African Educational Research Journal
Special Issue 8(1), pp. S17-S25, July 2020
DOI: 10.30918/AERJ.8S1.20.003
ISSN: 2354-2160
Full Length Research Paper

Effects of training on firefighters' physical readiness, fitness and BMI levels

Yetkin Utku Kamuk

Department of Coaching Education, Faculty of Sports, Hitit University, Corum, Turkey.

ABSTRACT

Firefighting is arduous work and it requires a high level of physical fitness and readiness. The purpose of this study is to assess the physical fitness and readiness levels of the Turkish firefighters and investigate the effects of 12-week exercise on firefighters' fitness levels. The study was an experimental study in which 41 firefighters were participated voluntarily. Ethics committee approval and written consents were obtained prior to the study. The experiment group attended to a 12-week planned exercise sessions for two times per week for 90 min. The control group did not participate into a planned exercise during that period. Any caloric restrictions were not recommended nor were calorie intakes controlled in either group. As the Shapiro-Wilk and Q-Q plot tests revealed that the data were normally distributed, independent samples t-test, paired-samples t-test, and Pearson's r to analyse data. The results indicated that body mass index levels of the firefighters in both groups were over the critical level suggested by the World Health Organization and their VO_2max levels did not meet the minimum requirements. It was also found that BMI had disruptive effects on physical performance. The experimental group had significant improvement after attendance to 12-week training but the control group's performances were worsened. It was concluded that the firefighters' physical performances were low and they were highly prone to be obese. Instant measures, including promoting exercise and regularly testing the physical performance levels of the personnel, should be taken to reverse the current undesirable situation.

Keywords: Performance, hardwork, exercise.

E-mail: yetkinkamuk@hitit.edu.tr.

INTRODUCTION

Firefighting demands a high level of fitness to safely perform arduous, day-long work in difficult environmental conditions, including steep terrain, extreme temperatures, altitude, and smoke, and to meet unforeseen emergencies (U.S. Forest Service, 2020). Since it is an arduous work, firefighters have to be ready, both physically and mentally, to face an unknown and unplanned mission. In the USA, every year approximately eighty thousand firefighters are injured and around 100 firefighters die while on duty (CDCP, 2020).

Firefighters face many external stresses and threats and fulfil their duties, but more importantly, they may find it difficult to survive on duty due to insufficient physical fitness levels. It has been reported that 45% of deaths during duty are sudden heart failures and firefighters do not have high aerobic and anaerobic capacity (Smith, 2011). Firefighters should always be ready to cope with the high stress and it is absolutely unacceptable to lose human life or property due to the firefighters' insufficient physical fitness levels or lack of physical readiness when its firefighters' duty to provide public safety (Calcagno, 2012).

Physical fitness is a multi-dimensional concept that expresses the body's ability to perform its functions effectively and efficiently. Fitness also means that the individual works efficiently, enjoys free time activities, is healthy, and free from and resistant to the diseases. Physical fitness has five dimensions as cardiorespiratory endurance, power, muscular endurance, flexibility and body composition. Each dimension has a direct relationship to good health and a good marker for physical performance (Corbin et al., 2019).

Physical readiness is different from fitness and generally refers to being capable of being able to accomplish something that the person is called to do (Mullen, 2010). Physical readiness is crucially important in firefighters and even though the firefighters are selected through a series of tough tests, their physical fitness and readiness levels are adversely affected by factors such as increased use of technology, high calorie intake, smoking, aging and low physical fitness. The most important of these factors is the low level of physical fitness (Wyss, 2010).

The primary duty of the firefighters is to put off fires to save lives and properties but it is a high-demanding job. A large number of fires occur at night, often when people are asleep. Since the human body is programmed to sleep during these hours, fighting with fires at night means extra physiological stress for firefighters, and in these tasks, much more energy is spent when compared to possible fires during the day. Other sources of physiological stress are increased metabolic heat due to the extra temperature produced by working muscles, increased metabolic working speed due to impermeable and thick protective clothing and shoes, and increased body temperature due to heat emitted from the flames in the fire site (Smith et al., 2001).

