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Scores of Fatigue Complaints in High School Students in Physical Education Classes

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Abstract

This study was undertaken to give scientific basis in introducing exercise into our daily lives. Fatigue scores, the Flicker value, the counter value, grip strength and counting steps were analyzed in 109 female high school students before and after physical education classes during the third school period. These female students were chosen because of their lower fatigue scores, particularly before lunch time. Fatigue scores were obtained in tumbling exercises, softball, badminton, team handball, basketball and a 2.2-km distance run during 50-min classes. Step-counting activities were the lowest in tumbling with 640 steps, and the highest in the 2.2-km distance run with 2,580 steps. In all activities except the distance run, fatigue scores decreased, and the Flicker value and the counter value increased after exercise. Grip strength decreased only in softball and the distance run. In the distance run, all measurements of the tests showed tendencies toward fatigue. However, with lighter exercises, the fatigue scores decreased by 1,760 steps; also, the Flicker value and the counter value showed improvement of physical function. Therefore, it is suggested that exercise having around 1,760 steps, corresponding to approximately 35 steps/min, might be the upper limit of physical load at which fatigue symptoms increase in a physical education class. Physical activities in the physical education classes showed two types of effects: recreational effects and training effects.

KEYWORDS: physical education class, fatigue score, Flicker value, counter value, grip strength

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Scores of Fatigue Complaints in High School Students in Physical Education Classes

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This study was undertaken to give scientific basis in introducing exercise into our daily lives. Fatigue scores, the Flicker value, the counter value, grip strength and counting steps were analyzed in 109 female high school students before and after physical education classes during the third school period. These female students were chosen because of their lower fatigue scores, particularly before lunch time. Fatigue scores were obtained in tumbling exercises, softball, badminton, team handball, basketball and a 2.2-km distance run during 50-min classes. Step-counting activities were the lowest in tumbling with 640 steps, and the highest in the 2.2-km distance run with 2,580 steps. In all activities except the distance run, fatigue scores decreased, and the Flicker value and the counter value increased after exercise. Grip strength decreased only in softball and the distance run. In the distance run, all measurements of the tests showed tendencies toward fatigue. However, with lighter exercises, the fatigue scores decreased by 1,760 steps; also, the Flicker value and the counter value showed improvement of physical function. Therefore, it is suggested that exercise having around 1,760 steps, corresponding to approximately 35 steps/min, might be the upper limit of physical load at which fatigue symptoms increase in a physical education class. Physical activities in the physical education classes showed two types of effects: recreational effects and training effects.

Key words: physical education class, fatigue score, Flicker value, counter value, grip strength

Health promotion is the ultimate goal of physical exercise in the current understanding of preventive medicine. Exercise is important to increase our fitness level, and to prevent adult diseases (1-3). Therefore, it is beneficial to approach exercise positively in our daily lives.

Exercising reduces complaints related to fatigue (4). Thus, we have been surveying symptoms related to fatigue (5) as a means of analyzing complaints. This survey was designed to evaluate industrial fatigue. Later, this fatigue survey was used for analysis of fatigue caused by physical exercise to better understand the effects of physical exercise on health (4, 6).

However, to analyze the effects of exercise on physical function, it is necessary to use a standard criterion as well as using a combination of subjective and objective indices of fatigue. Therefore, several studies have been done in which the effects of physical exercise were analyzed using either subjective or objective indices (7-9). No research, however, has been done on the effects of different types of exercises using both subjective and objective indices related to fatigue.

The present study was done to analyze the effects of several types of exercise using both subjective and objective indices related to fatigue, which included the fatigue scores of complaints, the Flicker value, the counter value in counting with thumbs, and grip strength.

