of between-subjects effects are presented in Table 4. Similar to the results of tests of within-subject effects, those of tests of between-subjects effects were found to be significant only in OCC ($p=0.025$) and QRSD ($p=0.011$). It can be seen that the difference in the mean vector of measurement variables between the experimental and control groups was caused by that between these two variables. This is interpreted as having the same implication as the results in Table 3.

Table 4. Univariate F tests of between-subjects effects for ECG-10

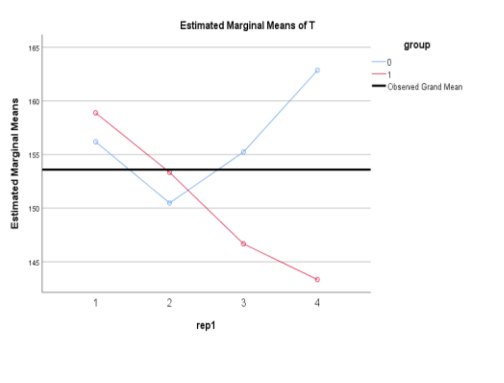
Measure	df	Mean Square	F	Sig.
P wave	1	456.792	1.647	.207
QRS complex	1	.977	.002	.965
T wave	1	307.753	.366	.549
PQ segment	1	7.387	.022	.882
PR interval	1	96.463	.873	.356
OCC	1	23796.197	5.450	.025
QRSD	1	458.907	7.177	.011
QTC	1	49.154	.132	.719



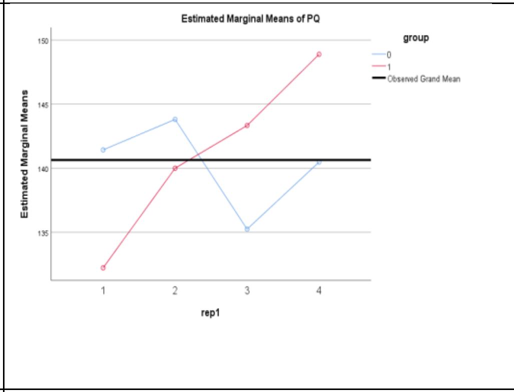
P wave



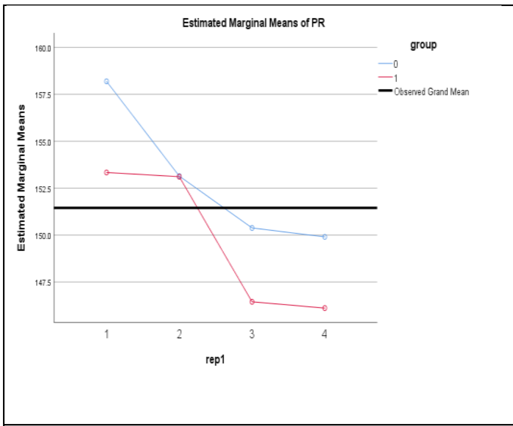
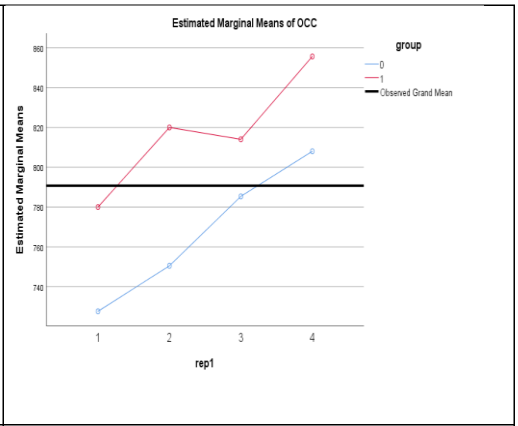
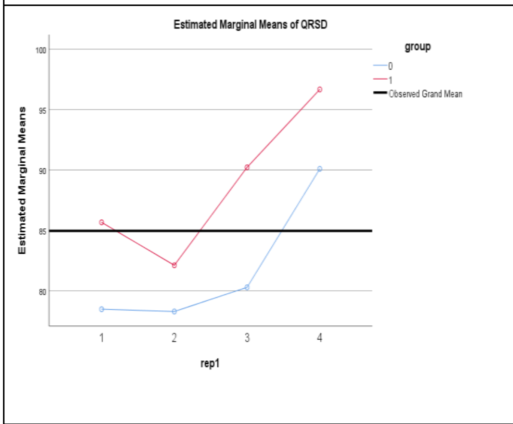
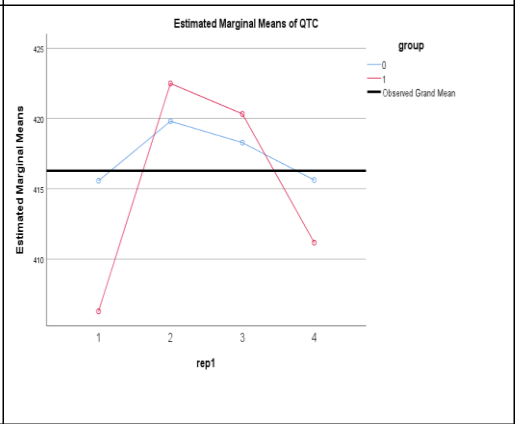
QRS complex



