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The Effects of 12-Week Training for the Physical Fitness and Cardiovascular Factors to Examine Physical Fitness on Firefighters Test-Taker

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소방공무원 수험생의 체력검정을 위한 12주간 훈련이 체력요인, 심혈관계요인에 미치는 영향

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Abstract The purpose of this study was to investigate the effects of 12-week training on changes in physical fitness and cardiovascular factors for firefighters. For this purpose, 40 men in their 20s and 30s who agreed to participate voluntarily were recruited. They were divided into four groups: the firefighters' physical fitness test training group (hereinafter referred to as PT group), firefighters' physical fitness test and aerobic training group (hereinafter referred to as PT+AR group), firefighters' physical fitness test and both aerobic and anaerobic training group (hereinafter referred to as PT+CO group). Physical fitness factors (grip strength, back muscle strength, seated forward bend, standing long jump, sit-ups, 20-meter shuttle run), cardiovascular factors (total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, glucose, waist circumference, systolic blood pressure, diastolic blood pressure) and the relationship between Framingham Heart Risk Score and physical/cardiovascular factors were compared and analyzed, and the following conclusions were obtained. Aerobic training, anaerobic training, and combined training, including 12 weeks of firefighter physical examinations, all had positive effects on fitness and cardiovascular factors, which would be an appropriate way for firefighter examinees to improve physical strength and reduce the risk of cardiovascular disease.

Key Words : Firefighter, Test-takers, Physical fitness test, Physical strength factor, Cardiovascular system factor

요 약 본 연구는 소방공무원 수험생을 대상으로 12주간 훈련이 체력요인, 심혈관계요인 변화에 미치는 효과를 규명하고자 하였다. 이를 위해 자발적 참여를 동의한 20-30대 남자 40명을 소방공무원 체력검사종목 훈련군(이하 PT group), 소방공무원 체력검사종목과 유산소훈련 병행군(이하 PT+AR group), 소방공무원 체력검사종목과 무산소훈련 병행군(이하 PT+AN group), 소방공무원 체력검사종목과 유무산소복합훈련 병행군(PT+CO group)으로 나누어 실시하였다. 분석항목으로는 체력요인(악력, 배근력, 앉아 윗몸 앞으로 굽히기, 제자리멀리뛰기, 윗몸일으키기, 20m왕복오래달리기), 심혈관계요인(총콜레스테롤, 중성지방, 고밀도지단백 콜레스테롤, 저밀도지단백 콜레스테롤, 글루코스, 허리둘레, 수축기혈압, 이완기혈압) 및 Framingham Heart Risk Score와 체력요인, 심혈관계 요인의 관계를 비교 분석하였으며 다음과 같은 결론을 얻었다. 본 연구에서 실시한 12주간 체력검정을 위한 훈련이 체력과 심혈관계에 효과적임을 확인 할 수 있었다. 따라서, 체력검정을 위한 훈련이 소방공무원 수험생들의 체력향상과 심혈관질환 위험을 감소시키는데 효과가 있는 것으로 판단된다.

키워드 : 소방공무원, 수험생, 체력검정, 체력요인, 심혈관계요인

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1. Introduction

In the past few decades, a large number of high-rise buildings and large commercial centers have been built, increasing the demands on the skills and physical abilities of firefighters, which places high demands on the physical abilities and health of firefighters. In addition, inhalation resistance increases at the fire site and the demands on the physical abilities of firefighters are very high when using respirator[1-3].

Firefighters engage in heavy liftings that require muscle strength, climb stairs and ladders, carry and use heavy tools, and has to engage in awkward body postures in order to perform the difficult rescue missions. Thus, firefighter training includes education regarding the benefits of a body conditioning program for job performance[4,5].

Fire officials who perform special duties in sites with many risk factors, such as fire suppression and rescue mission, wear protective equipment that weighs 20 to 30kg for their own safety[6]. Higher physical strength is required for firefighters due to the heavy protective equipment, and also the extreme environment where they perform their duties[6-8]. Moreover, a lot of stress is derived from the shift work system, and when the physiological rhythm cycle is disrupted because of it, it has a significant short-term or long-term effect on physical and mental health[9].

The management of the working environment of firefighters is insufficient. They are exposed to repetitively stressful environments due to heavy workload, job instability, lack of appropriate compensation, high tension work, and lack of sleep[10]. Increased physical and mental stress can be seen as a result of specific hormones stimulated due to irregular daily life due to lack of sleep[11]. In addition, compared to day workers, night workers tend to have a decreased quality of life and physical strength, and if they are maladapted to shift work, the risk of various diseases such as cardiovascular and digestive diseases increase[12,13].

Nevertheless, firefighters who are on standby 24 hours a day are faced with the reality of having to protect and respond to the safety, life, and property of the people, even in unpredictable and dangerous situations in harsh environments and various accident sites[14].

Firefighters are exposed to chemical and biological harms, mental and physical stress, complex working conditions, and repetitive movements due to accidents such as fire, building collapse, traffic accidents, and forest fires, and abnormal natural disasters. This has led to the increased probability of developing diseases in various parts as in digestive system, musculoskeletal system, cancer, and cardiovascular diseases[15,16].