Subjects and Methods

Complaints related to fatigue in daily lives, which we refer to in this research as fatigue scores, were obtained from 20 male and 27 female high school students whose average age was 15.7 years old. Subjects were selected from healthy students who had no abnormal findings in

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Table 1 Questionnaire of symptoms related to fatigue

Group I		Group II		Group III	
Symptom number ^a	Drowsiness and dullness	Symptom number ^a	Difficulty of concentration	Symptom number ^a	Projection of physical disintegration
1	Head feeling weary	11	Feeling distracted	21	Headaches
2	Feeling exhausted	12	Feeling uncommunicative	22	Stiff neck
3	Legs feeling tired	13	Feeling irritated	23	Backaches
4	Feeling like yawning	14	Feeling restless	24	Difficulty in breathing
5	Feeling mentally sluggish	15	Feeling a loss of interest	25	Dry mouth
6	Feeling sleepy	16	Feeling of forgetfulness	26	Hoarse voice
7	Eyes feeling tired	17	Making many mistakes	27	Feeling dizzy
8	Feeling uncoordinated	18	Feeling worried	28	Eyes twitching
9	Feeling unsteady on one's feet	19	Feeling unable to be still	29	Hands and legs trembling
10	Feeling like lying down	20	Feeling impatient	30	Feeling sick

^a: Each fatigue symptom has each number.

routine medical checkups. The assessment of fatigue symptoms was based on the fatigue scale of the Japanese Industrial Fatigue Research Committee (Table 1) (5).

Students were asked to answer 10 questions in each of the following three symptom groups: Group I, drowsiness and dullness; Group II, difficulty of concentration; and Group III, projection of physical disintegration. Fatigue scores were graded on a scale of 0-3, with 3 representing a high level of fatigue. Fatigue scores were checked seven times a day: upon waking (average waking time of male students was 6:35 a.m. and of female students was 6:46 a.m.); at 8:20 a.m. before the first lesson started; at 10:10 a.m. after the second lesson; at 12:10 p.m. before lunch; at 2:50 p.m. after the 6th lesson; at 6:00 p.m. before dinner; and at bedtime. The average bedtime of male students was 0:26 a.m. and of female students was 0:23 a.m..

Changes in fatigue scores, the Flicker value, the counter value, grip strength and counting steps were analyzed on 109 female high school students before and after a 50-min physical education class in the third school period. These students were offered the same instruction by one teacher for each activity. The subjects for each activity were selected at random from 109 students, including 27 female students, from various classes. From these 109 students, whose age ranged from 16 to 18 years, 27 female students were chosen for the actual investigation of diurnal changes in their fatigue scores.

We selected six physical education activities including a tumbling exercise and a distance run as an individual sport, badminton which is a net-type game, softball which

is a baseball-type game, and team handball and basketball which are goal-type games as group sports (10).

Flicker values (9, 11), which represent the functional level of the cerebral cortex, were determined three times using an apparatus for the measurement of Flicker's value (OG Giken Co., Okayama, Japan), and average scores were used. Counter values (12), which represent performance efficiencies, were measured for 30 sec by counting with thumbs at maximum speed using a hand count device (Crown Co., Tokyo, Japan). Grip strength (11), which represents muscular strength, was determined twice using a grip dynamometer (Senoh Co., Tokyo, Japan). The higher value of the two was used.

In each class, students performed only one of the following exercises; tumbling, softball, badminton, team handball, basketball or a 2.2-km distance run during a 50-min physical education period. After a 5-min warm-up exercise, the students would play either a game of softball, badminton, team handball or basketball. In the tumbling exercise, students began with stretching exercises lasting 7 min. The tumbling activity class consisted of forward and backward rolls, handstands, forward rolls, balancing exercises for 20 min and a combination thereof for 18 min. For the distance run class, students initially walked 500m, and then were instructed to run at maximum speed for 2.2-km on the road.

During physical education class, the students used a step counter attached at their waists to measure the number of steps taken.

Two-way analysis of variance was used to statistically analyze the difference among the scores of the three

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symptom groups and diurnal changes in fatigue scores, and the paired *t*-test was used to analyze the differences between means before and after exercise (13). The distribution of the differences between means showed a normal distribution.

Results

Diurnal Changes of Fatigue Scores in High School Students

The fatigue scores were higher in the morning and just before going to bed at night. Both male and female students showed a U-shaped curve during the day (Fig. 1). Scores for the first class in the morning and at 6:00 p.m. were low compared with those in the early morning and late evening. The scores were lowest in subjects just before having lunch.