T wave



PQ segment

	
PR interval	QCC
	
QRSD	QTC

0: Control group not wearing sportswear; 1: Experimental group wearing sportswear

Figure 1. Profile plots of changes in ECG waveforms depending on whether sportswear was worn

Figure 1 shows the result of analysis of the ECG waveform of the exercise performed for 4 weeks. Variations in the PQ interval, OCC, and QRSD results were found in the experimental group wearing sportswear through 4 repeated measures. This is judged to be the result of a change in the cardiac cycle caused by changes in the ventricles.

3.2. Pulmonary Function Test 10 Min After Exercise (PFT-10)

The results of multivariate F tests are summarized in Table 5. The difference between the mean vectors of all 8 variables depending on whether sportswear was worn was found to be significant (F(8, 30)=6.695, p<.001). The variation of 8 variables according to repeated measures was significant (F(24,14)=4.950, p=.002). The variation over time between both groups depending on whether sportswear was worn was not significant, so there were no interaction effects between repeated measures and both groups. In other words, it can be said that the variation over time between the two groups depending on whether sportswear was worn was similar

Table 5. Multivariate F tests of effects of between- and within-subjects for PFT-10

Effect		Value**	F	Hypothesis df	Error df	p-value
Between-subjects (groups)		.359	6.695	8	30	.000
Within-subjects	rep*	.105	4.950	24	14	.002
	rep*group	.211	2.186	24	14	.065

* rep: repetition
** value: based on Wilk's lambda

The results of tests of within-subject effects are as follows. According to Mauchly's Test of Sphericity conducted, all variables other than ERV and EC did not satisfy the sphericity assumption. The variables were corrected for degrees of freedom using methods such as Greenhouse-Geisser, Huynh-Feldt, and Lower-bound, and the final results are presented in Table 6 below; as there were no interaction effects, only those related to repeated measures among within-subject effects are presented.

Table 6. Univariate F tests of within-subject effects for PFT-10

Measure	Type III Sum of Squares	df	Mean Square	F	Sig.
SVC*	16.592	2.138	7.762	5.659	.004
ERV	4.949	3	1.650	2.417	.070
IRV*	12.555	2.074	6.055	21.001	.000
EC	.847	3	.282	.272	.846
TV*	.070	2.208	.032	.975	.388
FVC*	4.149	1.804	2.301	8.382	.001
FEF*	4.476	1.985	2.255	2.208	.118
MVV*	738.672	1.338	552.162	4.475	.029

* Measures that do not meet the sphericity assumption. We just present the Greenhouse-Geisser correction method. However, alongside the Greenhouse-Geisser method, Huynh-Feldt, Lower-bound corrections are also checked. Unless otherwise stated, three methods indicate the same significance flag. Abbreviation: PFT: Pulmonary function test; SVC: Slow vital capacity; ERV: Expiratory reserve volume; IRV: Inspiratory reserve volume; EC: Expiratory capacity; TV: Tidal volume; FVC: Functional residual capacity, FEF: Forced expiratory flow, MVV: Maximal voluntary volume.