Maguire, Hunting, Smith & Levick[17] also reported that 13 out of 70 deaths among emergency medical service workers in the United States died from cardiovascular accidents between 1994-1997. Health-related research is urgently needed, such as improving cardiovascular factors through the development and application of training programs that are optimized for firefighters.

Therefore, the purpose of this study is to investigate the effects of 12-week training of firefighting officials' examinees on physical fitness factors and cardiovascular factors, and thus offering basic data for training programs for improving the physical strength of firefighters and preventing cardiovascular risks.

2. Research Method

2.1 Subject Study

The subjects of this study were 40 males in their 20s and 30s who agreed to voluntarily participate in the 12-week experimental procedure among firefighter official examinees. They were randomly divided into four groups: the firefighters' physical fitness test training group (hereinafter referred to as PT group), firefighters' physical fitness test and aerobic training group (hereinafter referred to as PT+AR group), firefighters' physical fitness test, and both aerobic and anaerobic training group (hereinafter referred to as PT+CO group). All of these subjects are not at risk of cardiovascular disease, and the purpose and method of this study were fully explained prior to the experiment. There was no significant difference in the physical characteristics of each group, and the physical characteristics of the subjects were as shown in Table 1.

Table 1. Physical characteristic of subjects

Group	N	Ages(year)	Height(cm)	Weight(kg)	BMI(kg/m^2)	%fat(%)
PT Group	N=10	28.40±1.57	174.80±0.42	77.40±14.23	22.32±4.70	14.46±8.73
PT+AR Group	N=10	27.00±1.88	176.50±2.87	76.08±10.01	24.36±2.73	19.82±2.06
PT+AN Group	N=10	28.10±1.66	177.80±3.61	73.46±6.11	23.22±1.66	18.62±1.92
PT+CO Group	N=10	26.90±1.28	178.20±6.84	67.34±6.75	21.18±1.39	14.36±4.19

Values are mean ± standard deviation.
PT = Fire fighter's physical fitness training.
PT+AR = Fire fighter's physical fitness training + aerobics training.
PT+AN = Fire fighter's physical fitness training + anaerobics training.
PT+CO = Fire fighter's physical fitness training + combined training.

Table 2. The content and method of the experiment

Subject		List of Measurement	Measurement Method
Body Composition		Body weight Height % Body fat Body fat mass	Participants fasting for 8 hours → 30 minutes rest after arriving in the laboratory → Measurement taken a day before the start of the training, and a day after the 12 weeks training ends
Blood Pressure		Systole and diastole	Five minutes of rest → Choose the appropriate tough for the arm size, take a total of three measurements every 30 seconds → use the second and third blood pressure averages
Measurement of Fitness	Muscular strength	Grip strength (kg)	Posture : Feet wide as the shoulder, holding the dynamometer at a right angle with the second joint of the finger Measurement : Measure two times each(left and right), and choose the best record
		Back muscle strength (kg)	Posture : Pose the feet 15cm apart, tilting the upper body slightly forward(make the measuring device and the upper body make 30° Measurement: Measure the abdominal strength by raising the body with power(check two times, and select a better record
	Flexibility	Sit & reach test (cm)	Posture : The soles of both feet touching the floor of the measuring instrument, and the gap between two feet should be less than 5cm Measurement: Rise up from the knees and reach out the hands to measure appropriately. Note : Participants should take off their shoes, and they should not bend their knees, abruptly reach out their hands, and should not use lumbar reflex.
	Leg power	Standing long jump (cm)	Jump behind the takeoff line using the rebound of arms, legs, and body. Measure twice, and choose a better record.
	Muscular endurance	Sit-ups (number of times)	Posture : Pose the feet 3cm apart, knees making a right angle, both hands crossed and put in front of the chest, and the fingertips pointing the shoulder. Note : Check for a minute(60 seconds)
	Cardiovascular endurance	20m shuttle run (number of times)	Go and return the 20m running course, and the participant should run within a certain running cycle(the starting sign gets faster) Note : The measurement stops when the participant fail to come back before the next starting signal rings.
Blood test		FBG, TG Glucose, TC HDL-C, LDL-C	Needs the approval of the participant to collect blood, and should minimize the influence of the external environment Note : Should check if the participants have fasted themselves for 8 hours.
Framingham heart risk score		Age, LDH-C/TC HDL-C, Blood pressure, Diabetes status Smoking status	Calculate the absolute risk rate, divide it with the average absolute rate of same age and gender, and ultimately calculate the relative risk rate.

2.2 Experiment Contents and Methods

In this study, body composition, physical fitness factors, and cardiovascular factors were measured before and after training to investigate the effects of 12-week training for firefighters' physical fitness test on firefighters' physical and cardiovascular factors. The training group participated in 90 minutes of training 3 days a week for 12 weeks in total, and exercise intensity adjustment according to training adaptation was conducted in 4 week unit. The experimental contents and methods of this study are shown in Table 2. Also, training prescriptions and programs were as described in Table 3, 4, 5, 6.