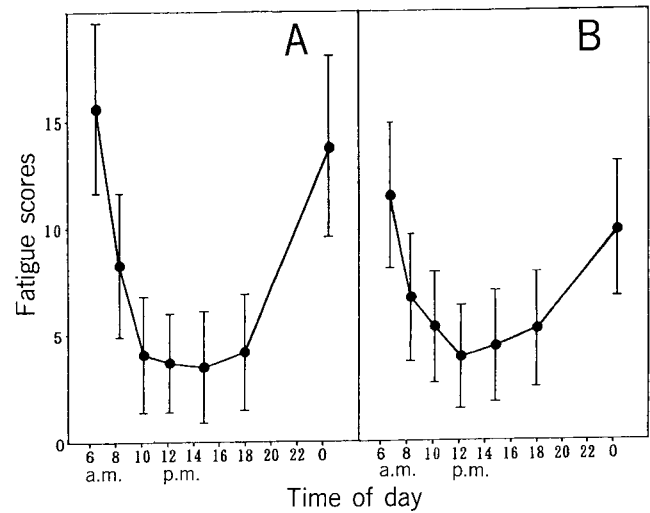


Fig. 1 Diurnal changes of fatigue scores of high school students. Dots: means; Vertical lines: S.E. A: Male students and B: Female students.