Since the interventions are directly related to human life, firefighters are required to have high levels of both professional knowledge and physical fitness. It is known that firefighters with high physical performance perform their duties faster and effectively and cause decrease in both deaths and damage in properties (Deng et al., 2001).

Although firefighters have vitally important responsibilities, there are numerous studies shown that many US firefighters were below the required physical readiness level (Baur et al., 2011; Elsner and Kolkhorst, 2008; Kales et al., 1999). Lower levels of physical fitness were shown to have detrimental effects on firefighters' professional performances such as fire intervention, search and rescue, carrying survivors and moving equipment (Holmer and Gavhed, 2007; Heimburg et al., 2006).

The most common cause of death among firefighters in the past 40 years has been reported to be heart-related problems. Excess fat mass in the body adversely affects cardiorespiratory fitness by promoting the risk of heart failures. Fat emerges because of excess calorie intake and inactive lifestyle (Fahy et al., 2015; Hunter et al., 2017).

The aim of this study was to determine the physical fitness and readiness levels of the Turkish firefighters and to examine the effects of attendance to 12-week training on firefighters' fitness and readiness levels.

MATERIALS AND METHODS

Participants

The participants of the present study were chosen from the fire department of the Municipality of Corum city in Turkey. Forty-one firefighters voluntarily participated in the study and the subjects gave their written consents prior to the study. Local university ethics committee approved the study (Protocol No: HITU/2019-138). The subjects were randomly divided into two groups as experiment (EG, n=21) and control (CG, n=20). All the subjects were males and full time firefighters on active duty at the time of study.

Data collection

The subjects were exposed to a series of anthropometric measurements, fitness tests, and a job-related readiness test. Anthropometric measurements included height, weight; waist, hip, and forearm circumferences. Body mass index (BMI), and waist-to-hip ratio (WHR) were also calculated. All the anthropometric measurements were carried out by strictly following the procedures explained in ISAK (2001).

Muscular endurance was tested by applying push-up and sit-up tests (ACSM, 2014) and overhead 5-kg medicine ball throw test was also conducted. Handgrip (HG) test was done by using Takei Kiki Kogyo (Japan) hand dynamometer to assess strength (ACSM, 2014; Gatt et al., 2018) and relative HG strength was calculated by dividing HG performance by weight in kg. Sit and reach test was used to assess flexibility (ACSM, 2014; Thorndyke, 1995). Maximal oxygen consumption levels were measured by 20-meter shuttle run test as prescribed by Leger et al. (1988).

Physical readiness levels of the firefighters were evaluated by using the Performance Related Physical Fitness Test (PRPFT) for Fire Fighters recommended by the Canada National Defence (1998). The test consisted of 10 simulated firefighting tasks and the subjects were instructed to perform the test in full turn-out gear and a self-contained breathing apparatus. The subjects were not allowed to run during or between the tasks but walk in high pace. The time spent to complete the circuit was recorded as the subject's performance.

The exercise program for the experiment group was prepared to cover a safe and effective fitness program and it included cardiorespiratory fitness, muscular strength, muscular endurance, flexibility and agility exercises. The exercise program is provided in Table 1. Each week the same program was repeated for three days and the fire fighters attended to two sessions per week because of their 24-hour on duty/48-hours rest shift.

Mondays, Wednesdays and Fridays were the

Table 1. The 12-week exercise program applied to the subjects.