Table 3. 12 Weeks fire fighters physical fitness training program

Category	Type	Intensity/Frequency	Methods
Warm-up(15min)	Stretching		Upper & lower body stretching
Exercise (60min)	Fire fighter's Physical Fitness test for repetition training	THR by POLAR 1~4wks 60% 5~8wks 65% 9~12wks 70% HRmax 60~70% 3 times / wks	1. Grip strength 3 times 2. Back strength 3 times 3. Sit-ups 3 set 4. Standing Long Jump 3 times 5. Sit & reach test 3 set 6. 20m Shuttle run 1 set
Cool-down(15min)	Stretching		Upper & Lower body stretching

Table 4. 12 Weeks fire fighters physical fitness training + aerobic training program

Category	Type	Intensity/Frequency	Methods
Warm-up(15min)	Stretching		Upper & Lower body stretching
Exercise (60min)	Fire fighter's physical fitness test for repetition training (20min)	THR by POLAR 1~4wks 60% 5~8wks 65% 9~12wks 70% HRmax 60~70% 3 times / wks	1. Grip strength 1 times 2. Back strength 1 times 3. Sit-ups 1 set 4. Standing long jump 1 times 5. Sit & reach 1 set 6. 20m Shuttle run 1 set
	Aerobic training/ treadmill(40min)		Aerobic training(treadmill running)
Cool-down(15min)	Stretching		Upper & lower body stretching

Table 5. 12 Weeks fire fighters physical fitness training + anaerobic training program

Category	Type	Intensity/Frequency	Methods	
Warm-up(15min)	Stretching		Upper & Lower body stretching	
Exercise (60min)	Fire fighter's physical fitness test for repetition training (20min)	1~4wks 60% 5~8wks 65% 9~12wks 70% 1RM 60~70% 3 times / wks	1. Grip strength 1 times 2. Back strength 1 times 3. Sit-ups 1 set 4. Standing long jump 1 times 5. Sit & reach 1 set 6. 20m Shuttle run 1 set	
	Resistance Training (40min)		Sequence of resistance training	
			1. Shoulder, Chest, Arm	1) Shoulder press 2) Chest press 3) Bench press 4) Arm curl (10rep / 2set ~ 15rep / 3set)
			2. Abdomen	1) Sit-up 2) Leg raise 3) Crunch 4) Side bend (10rep / 2set ~ 15rep / 3set)
			3. Leg	1) Leg press 2) Leg extension 3) Leg curl 4) Calf raise (10rep / 2set ~ 15rep / 3set)
Cool-down(15min)	Stretching		Upper & lower body stretching	

Table 6. 12 Weeks fire fighters physical fitness training + combined training program

Category	Type	Intensity/Frequency	Methods	
Warm-up(15min)	Stretching		Upper & lower body stretching	
Exercise (60min)	Fire fighter's physical fitness test for repetition training(20min)	THR by POLAR 1~4wks 60% 5~8wks 65% 9~12wks 70% HRmax 60~70% 3 times/wks	1. Grip strength 1 times 2. Back strength 1 times 3. Sit-up 1set 4. Standing long jump 1 times 5. Sit & reach 1 set 6. 20m Multi-stage shuttle run 1 set	
	Resistance training (20min)	1~4wks 60% 5~8wks 65% 9~12wks 70% 1RM 60~70% 3 times/wks	sequence of resistance training	
			1.Shoulder, Chest, Arm	1) Shoulder press 2) Chest press 3) Bench press 4) Arm curl (10rep / 1set ~ 15rep / 2set)
			2. Abdomen	1) Sit-up 2) Leg raise 3) Crunch 4) Side bend (10rep / 1set ~ 15rep / 2set)
			3. Leg	1) Leg press 2) Leg extension 3) Leg curl 4) Calf raise (10rep / 1set ~ 15rep / 2set)
	Aerobic training/ treadmill (20min)	THR by POLAR 1~4wks 60%, 5~8wks 65%, 9~12wks 70% HRmax 60~70% 3 times/wks	Aerobic training(treadmill running)	
Cool-down(15min)	Stretching		Upper & lower body stretching	

2.3 Data Processing

The analysis of the data in this study was conducted using the SPSS PC+ for window (version 21.0) statistics program, and the average(M) and standard deviation (SD) were calculated in order to get descriptive statistics of all measured data. To verify the difference between the average results of pre-experiment and post-hoc results, two-way ANOVA with repeated measures was used. An intra-individual contrast test was performed to investigate whether there lies the homogeneity of the prior values between groups, and the changes in the pre and post-hoc values. In order to examine the correlation between the Framing Heart Risk Score and each measurement variable, the Pearson correlation coefficient for the post-mortem measurements was calculated. The significance level of statistical analysis was set to $p<.05$ level.

3. Results

The purpose of this study was to examine how an experiment of 12 weeks training effects changes in physical fitness and cardiovascular factors after classifying them into four groups: the firefighters' physical fitness test training group (hereinafter referred to as PT group), firefighters' physical fitness test and aerobic training group (hereinafter referred to as PT+AR group), firefighters' physical fitness test and both aerobic and anaerobic training group (hereinafter referred to as PT+CO group).