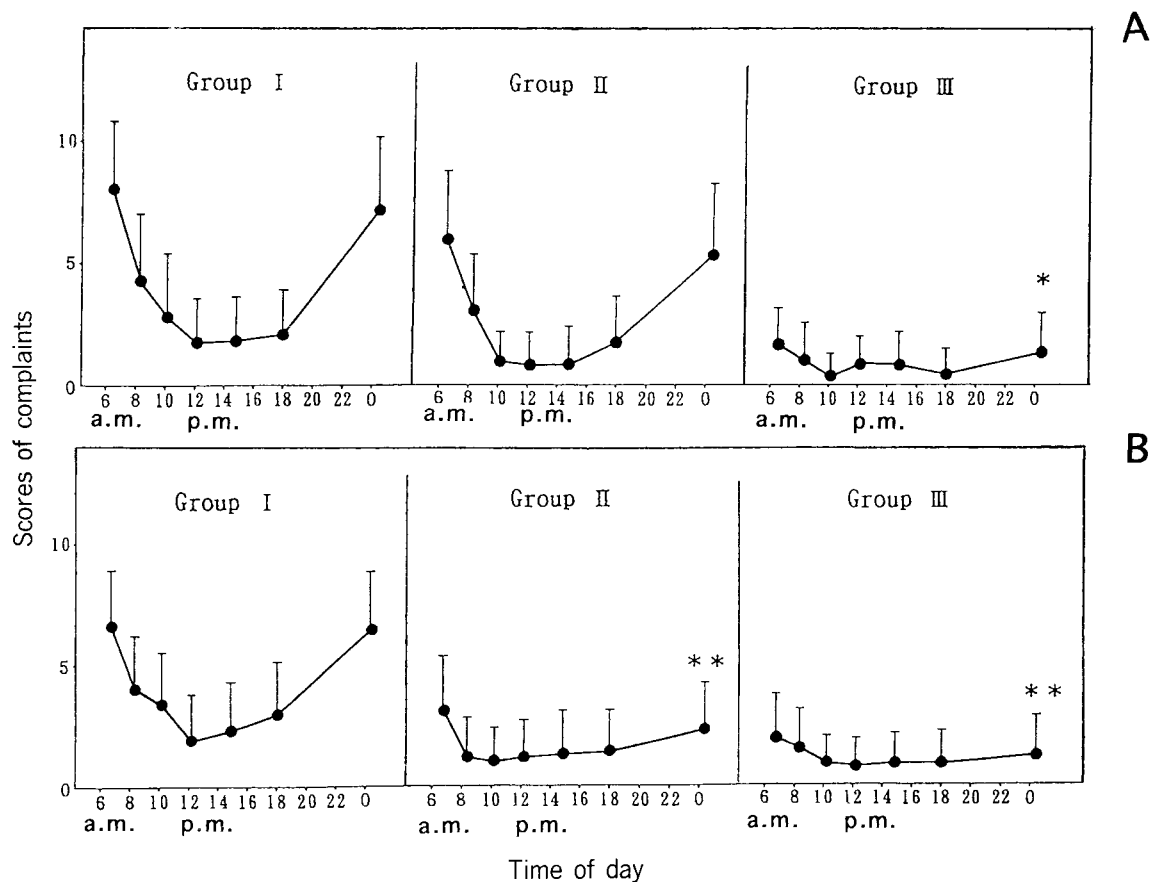


Fig. 2 Diurnal changes in fatigue scores of three symptom groups. Group I: fatigue symptoms no 1-20; Group II: no 11-20; and Group III: 21-30 as listed in Table I. A: Male students and B: Female students. * $P < 0.05$ versus group I, ** $P < 0.01$ versus group I. Symbols: See Fig. 1.

There were no significant differences between the male and female fatigue scores at any time. Sleeping time between males and females showed no significant differences either. The average sleeping time of males was 6.18 ± 1.22 h and that of females was 6.40 ± 1.60 h.

In fatigue scores of males, there were no significant differences between groups I and II. There were,

however, significant differences between groups I and III and between groups II and III in males ($P < 0.05$, Fig. 2). In females, the fatigue score of group I was significantly higher than that of groups II and III ($P < 0.01$). In other words, changes in fatigue scores of groups II and III of females remained low compared with the scores of groups I. Therefore, female students were chosen because of their lower and more stable fatigue scores. Fatigue scores of group III of both males and females were below 2 throughout the day, and there were no significant changes. Also, fatigue scores at waking time and bedtime were significantly higher than scores at other times ($P < 0.01$).

Fatigue symptoms, which significantly decreased before lunch as compared with the scores of waking time in both males and females, were "head feeling weary", "feeling exhausted", "feeling like yawning", "feeling

Table 2 Number of steps during physical education classes

Activities	Number of steps/50 min ^{a)}
Tumbling	640 $\pm$ 500
Softball	910 $\pm$ 190
Badminton	1360 $\pm$ 280
Team handball	1720 $\pm$ 470
Basketball	1760 $\pm$ 450
Distance run	2580 $\pm$ 200

a) Mean $\pm$ SD.