Wk	Type	Intensity (%)	Time	Wk	Type	Intensity (%)	Time
1	Warm-up	40	15ˈ	7	Warm-up	40	15ˈ
	Stretching	90-100	15ˈ		Stretching	90-100	15ˈ
	Agility	60-75	30ˈ		Muscular fitness	60-70	45ˈ
	Aerobic endurance	45-60	45ˈ		Flexibility	85-100	30ˈ
	Cool-down	40	15ˈ		Cool-down	40	15ˈ
2	Warm-up	40	15ˈ	8	Warm-up	40	15ˈ
	Stretching	90-100	15ˈ		Stretching	90-100	15ˈ
	Agility	60-75	30ˈ		Circuit training	70-75	75ˈ
	Aerobic endurance	45-60	30ˈ		Cool-down	40	15ˈ
	Flexibility	85-100	15ˈ				
	Cool-down	40	15ˈ	9	Warm-up	40	15ˈ
					Stretching	90-100	15ˈ
3	Warm-up	40	15ˈ		Speed training	80-90	45ˈ
	Stretching	90-100	15ˈ		Flexibility	85-100	30ˈ
	Aerobic endurance	45-60	45ˈ		Cool-down	40	15ˈ
	Muscular fitness	45-60	15ˈ				
	Flexibility	85-100	15ˈ	10	Warm-up	40	15ˈ
	Cool-down	40	15ˈ		Stretching	90-100	15ˈ
					Circuit training	70-75	75ˈ
4	Warm-up	40	15ˈ		Cool-down	40	15ˈ
	Stretching	90-100	15ˈ				
	Aerobic endurance	50-65	30ˈ	11	Warm-up	40	15ˈ
	Muscular fitness	50-60	30ˈ		Stretching	90-100	15ˈ
	Flexibility	85-100	15ˈ		Speed training	80-90	30ˈ
	Cool-down	40	15ˈ		Agility	60-75	45ˈ
					Cool-down	40	15ˈ
5	Warm-up	40	15ˈ				
	Stretching	90-100	15ˈ	12	Warm-up	40	15ˈ
	Aerobic endurance	50-65	45ˈ		Stretching	90-100	15ˈ
	Muscular fitness	50-60	30ˈ		Aerobic endurance	60-70	45ˈ
	Cool-down	40	15ˈ		Muscular fitness	65-75	30ˈ
					Cool-down	40	15ˈ
6	Warm-up	40	15ˈ				
	Stretching	90-100	15ˈ				
	Aerobic endurance	60-70	45ˈ				
	Muscular fitness	55-65	15ˈ				
	Agility	60-75	15ˈ				
	Cool-down	40	15ˈ				

exercising days and each firefighter was on duty on one of these days per week. Participants were encouraged not to miss the exercise sessions and the participants were excluded from the study if he missed three sessions in total or two sessions in a row. The subjects were tested in three consecutive days, allowing one day only for the PRPFT, by giving enough resting period between the tests and. Pre-tests were carried out before the 12-week exercise intervention and the post-tests were done following the intervention (Table 1).

Statistical analysis

All test results were recorded to the digital database following every single test. Statistical analysis was performed via IBM SPSS 22.0 commercial software (New York, USA). *Q-Q* Plot and Shapiro-Wilk tests were used to test normal distribution of the data. Descriptives were given as mean ± SD (95% CI). Since it was seen that the data were normally distributed (p for S-W>0.05), independent samples t-test and paired samples t-test were used to analyse the differences between dichotomous variables. Pearson's r was used to inspect the correlation levels between variables. Statistical significance level was set at $p < .05$.

RESULTS

Descriptives of the study group was shown in Table 2. The subjects in the experiment group were younger than the ones in the control group. Both groups' mean BMI values were beyond the recommended healthy ranges. It was shown that the subjects PRPFT performances were almost at maximum in both experiment and the control groups (PRPFT loads were 94.9 ± 8.6% and 95.42 ± 6.75%, respectively).

The effects of 12-week exercise on the anthropometry of the subjects were analysed by using paired samples t test. The results were shown on Table 3. The results provided on Table 3 revealed that exercise had statistically significant effects on waist circumference ($t = 5.595$, $p < .01$) and W/H ratio ($t = 5.184$, $p < .01$). It was found that exercising had an effect on weight, BMI and hip circumference but the amount of decreases were not enough to reach at a critical level to observe statistically significant differences ($p > .05$). The control group had statistically significant differences in weight ($p = .04$), BMI ($p = .04$), hip circumference ($p < .01$), and W/H ratio ($p = .01$). All of these variables of the control group were deteriorated during the 12-week period.

Table 2. Descriptive statistics of the study group.