3.1 Changes in Physical Fitness Factors

The average and two-way repeated ANOVA results for each groups' changes in the physical strength factor due to the 12-week training are equal to Table 7, 8. Two-way repeated ANOVA results for grip strength ($F=24.772$, $p< .001$) showed significant differences. However, there was no significant difference in the interaction effect of the time x group. A two-way repeated ANOVA assay result ($F=10.023$, $p< .01$) for back muscle strength showed a significant difference. However, there was no significant difference in the interaction effect of the time x group. As a result of two-way repeated ANOVA analysis on

the change of seated forward bend, there was a significant difference in timing (F=6.033, p<.05). However, there was no significant difference in the interaction effect of the time x group. As a result of two-way repeated ANOVA analysis of the standing long jump, there was a significant difference in the timing (F=22.006, p<.001). However, there was no significant difference in the interaction effect of the time x group. As a result of two-way repeated ANOVA analysis on sit-ups, there was a significant difference in timing (F=32.627, p<.001). However, there was no significant difference in the interaction effect of the time × group. As a result of two-way repeated ANOVA analysis on the 20-meter shuttle run, there was a significant difference in the group ((F=6.372, p<.001) and the period (F=15.784, p<.001), whereas there were no significant changes in the interaction effect of the period x group.

Table 7. Two-way repeated ANOVA about the change of strength factors 1

Item	Period	Group	N	M±SD	Group	SS	df	MS	F	p
hand grip strength (kg)	pre (0 Weeks)	PT	10	52.36±8.34	group	392.554	3	130.851	2.732	.058
		PT+AR	10	53.24±3.96	error	1724.464	36	47.902		
		PT+AN	10	52.56±3.26	period	186.661	1	186.661	24.772	.001***
		PT+CO	10	57.78±5.96	period*group	16.826	3	5.609		
	post (12 Weeks)	PT	10	54.50±3.56	error	271.264	36	7.535	.744	.533
		PT+AR	10	57.82±4.05						
		PT+AN	10	55.40±3.43						
		PT+CO	10	60.44±7.01						
back strength (kg)	pre (0 Weeks)	PT	10	204.70±23.68	group	5416.834	3	1805.611	2.574	.069
		PT+AR	10	185.85±24.76	error	25257.413	36	701.595		
		PT+AN	10	208.20±28.61	period	2085.903	1	2085.903	10.023	.003**
		PT+CO	10	208.30±18.00	period*group	828.409	3	276.136		
	post (12 Weeks)	PT	10	206.00±22.02	error	7492.313	36	208.120	1.327	.281
		PT+AR	10	202.70±17.85						
		PT+AN	10	215.10±15.26						
		PT+CO	10	224.10±16.87						
Sit & reach test (cm)	pre (0 Weeks)	PT	10	19.06±6.54	group	96.121	3	32.040	.722	.546
		PT+AR	10	17.41±4.87	error	1598.603	36	44.406		
		PT+AN	10	18.58±3.77	period	10.878	1	10.878	6.033	.019*
		PT+CO	10	20.34±1.34	period*group	1.076	3	.359		
	post (12 Weeks)	PT	10	20.14±8.39	error	64.911	36	1.803	.199	.896
		PT+AR	10	18.06±4.33						
		PT+AN	10	19.02±3.47						
		PT+CO	10	21.12±0.94						

PT = firefighter's physical fitness training.
PT+AR = firefighter's physical fitness training + aerobics training.
PT+AN = firefighter's physical fitness training + anaerobics training.
PT+CO = firefighter's physical fitness training + combined training
*p<.05, p<.01, ***p<.001

Table 8. Two-way repeated ANOVA about the change of strength factors 2

Item	Period	Group	N	M±SD	Group	SS	df	MS	F	p
standing broad jump (cm)	pre (0 Weeks)	PT	10	233.20±20.93	group	320.438	3	106.813	.048	.748
		PT+AR	10	239.60±8.56	error	9413.450	36	261.485		
		PT+AN	10	239.20±8.25	period	1911.012	1	1911.012	22.006	.001***
		PT+CO	10	237.60±16.16	period*group	251.238	3	83.746		
	post (12 Weeks)	PT	10	245.80±15.59	error	3126.250	36	86.840	.964	.420
		PT+AR	10	243.30±12.38						
		PT+AN	10	250.40±11.63						
		PT+CO	10	249.20±4.46						

Table 8. Continued..