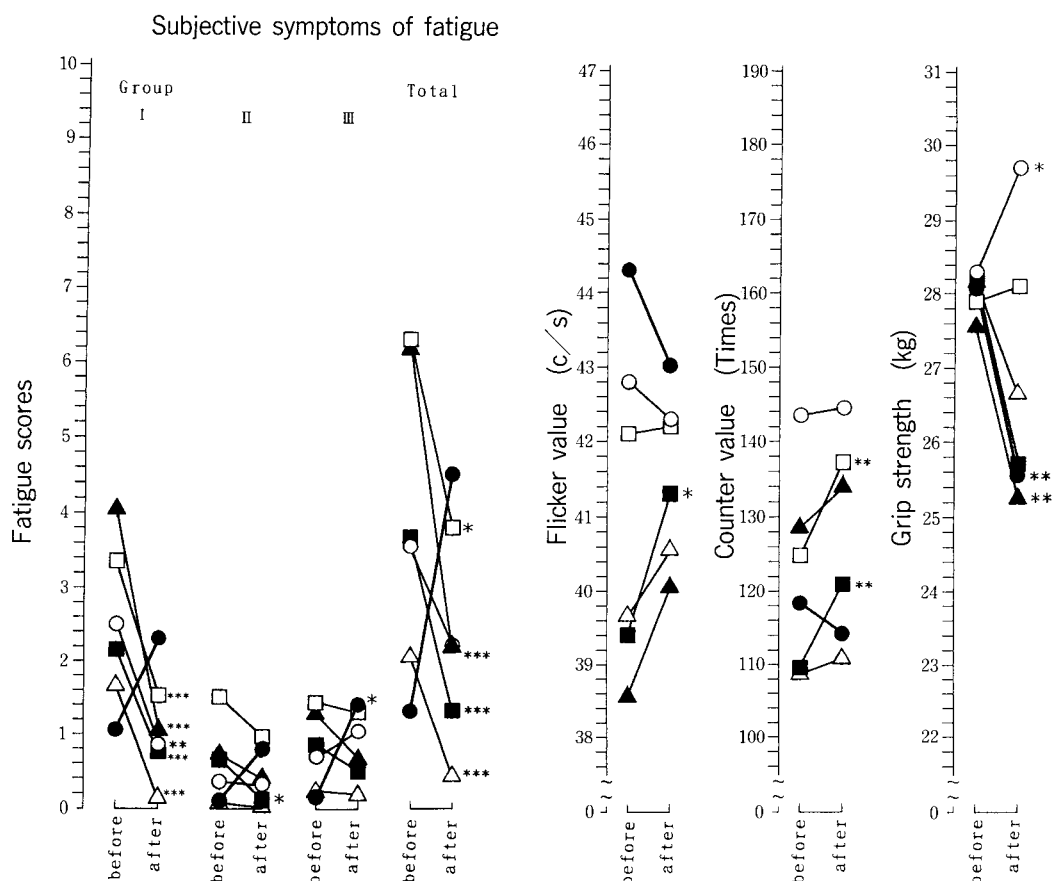


Fig. 3 Changes of fatigue scores, the Flicker value, the counter value and grip strength by physical exercises. $\triangle$ Tumbling (N = 46); $\blacktriangle$ Softball (N = 23); $\square$ Badminton (N = 40); $\blacksquare$ Handball (N = 40); $\circ$ Basketball (N = 38); $\bullet$ Distance run (N = 44). (Each value represents the mean) Groups I, II and III: See Fig. 2. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ (before versus after exercise)

Table 3 Changes in the scores of complaints of fatigue caused by tumbling, softball and badminton in physical education class

Group	Symptom number ^a	Scores (point)					
		Tumbling (46)		Softball (23)		Badminton (40)	
		Before	After	Before	After	Before	After
I	1	0.10 ± 0.37	0.04 ± 0.20	0.26 ± 0.44	0.13 ± 0.34	0.30 ± 0.68	0.17 ± 0.50*
	2	0.17 ± 0.38	0.02 ± 0.14*	0.56 ± 0.66	0.34 ± 0.48	0.45 ± 0.74	0.22 ± 0.57**
	3	0.06 ± 0.24	0	0.43 ± 0.58	0.26 ± 0.44	0.32 ± 0.69	0.22 ± 0.57
	4	0.21 ± 0.41	0**	0.43 ± 0.58	0.04 ± 0.20**	0.32 ± 0.69	0.05 ± 0.22*
	5	0.19 ± 0.40	0.02 ± 0.14**	0.47 ± 0.51	0***	0.42 ± 0.81	0.22 ± 0.61*
	6	0.45 ± 0.68	0.08 ± 0.35***	0.78 ± 0.79	0.08 ± 0.28***	0.45 ± 0.78	0.17 ± 0.54**
	7	0.19 ± 0.45	0.02 ± 0.14**	0.47 ± 0.59	0.04 ± 0.20**	0.40 ± 0.81	0.12 ± 0.40*
	10	0.19 ± 0.54	0*	0.43 ± 0.66	0.17 ± 0.49	0.27 ± 0.71	0.15 ± 0.53
II	15	0.04 ± 0.20	0.02 ± 0.14	0.13 ± 0.34	0	0.17 ± 0.54	0.07 ± 0.34*
	18	0.02 ± 0.14	0.02 ± 0.14	0.04 ± 0.20	0	0.15 ± 0.57	0.10 ± 0.37
III	21	0.02 ± 0.14	0.06 ± 0.32	0.04 ± 0.20	0	0.30 ± 0.72	0.12 ± 0.40*
	22	0.06 ± 0.32	0	0.39 ± 0.58	0.13 ± 0.34*	0.37 ± 0.80	0.27 ± 0.55
	24	0	0.02 ± 0.14	0.08 ± 0.41	0.13 ± 0.45	0.05 ± 0.22	0.12 ± 0.33
	25	0.04 ± 0.20	0	0.30 ± 0.47	0.17 ± 0.49	0.07 ± 0.26	0.22 ± 0.47*
	26	0.02 ± 0.14	0	0.04 ± 0.20	0	0.05 ± 0.31	0.05 ± 0.22
	27	0	0	0.13 ± 0.45	0.08 ± 0.41	0.12 ± 0.51	0.07 ± 0.34
	30	0	0	0.13 ± 0.62	0.13 ± 0.62	0.07 ± 0.47	0.12 ± 0.40