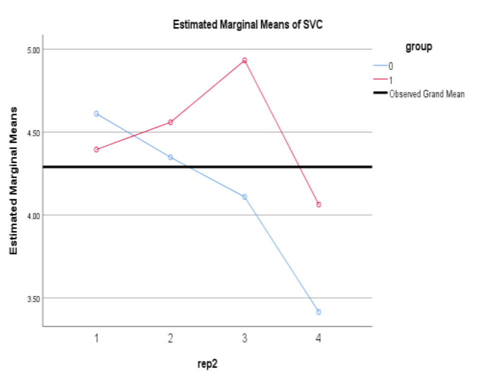
Based on the analysis, the variation according to repeated measures was statistically significant in SVC (p=0.004), IRV (p<.001), FVC (p=.001), and MVV (p=.029). When contrast analysis between repeated measures was performed on the four variables, it was found that the three variables (SVC, IRV, FVC) had a significant difference between the third and fourth measures. For MVV, there was a significant difference between the second and third measures.

The results of tests of between-subjects effects are presented in Table 7. Significant differences were observed between the groups in three variables (ERV, EC, and TV) that were not statistically significant in within-subject effects (p-values are 0.037, 0.033, 0.047, respectively).

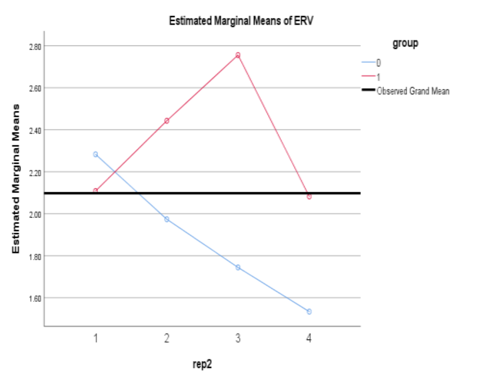
Table 7. Univariate F tests of between-subjects effects for PFT-10

Measure	df	Mean Square	F	Sig.
SVC	1	1.304	2.950	.094
ERV	1	2.083	4.663	.037
IRV	1	.364	2.674	.110
EC	1	2.822	4.886	.033
TV	1	.043	4.210	.047
FVC	1	.108	.347	.560
FEF	1	3.241	2.346	.134
MVV	1	2.670	.019	.892