Item	Period	Group	N	M±SD	Group	SS	df	MS	F	p
sit-up (times/60sec)	pre (0 Weeks)	PT	10	48.40±3.13	group	85.937	3	28.646	.926	.438
		PT+AR	10	49.80±4.63						
		PT+AN	10	48.00±6.28	error	1113.250	36	30.924		
		PT+CO	10	47.80±8.09	period	475.313	1	475.313	32.627	.001***
	post (12 Weeks)	PT	10	53.80±3.58						
		PT+AR	10	53.50±1.58	period*group	87.738	3	29.246		
		PT+AN	10	50.40±3.09					2.008	.130
		PT+CO	10	55.80±4.54	error	524.450	36	14.568		
shuttle run (times)	pre (0 Weeks)	PT	10	61.00±9.69	group	1918.238	3	639.413	6.372	.001***
		PT+AR	10	62.30±4.11						
		PT+AN	10	71.40±9.03	error	3612.650	36	100.351		
		PT+CO	10	69.20±8.09	period	357.012	1	357.012	15.784	.001***
	post (12 Weeks)	PT	10	63.00±9.18						
		PT+AR	10	66.80±10.65	period*group	92.238	3	30.746		
		PT+AN	10	74.20±5.43					1.359	.271
		PT+CO	10	76.80±2.52	error	814.250	36	22.618		

PT = firefighter's physical fitness training.
PT+AR = firefighter's physical fitness training + aerobics training.
PT+AN = firefighter's physical fitness training + anaerobics training.
PT+CO = firefighter's physical fitness training + combined training
*p<.05, p<.01, ***p<.001

3.2 Changes in Cardiovascular Factors

The average and two-way repeated ANOVA results for each groups' changes in the cardiovascular factor due to the 12-week training are equal to Table 9, 10. As a result of two-way repeated ANOVA analysis on total cholesterol, there was a significant difference in the group (F=3.243, p<.05). However, there was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis on triglycerides, there was a significant difference in timing (F=6.714, p<.05). However, there was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis on HDL-C, there was a significant difference in timing (F=12.798, p<.001). However, there was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis on LDL-C, there was no significant difference in the timing (F=3.343, p=.076). There was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis on glucose, there was no significant difference in the interaction effect of time, period × group. As a result of two-way repeated ANOVA analysis on waist circumference, there was a significant difference in timing (F=18.529, p<.001). However, there was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis of systolic blood pressure, there was a significant difference in timing (F=9.896, p<.01). However, there was no significant difference in the interaction effect of period × group. As a result of two-way repeated ANOVA analysis on diastolic blood pressure, there was no significant difference in the interaction effect of period, period × group. As a result of two-way repeated ANOVA analysis on the Framingham risk score, there was a significant difference in timing (F=13.893, p<.001). However, there was no significant difference in the interaction effect of period × group.

3.3 Correlation between Variables and Framingham Heart Risk Score

To determine the correlation between the

Framingham Heart Risk Score and the variables, the results for analyzing post-hoc test values are shown in Table 11. Variables with a high correlation that showed positive correlation are as follows; weight (p<.001), body fat mass (p<.01), body mass index (p<.001), body fat percentage (p<.001), systolic blood pressure (p<.001), diastolic blood pressure (p<.01), waist circumference (p<.001), total cholesterol (p<.001), triglycerides (p<.001), and LDL cholesterol (p<.001). Grab strength (p<.05), standing long jump (p<.05), sit-up (p<.05), 20-meter shuttle run (p<.01), and HDL cholesterol (p<.01) showed a negative correlation. The resulted values for seated forward bend, backmusclestrength, and the fasting blood sugar did not show a significant correlation.

Table 9. Two-way repeated ANOVA about the change of glucose & cardiovascular system factor 1

Item	Period	Group	N	M±SD	Group	SS	df	MS	F	p
total cholesterol (mg/dl)	pre (0 Weeks)	PT	10	179.00±21.61	group	6924.200	3	2308.067	3.243	.033*
		PT+AR	10	174.30±15.07						
		PT+AN	10	186.80±15.12	error	25624.000	36	711.778		
		PT+CO	10	165.40±20.71	period	732.050	1	732.050	3.760	.060
	post (12 Weeks)	PT	10	175.60±23.60	period*group	232.550	3	77.517		
		PT+AR	10	168.90±35.66					.398	.755
		PT+AN	10	183.20±13.07	error	7009.400	36	194.706		
		PT+CO	10	153.60±16.54						
trigly ceride (mg/dl)	pre (0 Weeks)	PT	10	98.80±18.68	group	8482.600	3	2827.533	1.612	.204
		PT+AR	10	87.90±47.57						
		PT+AN	10	90.00±22.44	error	63147.200	36	1754.089		
		PT+CO	10	70.00±35.50	period	2101.250	1	2101.250	6.714	.014*
	post (12 Weeks)	PT	10	92.20±22.13	period*group	232.550	3	79.517		
		PT+AR	10	74.10±51.81					.254	.858
		PT+AN	10	76.40±13.84	error	11266.200	36	312.950		
		PT+CO	10	63.00±22.90						
HDL-C (mg/dl)	pre (0 Weeks)	PT	10	52.40±4.24	group	1374.150	3	458.050	2.401	.084
		PT+AR	10	56.10±13.87						
		PT+AN	10	64.20±6.37	error	6866.800	36	190.744		
		PT+CO	10	59.80±9.78	period	369.800	1	369.800	12.798	.001***
	post (12 Weeks)	PT	10	56.00±9.79	period*group	93.000	3	31.000		
		PT+AR	10	61.50±16.82					1.073	.373
		PT+AN	10	65.40±7.32	error	1040.200	36	28.894		
		PT+CO	10	66.42±9.94						
LDL-C (mg/dl)	pre (0 Weeks)	PT	10	114.60±35.46	group	3489.519	3	1163.173	1.885	.150
		PT+AR	10	105.20±29.72						
		PT+AN	10	115.00±23.44	error	22210.725	36	616.965		
		PT+CO	10	98.40±25.13	period	855.625	1	855.625	3.343	.076
	post (12 Weeks)	PT	10	112.60±21.51	period*group	1107.275	3	369.092		
		PT+AR	10	102.50±31.86					1.442	.858
		PT+AN	10	114.80±19.85	error	11266.200	36	312.950		
		PT+CO	10	84.80±15.88						
Glucose (mg/dl)	pre (0 Weeks)	PT	10	89.60±11.00	group	385.938	3	128.646	1.979	.135
		PT+AR	10	96.40±6.78						
		PT+AN	10	93.60±7.32	error	2340.050	36	65.001		
		PT+CO	10	95.40±4.24	period	63.013	1	63.013	1.354	.252
	post (12 Weeks)	PT	10	89.00±5.84	period*group	27.238	3	9.079		
		PT+AR	10	92.70±3.19					.195	.899
		PT+AN	10	92.00±9.42	error	1675.250	36	46.535		
		PT+CO	10	94.20±8.59						