^a: Fatigue symptoms according to the symptom numbers are shown in Table 1. *, $P < 0.05$; **, $P < 0.01$; and ***, $P < 0.001$ (before versus after exercise). Numbers in parentheses indicate numbers of cases.

mentally sluggish", "feeling sleepy", "eyes feeling tired", "feeling uncoordinated", "feeling like lying down" in group I, and "feeling distracted" and "feeling uncommunicative" in group II.

Effect of Exercise on Body Function

The 109 female high school students were chosen for the analysis because of their lower fatigue scores. Low scores were shown particularly before lunch time, and changes of fatigue scores, the Flicker value, the counter value, grip strength and counting steps were analyzed before and after physical education class in the third school period.

The step scores of activities are shown in Table 2. In tumbling, softball, badminton, and team handball (Fig. 3), the fatigue scores significantly decreased after physical education ($P < 0.01 \sim 0.001$). However, in the distance run, the fatigue score increased significantly after the exercise ($P < 0.01$).

In the distance run, the fatigue scores in all the three fatigue symptom groups, tended to increase after exercise

with group III showing a significant increase ($P < 0.05$). In basketball, which had the second highest score in number of steps, the scores of complaints of fatigue in groups I and II decreased after exercise, while the scores of group III showed a tendency to increase after exercise. Fatigue scores tended to decrease after exercise.

In each symptom group, the scores of the symptoms of "feeling sleepy" and "feel like yawning" decreased, and scores of "difficulty in breathing" increased after exercise in all activities (Tables 3, 4). In tumbling, softball, badminton and team handball, the fatigue scores in groups I, II and III decreased after exercise. The scores decreased significantly in group I ("drowsiness and dullness") after exercise ($P < 0.001$). In the 2.2-km distance run, and the scores of all the three groups increased after exercise, especially those of fatigue symptoms of "feeling exhausted", "legs feeling tired", "difficulty in breathing", "dry mouth", "feeling dizzy" and "feeling sick" ($P < 0.05 \sim 0.01$).

The correlation coefficient between the fatigue scores

Table 4 Changes in the scores of complaints of fatigue caused by team handball, basketball and distance run in physical education class

Group	Symptom number ^a	Scores (point)					
		Team handball (40)		Basketball (38)		Distance run (44)	
		Before	After	Before	After	Before	After
I	1	0.22 ± 0.57	0.10 ± 0.30	0.13 ± 0.34	0.02 ± 0.16	0.02 ± 0.15	0.13 ± 0.40
	2	0.27 ± 0.59	0.20 ± 0.46	0.26 ± 0.64	0.21 ± 0.62	0.11 ± 0.38	0.47 ± 0.82*
	3	0.07 ± 0.26	0.10 ± 0.30	0.21 ± 0.52	0.23 ± 0.54	0.13 ± 0.46	0.52 ± 0.84**
	4	0.37 ± 0.66	0.02 ± 0.15**	0.42 ± 0.85	0.02 ± 0.16**	0.22 ± 0.42	0.09 ± 0.36
	5	0.30 ± 0.60	0.10 ± 0.30*	0.31 ± 0.70	0.05 ± 0.32*	0.11 ± 0.38	0.20 ± 0.55
	6	0.50 ± 0.75	0.07 ± 0.26***	0.68 ± 0.87	0.10 ± 0.31***	0.31 ± 0.63	0.13 ± 0.40
	7	0.27 ± 0.50	0.05 ± 0.22*	0.15 ± 0.36	0.05 ± 0.32	0.06 ± 0.25	0.13 ± 0.40
	10	0.05 ± 0.22	0	0.23 ± 0.63	0.10 ± 0.31	0.04 ± 0.21	0.20 ± 0.63
II	15	0.07 ± 0.26	0.10 ± 0.30	0.10 ± 0.31	0.07 ± 0.27	0.02 ± 0.15	0.09 ± 0.36
	18	0.15 ± 0.36	0*	0	0	0	0.04 ± 0.30
III	21	0.07 ± 0.26	0.07 ± 0.26	0.02 ± 0.16	0	0.02 ± 0.15	0.06 ± 0.33
	22	0.22 ± 0.53	0.05 ± 0.22*	0.15 ± 0.43	0.05 ± 0.22	0.04 ± 0.21	0
	24	0	0.02 ± 0.15	0.07 ± 0.35	0.23 ± 0.63	0.02 ± 0.15	0.31 ± 0.80*
	25	0.10 ± 0.37	0.12 ± 0.40	0.21 ± 0.52	0.42 ± 0.75	0.02 ± 0.15	0.34 ± 0.74**
	26	0.12 ± 0.33	0.02 ± 0.15*	0.02 ± 0.16	0.05 ± 0.32	0	0.04 ± 0.30
	27	0	0.07 ± 0.34	0	0.05 ± 0.22	0.02 ± 0.15	0.20 ± 0.55*
	30	0.07 ± 0.47	0.02 ± 0.15	0.02 ± 0.16	0.10 ± 0.50	0.02 ± 0.15	0.25 ± 0.57**