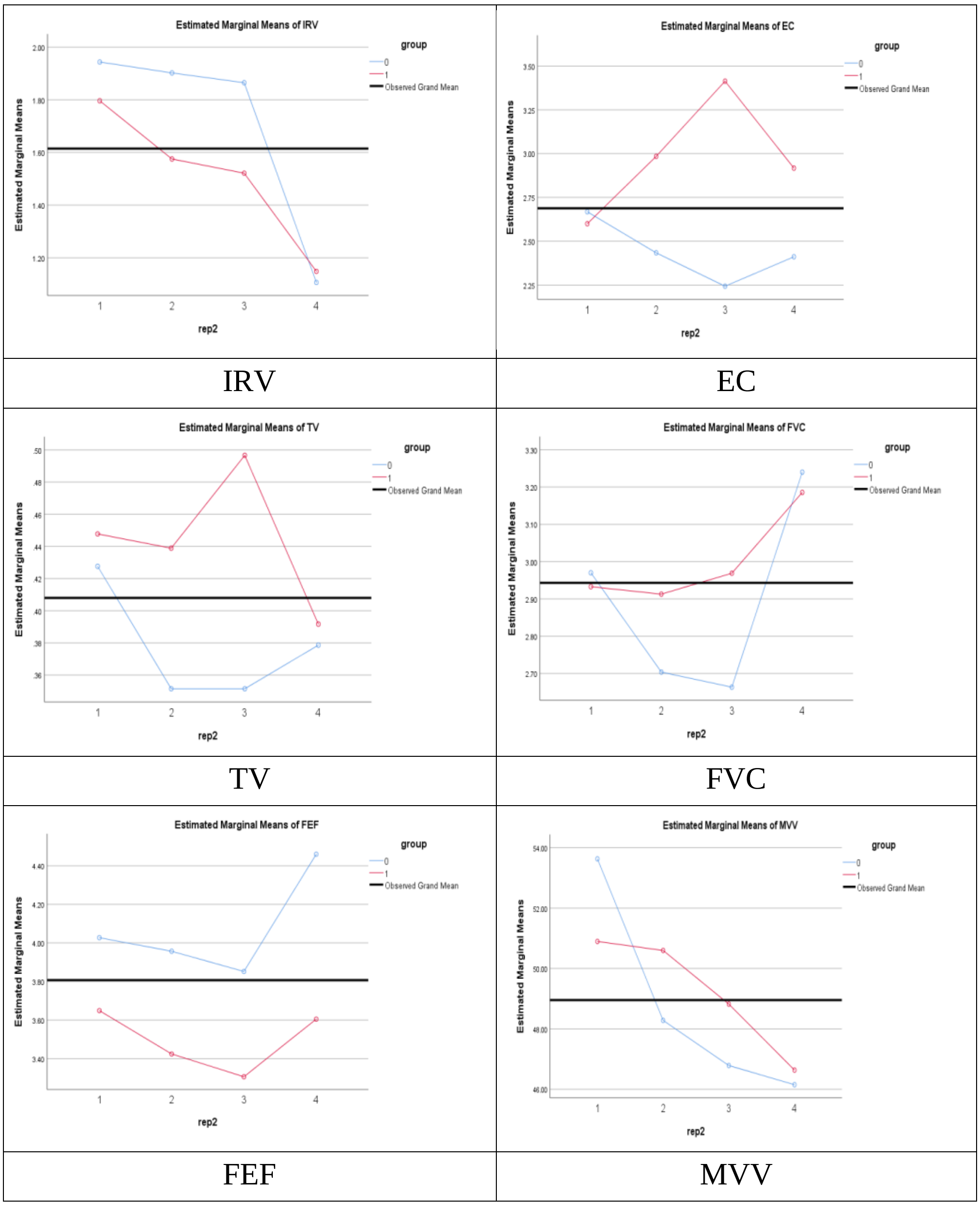
Abbreviation: SVC: Slow vital capacity; ERV: Expiratory reserve volume; IRV: Inspiratory reserve volume; EC: Expiratory capacity; TV: Tidal volume; FVC: Functional residual capacity; FEF: Forced expiratory flow; MVV: Maximal voluntary volume.



SVC



ERV



0: Control group not wearing sportswear; 1: Experimental group wearing sportswear

Figure 2. Profile plots of pulmonary function variables depending on whether sportswear was worn

The results of SVC in pulmonary function tests, which are attributed to the results of IRV, FVC, and MVV, showed a change in the volume of lung capacity in the experimental group wearing sportswear based on repeated measures for 4 weeks. This is considered to show a change in the volume in lung capacity as well as that in the function of the ventricle, similar to the result of the ECG.