PT = firefighter's physical fitness training.
PT+AR = firefighter's physical fitness training + aerobics training.
PT+AN = firefighter's physical fitness training + anaerobics training.
PT+CO = firefighter's physical fitness training + combined training
*p<.05, p<.01, ***p<.001

Table 10. Two-way repeated ANOVA about the change of glucose & cardiovascular system factor 2

Item	Period	Group	N	M±SD	Group	SS	df	MS	F	p
waist circumference (cm)	pre (0 Weeks)	PT	10	82.40±11.34	group	262.700	3	87.567	.724	.544
		PT+AR	10	85.30±7.34	error	4356.100	36	121.003		
		PT+AN	10	80.00±6.76	period	84.050	1	84.050	18.529	.001***
		PT+CO	10	81.60±6.65	period*group	34.650	3	11.550		
	post (12 Weeks)	PT	10	82.40±11.55	error	163.300	36	4.536	2.546	.071
		PT+AR	10	82.00±5.57						
		PT+AN	10	78.20±5.05						
		PT+CO	10	78.50±6.25						
systolic blood pressure (mmHg)	pre (0 Weeks)	PT	10	124.00±8.43	group	280.937	3	93.646	.667	.578
		PT+AR	10	129.00±7.37	error	5056.250	36	140.451		
		PT+AN	10	128.00±7.88	period	2.703	1	2.703	9.896	.003**
		PT+CO	10	128.00±4.21	period*group	427.813	1	427.813		
	post (12 Weeks)	PT	10	122.00±12.29	error	303.438	3	101.146	2.340	.090
		PT+AR	10	119.00±7.37						
		PT+AN	10	128.00±16.86						
		PT+CO	10	121.50±6.25						
diastolic blood pressure (mmHg)	pre (0 Weeks)	PT	10	86.00±8.43	group	420.000	3	140.000	1.059	.379
		PT+AR	10	86.00±11.73	error	4760.000	36	132.222		
		PT+AN	10	88.00±10.32	period	320.000	1	320.000	3.945	.055
		PT+CO	10	86.00±8.43	period*group	360.000	3	120.000		
	post (12 Weeks)	PT	10	88.00±12.29	error	2920.000	36	81.111	1.479	.236
		PT+AR	10	82.00±9.18						
		PT+AN	10	84.00±10.74						
		PT+CO	10	76.00±10.74						
Framingham Heart Risk Score (%)	pre (0 Weeks)	PT	10	1.22±0.41	group	1.690	3	.563	1.389	.262
		PT+AR	10	1.11±0.55	error	14.607	36	.406		
		PT+AN	10	1.11±0.39	period	.325	1	.325	13.893	.001***
		PT+CO	10	0.89±0.18	period*group	.117	3	.039		
	post (12 Weeks)	PT	10	1.10±0.52	error	.842	36	.023	1.672	.190
		PT+AR	10	0.95±0.71						
		PT+AN	10	1.10±0.48						
		PT+CO	10	0.67±0.12						

PT = firefighter's physical fitness training.
PT+AR = firefighter's physical fitness training + aerobics training.
PT+AN = firefighter's physical fitness training + anaerobics training.
PT+CO = firefighter's physical fitness training + combined training
*p<.05, p<.01, ***p<.001

Table 11. The correlation between Framingham Heart Risk Score and others variables

Item	Variables	Body weight	Body mass	% Body Fat	BMI	SBP	DBP	WHR	Grip strength	Back strength
Correlation of Framing Heart Risk Score	Correlation	.575	.217	.436	.730	.526	.477	.607	-.336	-.108
	Sig. (2-tailed)	.000	.178	.005	.000	.000	.002	.000	.034	.505
	Variables	Sit & Reach test	Standing long jump	sit-ups	20m shuttle run	TC	TG	LDL-C	HDL-C	Glucose
	Correlation	.163	-.346	-.368	-.505	.728	.719	.830	-.517	-.015
	Sig. (2-tailed)	.314	.029	.019	.001	.000	.000	.000	.001	.925

4. Discussion

In this study, effects of 12-week training for physical fitness test and changes in physical and cardiovascular factors of firefighters are examined and intends to discuss based on the results of this study and previous ones.