^a: Fatigue symptoms according to the symptom numbers are shown in Table 1. *, $P < 0.05$; **, $P < 0.01$; and ***, $P < 0.001$ (before versus after exercise). Number in parentheses indicate numbers of cases.

of "feeling exhausted" and grip strength was -0.404 ($P < 0.001$), and that between "legs feeling tired" and grip strength was -0.307 ($P < 0.05$). No significant relationships were found among other scores of complaints of fatigue symptoms and grip strength.

In tumbling, softball, badminton, team handball and basketball, fatigue scores decreased after exercise; significant decreases were found in symptoms of drowsiness such as "feeling like yawning", "feeling mentally sluggish" and "feeling sleepy" ($P < 0.05 \sim 0.001$). In tumbling, softball, badminton and team handball, the score of "eyes feeling tired" decreased significantly after exercise ($P < 0.05 \sim 0.01$).

The following scores all decreased significantly after exercises: "feeling exhausted" and "feeling like lying down" ($P < 0.05$) in tumbling; "stiff neck" ($P < 0.05$) in softball; "head feeling weary", "feeling exhausted", "feeling a loss of interest" and "headaches" ($P < 0.05 \sim 0.01$) in badminton; and "feeling worried", "stiff neck" and "hoarse voice" ($P < 0.05$) in team handball. "Dry

mouth" in badminton, however, increased significantly ($P < 0.05$).

Of the 30 symptoms of fatigue concerned with body functions, complaints related to legs increased in the distance run ($P < 0.05$). Complaints related to whole-body fatigue also increased in the distance run ($P < 0.05$) but decreased in tumbling ($P < 0.05$), and badminton ($P < 0.01$). Complaints of body stiffness and neck (and shoulder) stiffness decreased in softball ($P < 0.05$) and team handball ($P < 0.05$). Scores of complaints of "aches and feeling mentally weary" decreased in badminton ($P < 0.05$), and complaints of "being sluggish" decreased in all activities except the 2.2-km distance run ($P < 0.05 \sim 0.001$).

The Flicker value increased after exercise in tumbling, softball, badminton and team handball ($P < 0.05$), and it decreased after exercise in basketball and the distance run. In the distance run, which had the largest number of steps, the counter value tended to decrease also after exercises.

In softball and the 2.2-km distance run, grip strength decreased significantly after exercise ($P < 0.01$). Grip strength decreased in the distance run in all students. Also, fatigue scores increased whereas other objective indices decreased in the distance run.

Discussion

In the surveys of industrial fatigue done to date, studies have been performed in which the number of complaints of subjective symptoms of fatigue were counted (4). However, there are different levels of complaints for fatigue symptoms, and this subjective research method cannot properly record the level of fatigue. In the present study, we used a fatigue score which was compiled by recording responses to four multiple-choice questions about each symptom. Thus, subjects could express their stress level of each fatigue symptom. This helped us to understand the changes of complaints of fatigue symptoms more accurately, and clarified the origin of the complaint symptoms.