3.3. Autonomic Nervous System 10 Min After Exercise (ANS-10)

The results of multivariate F tests are summarized in Table 8. The difference between the mean vectors of all 10 variables depending on whether sportswear was worn was statistically significant (F(10, 28)=4.699, p=.001). The variation of 10 variables according to repeated measures was not statistically significant. The variation over time between the experimental and control groups was not statistically significant, either, and there were no interaction effects between repeated measures and the groups. Therefore, only the results of tests of between-subjects effects and profile plots are presented in this section.

Table 8. Multivariate F tests of effects of between- and within-subjects for ANS-10

Effect		Value**	F	Hypothesis df	Error df	p-value
Between-subjects (groups)		.373	4.699	10.000	28.000	.001
Within-subjects	rep*	.119	1.966	30.000	8.000	.160
	rep*group	.242	.836	30.000	8.000	.666

* rep: repetition
** value: based on Wilk's lambda

The results of tests of between-subjects effects are presented in Table 9. There were no between-subjects effects in all variables except LA(p=.026) and RLB(p=.011).

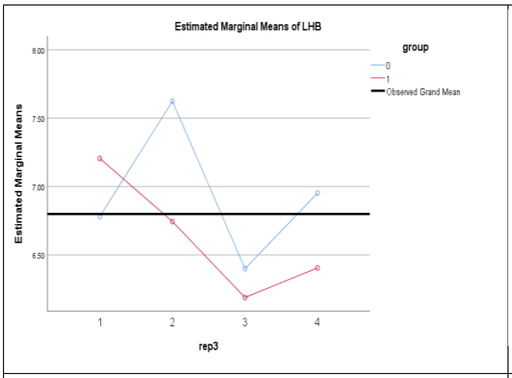
High Beta waves are brain waves predominantly expressed in the band of 20-29.9 Hz when emotional stress or anxiety is felt; Middle Beta waves (15-19 Hz) are expressed when conscious activities including learning and calculation are conducted; Low Beta waves (12-14.9 Hz) are expressed in a state of recognizing the surroundings; Alpha waves (8-11.9 Hz) are expressed in a state of wakeful relaxation; and Theta waves (4-7.9 Hz) are expressed in deep rest and sleep.

Table 9. Univariate F tests of between-subjects effects for ANS-10

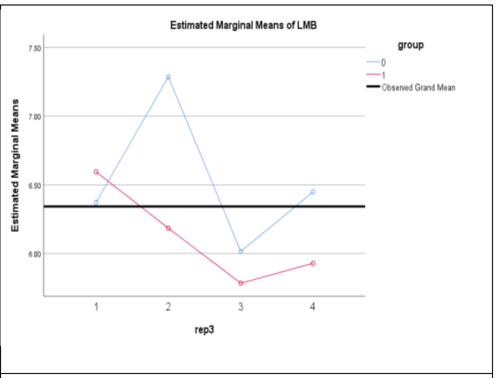
Measure	df	Mean Square	F	Sig.
LHB	1	.891	1.048	.313
LMB	1	1.610	1.895	.177
LLB	1	2.444	2.993	.092
LA	1	1.961	5.402	.026
LTh	1	1.877	2.571	.117
RHB	1	1.980	2.345	.134
RMB	1	2.712	3.886	.056
RLB	1	5.354	7.220	.011
RA	1	.718	1.974	.168

RTh	1	.029	.036	.851

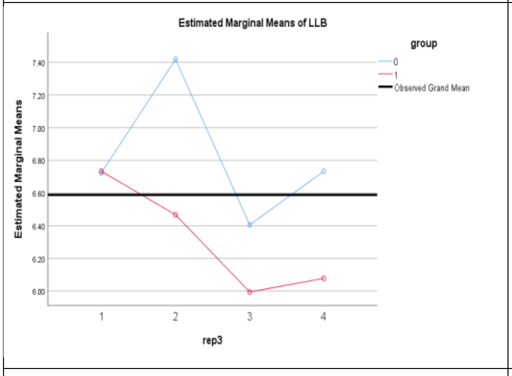
Abbreviation: LHB: Left High Beta wave; LMB: Left Middle Beta wave; LLB: Left Low Beta wave; LA: Left Alpha wave; LTh: Left Theta wave; RHB: Right High Beta wave; RMB: Right Middle Beta wave; RLB: Right Low Beta wave; RA: Right Alpha wave; RTh: Right Theta wave.