4.1 Changes in Physical Fitness Factors

According to a prior study on physical strength conducted by fire officials of Kim[18], it is stated that the as a result of dividing trained men and women in their 20s with athletic experience into two groups (A groups: high-intensity, small number of repetitions, B

groups: low-intensity, large number of repetitions) although there were no interaction effects in both muscle strength and muscular endurance, it was reported that those factors were found to be improved after 12 weeks and in order to improve muscle strength, it showed more positive results in high-intensity, small number of repetitions.

In the study of Hong & Han[19], as a result of taking a closer look at the differences in physical strength level between those who have been continuously engaged in physical training for more than six month and other non-athletic group, the former group appeared to have higher abilities in muscular strength, muscle endurance, and cardiorespiratory endurance, and the combined exercise was recommended as a method of heightening work performance skills. A correlation between physical strength and firefighting tasks of a male firefighter in his 20s and 40s that were studied by Ko et al[20], it was reported that a physical factor which affects the performance of firefighting tasks are as follows: cardiopulmonary endurance, muscular strength, quickness, and flexibility.

On the other hand, according to the prior studies on physical strength improvement centered on those in their 20s, Kim[21] reported that the 12-week resistance training for those in their 20s showed a positive impact on their physical strength. Ham[22] reported that 14 weeks of circuit weight training for men in their 20s had a positive effect on physical strength improvement, and also the study of So, Choi, & Yoon[23] found the circuit training to have very positive impact on physical strength factors. A study by Lee & Kang[24] reported that the 12-week combined training (weight training, plyometric, interval training) for male college students were reported to be effective in improving physical strength factors.

This study examined the differences in the effects of 12-week training of firefighting officials examinees on physical fitness factors between PT group, PT+AR group, PT+AN group, and PT+CO group. As a result, the variables that showed the most significant changes were grip strength and a 20-meter shuttle run. Grip strength showed a rather high increase in PT+AR group, whereas the 20-meter shuttle run showed a high increase in PT+CO group.

In addition, although there was no statistical significance, the PT group showed the smallest increase in back strength muscle and seated forward bend, while the standing long jump showed a small increase in the PT+AR Group. The sit-ups showed the smallest increase in PT+CO group, while the other three had a slightly larger increase. Although no statistical significance was found in the pre-experiment and post-hoc results of firefighting fitness tests, it showed a somewhat greater increase in PT+CO Group as it was proved by preceding study[19,24]. These results may be due to the small number of subjects in each group and the short experimental period, but the training of fire-fighting physical tests alone suggests that sufficient combined training can be achieved. Considering that the physical strength of the study subjects, who were 27 years old on average, was somewhat higher compared to the physical strength standard given by Jin & Lim[25], it can be figured that the increase range in each training effect was appeared to be relatively small. The study by Kim et al[26] reported that the trend of physical changes from 2002 to 2011 of the female examinees who applied for the Air Force Academy showed continuing decrease in their fitness level for 10 years, which calls for the scientific and systematic fitness programs and exercise training. According to a study conducted by

Park, Kim & Park[27], which examined a relationship between work pattern and physical strength of male police officers, internal work had a negative impact on physical fitness, while external work had a positive impact and that regular physical activity has a positive effect on the body's variables. This study also proved that the participation of firefighters in physical training classes has a positive effect on firefighters' physical fitness tests, and the voluntary participation of firefighters in physical fitness tests would increase the acceptance rate of firefighters.

4.2 Changes in Cardiovascular Factors

According to a prior study on cardiovascular factors for fire officials, Ha[28] reported that systolic blood pressure and relaxation blood pressure were not significant among the changes in cardiovascular risk factors due to job stress. In a study conducted by Yong[29], based on the data from Public Officials Pension Service (1993-2008), it was found that the cause of death for 46% of firefighting officials was internal disease and the 63% was cardiovascular disease. A study by Lee[30] identified the relationship between metabolic syndrome prevalence and related factors in male firefighters aged 30-59 and found that obesity, age, and duties affected metabolic syndrome. On the other hand, among the studies of relation between exercise and cardiovascular factors centered in twenties, Ahn[31] reported that 12 weeks of aerobic exercise showed a positive effects to the cardiovascular factors of male college students who have been smoking for more than five years. Kim, Kim & Lee[32] showed that a 12-week resistance movement for women in their 20s had no significant effect on the improvement of cardiovascular function, and the type of exercise, intensity, and time were the cause of it. According to a study by Kim, Kim & Lee[32], the body mass index has a very positive effect on cardiovascular function as a result of six weeks of intensive intermittent training for those in their 20s with a body mass index of 25kg·m^{-2}. In a study by Yang[33], the results of performing exercise (aerobic exercise, resistance exercise, combined exercise) and intake of quercetin concurrently for 12 weeks for obese female college students with a body mass index of 25 kg·m^{-2} or more or a body fat percentage of 30% or more, it was reported that it is an aerobic exercise which had the greatest effect in improving cardiovascular factors. As a result of examination of difference in cardiovascular factors of 4 groups based on 12-week training for physical fitness test in this study, total cholesterol, glucose, and relaxation blood pressure showed no time and interaction effects, while neutrophils, waist circumference, systolic blood pressure, Framingham Heart Risk Score showed no significant interaction effects, and only HDL-C showed significant changes in PT+CO groups. The reason is that all of the groups conducted in this study included the firefighting fitness test which showed a sufficient positive effect on cardiovascular factors, and HDL-C increased when the exercise consumed 1,200-2,200 kcal of energy per week[34], and the release of fatty acids from fat in muscles is increased and the ratio of fat used an energy source rises, as the glycogen is depleted during the combined exercise. Therefore, studies on the relationship with blood lipids have a negative impact on TG, LDL-C, HDL-C, and TC levels in diagnosing blood lipid, as can be seen in Catalina Romero et al[35], it is suggested that the training should be recommended for the prevention of cardiovascular disease among firefighting officials. When it is compared to the