As a result of using this method which included the fatigue scores, it became more clear that the pattern of changes of fatigue symptoms and the changes in the characteristic diurnal symptoms for high school students was similar to the diurnal changes of subjective symptoms of fatigue in female college students (14, 15). In this research on high school students, students who had approximately 6 h of sleep showed a pattern of diurnal changes similar to that of college students who had less than 5 h of sleep. These students also had the highest fatigue scores during their waking hours.

The researchers assume that the complaints of fatigue symptoms in group II come from the fact that students study in a sitting position throughout the day and need concentration for that study. Our research showed fewer complaints of fatigue symptoms of group II in females compared with males.

To find the diurnal changes of fatigue scores of high school students, it was necessary to have the students do exercise at the same time of the day, especially in the morning before lunch. In this way, we could clarify the effects of exercise by analyzing the complaints of fatigue scores before exercise. Generally speaking, increasing the physical load increases the fatigue score (16). In this research, in the 50-min of physical education class, activities of less than 1,760 steps led to a decrease in the fatigue score. Also, the Flicker value and counter value

indicated improvement of physical function.

Therefore, our research findings suggest that exercise having 1,760 steps, which is an average of 35 steps/min., is the margin of physical load. Exercise of over 1,760 steps increases fatigue scores and exercise of less than 1,755 steps decreases fatigue scores after physical education class. This finding was supported by changes of Flicker value and counter value. Also, the complaints of the fatigue symptom "feeling sleepy", were reduced after exercise. These results showed the invigorating effect of exercise. This is an important result in a sense that the fatigue symptom is not alleviated by sleeping but rather by a moderate level of exercise. Therefore, the invigorating effect of exercise is emphasized on the basis of the present study. From these results, it seems clear that moderate exercise is required for alleviation of fatigue symptoms. We assume that it means today's high school students lack exercise, and it is necessary and important that high school students do suitable exercise. This finding is consistent with the result of other research (6) which was done on American college students in tennis, racketball, bowling and weight training in physical education class. This study is an example of recovery from fatigue by doing exercise which promotes blood circulation and stimulates brain function (17).

In this research, the reason why physical load made fatigue scores decrease after exercise might have been the production of endorphine, which is a substance that has a narcotic effect like morphine. It affects the body by exercising the brain and giving it a "second wind" (18-21), "third wind" or "runner's high" (22). In this study, exercise made students feel euphoric, and tiredness was changed to a pleasant sensation (23, 24). Thus, we still need to take into consideration metabolic factors such as the secretion of endogenous substances such as endorphine (25, 26) in order to discuss these results.

Analyzing the complaints of fatigue and changes of the Flicker value after exercise, some activities show a negative correlation between the fatigue score of group I and all three groups and the Flicker value. We assume that some fatigue in the human body is caused by exercise, and we found that light exercise enhanced the Flicker value.

On the other hand, a distance run led to an increase in "feeling exhausted" in group I (dullness). Also, today's high school students do less exercise and increasing complaints of "feeling uncoordinated", "hands and legs trembling" and "feeling sick" after exercise which are the

complaints of groups I and III.

Endurance exercise such as the distance run made grip strength decrease and fatigue scores increase, and we assume this contributed to the decrease of the Flicker value and counter value after exercise. Grip strength showed an especially significant decrease.

There was negative correlation between the scores of complaints in "feeling exhausted" and "legs feeling tired" and grip strength. Therefore, complaints of dullness caused by running have a strong correlation with changes of grip strength. We assume that muscle fatigue caused by a distance run is a whole-body function (cardiovascular workout) rather than affecting only certain muscle groups. Therefore, this research showed that if we use many large muscle groups such as during a distance run, running will influence the muscle strength of the fine motor muscle groups.

According to Toyooka's (8) findings on marathon running, leg muscle strength and Flicker value significantly decreased after the race and grip strength slightly decreased. Each activity uses a different muscle group, so each activity naturally influences grip strength differently.

In conclusion, two types of effects of physical activities, one recreational and the other training, were found in physical education classes. Since male students had similar or even more severe complaints than female students, the invigorating effect of exercise would also apply to the male students, although further study is required to confirm these findings.

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