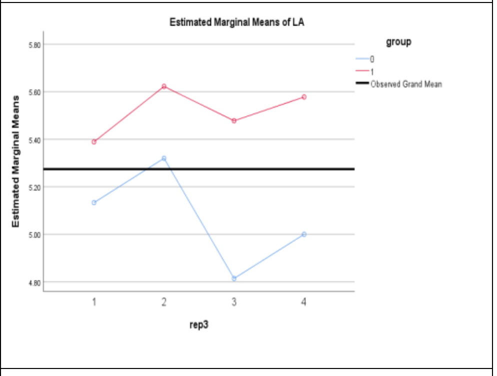
LHB



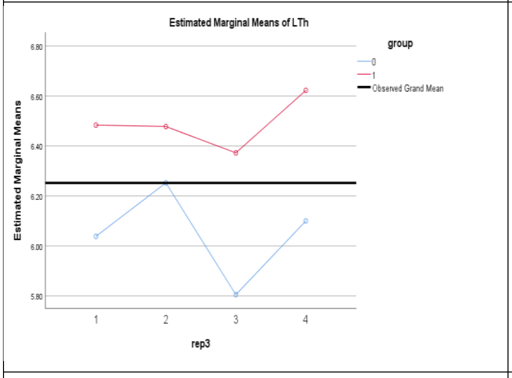
LMB



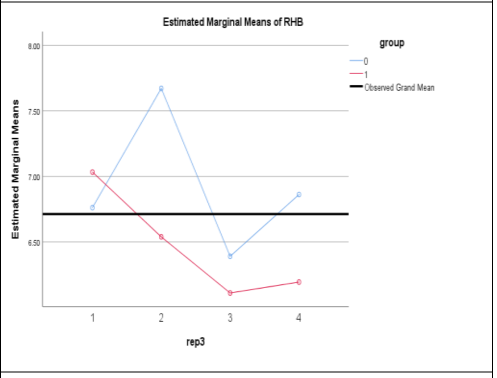
LLB



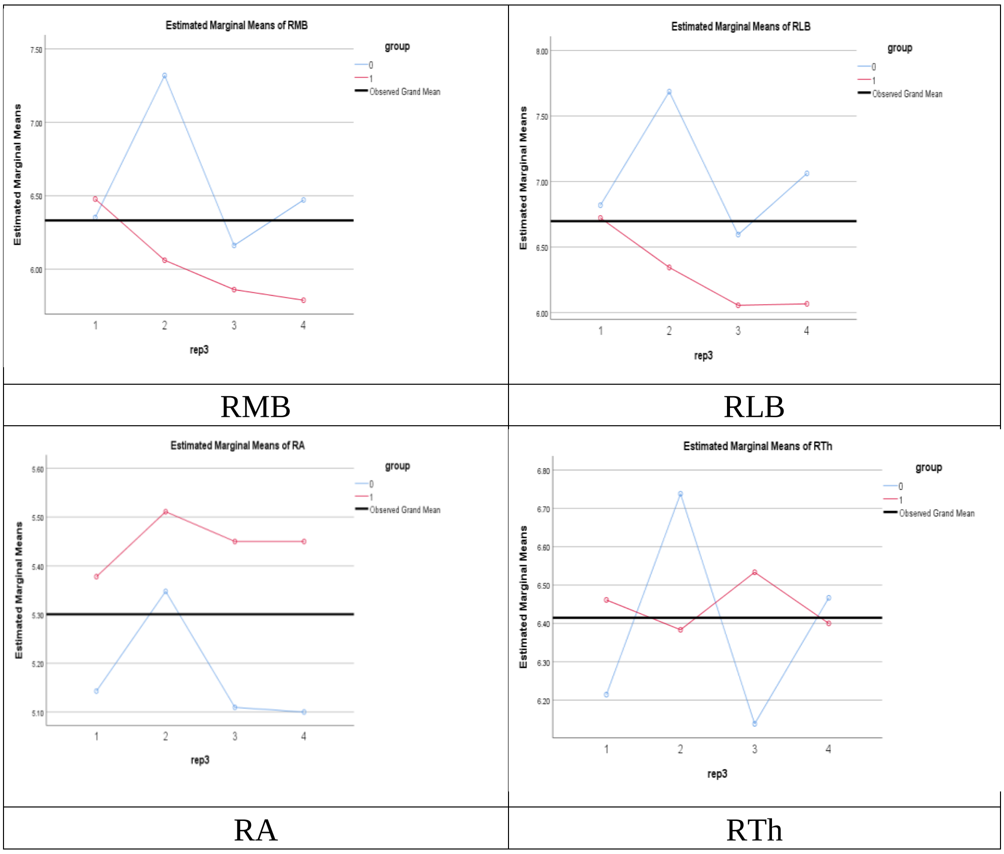
LA



LTh



RHB



0: Control group not wearing sportswear; 1: Experimental group wearing sportswear

Figure 3. Profile plots of brain waves in the left and right frontal poles depending on whether or not sportswear was worn

Changes in the ANS are considered to show a tendency to decrease in fast waves and have a stabilizing and sedating effect. Similar to the findings of previous studies that conducted moderate-intensity aquatic exercise [27], the Alpha waves increased. It is thought that, immediately after exercise, Beta waves increase and brain activity increases, and then depression or a calming effect appeared as the stable state was quickly restored. Brain waves are measured as sine wave complexes that appear variously in different frequencies; when neuronal synchrony increases, low-frequency is activated, and when it decreases, high-frequency is activated [28]. The effect of physical exercise was confirmed in the frontal area of the brain, and it can be said that stimulation through exercise is related to the development of the frontal lobe and brain health. Recent research has found that changes in brain waves through physical exercise can improve concentration, leading to the reinforcement of learning and cognitive abilities [29, 30].

It is considered that wearing sportswear during regular exercise not only improved physical health, but also improved mental health, reduced anxiety and depression, and strengthened the autonomic nervous system. As a result, it was found that exercising in sportswear has a positive effect on the control of the ANS and cardiac and pulmonary functions, as well as a tendency to slightly increase the activity of the PSNS, compared to exercising without sportswear.

4. Conclusion

This study observed the contraction and relaxation of the heart and the exchange of oxygen and carbon dioxide in the lungs by applying a more standardized method when regular moderate-intensity exercise was performed while wearing sportswear. Changes in the autonomic nervous system were investigated to indirectly confirm peripheral control functions of the heart and lungs. In particular, it was confirmed that the QTc change of bipolar induction II, which reflects the electrocardiographic direction of the heart, tends to be prolonged as the continuous exercise is performed. Medium-intensity exercise induces contraction and elongation of actin and myosin [31] to adapt to the load on the heart, and through this, an increase in the oxygen demand of myocardial cells can be expected. In the case of pulmonary function, it is interpreted that an active response is made for carbon dioxide emission from the lungs due to the relative increase in the maximum ventilation capacity. The increase in hemoglobin bicarbonate for the neutralization of carbon dioxide [32] is thought to have achieved the activation of the sympathetic nervous system for the equilibrium of the autonomic nervous system. It is known that the control tower of human movement is the parietal and frontal regions of the cerebrum. As a result, it is thought that the fast waves of the left and right cerebrum were generally activated. In conclusion, regular moderate-intensity exercise can be used as an auxiliary data for changes in the autonomic nervous system in patients with heart and lung disease.

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