cardiovascular factors that are suggested by ACSM[36], it is believed that the changes in the group and the timing of the study were appeared as relatively small because the subjects of the study were in the extremely normal level of the study.

Park[37] studied the correlation between lifestyle factors and exercise skills of male fire officials in their 50s who visited health examination center and as a result, she reported that programs which improves your aerobic strength could also in work skill improvement and preventing cardiovascular diseases, and the changes into a therapeutic lifestyle, including exercise, are recommended as the primary strategy for cardiovascular treatment[38]. Therefore, regardless of the training for fitness tests conducted in this study, it is important to focus on preventing the deterioration of the risk factors of cardiovascular disease through continuous and regular physical training.

4.3 Relationship between Framingham Heart Risk Score and Physical Fitness Factors and Cardiovascular Factors.

In this study, even in the correlation between the Framingham Heart Risk variables, systolic blood pressure, diastolic blood pressure, waist circumference, total cholesterol, triglycerides, and LDL cholesterol showed a positive correlation, while HDL cholesterol showed a negative correlation. In other words, FHRS and body mass index, systolic blood pressure, waist circumference, total cholesterol, triglycerides, and LDL cholesterol showed a high correlation of $p<.001$, body fat mass, body fat percentage, diastolic blood pressure, etc. also showed a high correlation of $p<.01$. Among the variables, 20-meter shuttle run and HDL cholesterol showed that as their value increase, FHRS decreases ($p<.01$). 20-meter shuttle run is a variable that measures cardiovascular endurance. As HDL cholesterol, which plays an important role in lipid circulation in the blood, increases, the risk of coronary artery disease decreases. Thus, the 20-meter shuttle run value is also believed to be closely related to the risk of coronary artery disease. Although the improvement in upper muscle strength and muscular endurance, such as grip strength, standing long jump, and other upper body exercises, also resulted in a significant reduction in FHRS($p<.05$), it was shown that the values of seated forward bend, back strength muscle and fasting blood sugar did not show a meaningful correlation with FHRS. Considering that the number of subjects is small and the control during the experiment is not fully achieved, it is necessary to make efforts to lower the prevalence rate of cardiovascular disease by early intervening in physical activities by identifying the relationship between large-scale FHRS and physical factors in the future.

5. Conclusion & Suggestion

The purpose of this study is to investigate the effects of 12-week training for physical fitness test of 2018 firefighter official examinees on changes in physical and cardiovascular factors, and during the selection of subject, the lifestyle habits, physiological levels or genetic traits were not considered. 40 males in 20-30s were randomly categorized to four groups (the firefighters' physical fitness test training group (PT group), firefighters' physical fitness test and aerobic training group (PT+AR group), firefighters' physical fitness test and both aerobic and anaerobic training group (PT+CO group) and participated in the experiment. The analysis items included physical fitness factors

(grip strength, backmusclestrength, seated forward bend, standing long jump, sit-ups, 20-meter shuttle run), cardiovascular factors (total cholesterol, neutral fat, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, glucose, waist circumference, systolic blood pressure, and diastolic blood pressure), and the relationship between Framingham Heart Risk Score and the physical factors and cardiovascular factors were compared and analyzed to obtain the following conclusions.

After 12 weeks of training, positive effects were found on physical strength and cardiovascular factors as a result of the training program. In conclusion, the participation in physical fitness training of firefighter examinees had a positive effect on the firefighter physical fitness test, and it is judged also to be effective in improving cardiovascular disease and helping to lower the prevalence of the cardiovascular disease. Furthermore, based on the results of this study, it is expected that it will be used as basic data for systematic and diverse physical training, improvement of cardiovascular factors, and more effective work performance for firefighters in the field as well as for existing firefighter candidates.

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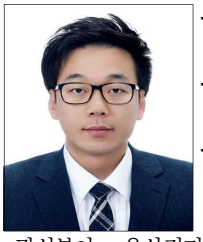

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