Variables	Experiment Group (*n*=21) Mean ± *SD* (95% *CI*)	Control Group (*n*=20) Mean ± *SD* (95% *CI*)
Age (years)	37.43 ± 4.68 (28.26-46.6)	43.90 ± 7.30 (29.59-58.21)
Height (cm)	175.55 ± 7.59 (160.67-190.43)	172.23 ± 6.01 (160.45-184.01)
Weight (kg)	83.38 ± 8.71 (66.31-100.45)	87.6 ± 14.19 (59.79-115.41)
BMI ($kg \cdot m^{-2}$)	27.13 ± 3.03 (21.19-33.07)	29.53 ± 4.46 (20.79-38.27)
Waist circumference (cm)	97.26 ± 6.8 (83.93-110.59)	102.58 ± 9.94 (83.10-122.06)
Hip circumference (cm)	102.63 ± 4.77 (93.28-111.98)	104.23 ± 7.24 (90.04-118.42)
Waist/hip ratio	0.95 ± 0.05 (0.85-1.05)	0.98 ± 0.05 (0.88-1.08)
VO_2max ($ml \cdot kg^{-1} min^{-1}$)	30.83 ± 5.34 (20.36-41.30)	24.91 ± 3.4 (18.25-31.57)
Push-up (reps)	15.71 ± 9.82 (0-34.96)	15.26 ± 9.53 (0.00-32.94)
Sit-up (reps)	32.71 ± 10.01 (13.09-52.33)	23.79 ± 10.85 (2.52-45.06)
Relative HG strength	0.566 ± 0.074 (0.42-0.71)	0.513 ± 0.103 (0.31-0.71)
5-kg Medicine Ball Throw (m)	4.66 ± 0.7 (3.29-6.03)	4.64 ± 0.51 (3.64-5.64)
Flexibility (cm)	20.48 ± 5.82 (9.07-31.89)	19.53 ± 6.4 (6.99-32.07)
PRPFT (s.)	343.01 ± 47.2 (250.50-435.52)	383.76 ± 56.02 (273.96-493.56)
PRPFT HR (bpm)	173.7 ± 16.34 (141.67-205.73)	168.32 ± 12.72 (143.39-193.25)
PRPFT load (%)	94.9 ± 8.6 (78.04-111.76)	95.42 ± 6.75 (82.19-108.65)

The results of the analysis between physical fitness tests were shown on Table 4. It was revealed that the experiment group's performances were improved significantly ($p < .01$) while the control group's performances were either deteriorated or not affected positively. The control group's VO_2max scores decreased significantly ($p < .01$) along with their performances on medicine ball throw ($p = .04$). Push-up, sit-up, relative HG strength and flexibility performances of the control group were also decreased but the differences were not statistically significant ($p > .05$).

The subjects' performance related physical fitness test scores were analysed and the results were given in Table 5. Both the experiment group and the control group were seen to be improved their PRPFT performances but the experiment group showed better development. Experiment group's heart rate, ergo, PRPFT load were increased but those increases were not statistically significant ($p > .05$). The same variables on the control group were tended to decrease but the decreases were not enough to be significant ($p > .05$).

The correlations between the PFPFT and the other variables were inspected by using Pearson's r and the results were given in Table 6. Sit-up ($r = -.528$), cardiorespiratory endurance ($r = -.519$), and push-up ($r = -.519$) were seen to have statistically significant and moderate negative correlations with PRPFT at $p < .01$ level. Waist circumference ($r = .457$), waist to hip ratio ($r = .442$), and BMI ($r = .360$) showed statistically significant and moderate positive correlations wits PRPFT at $p < .05$ level. Relative handgrip strength ($r = -.449$), medicine ball throw ($r = -.430$), and flexibility ($r = -.392$) variables were

Table 3. Analysis of differences between pre- and post-test values of anthropometric variables.

Variables		Mean	*SD*	*t*	*df*	*p*
Experiment group (*n*=21)	Weight (pre)	83.38	8.71	0.359	20	.72
	Weight (post)	83.24	7.94			
	BMI (pre)	27.13	3.03	0.344	20	.73
	BMI (post)	27.08	2.84			
	Waist circumference (pre)	96.82	6.83	5.595	20	.00*
	Waist circumference (post)	93.33	5.84			
	Hip circumference (pre)	102.29	4.69	0.137	20	.89
	Hip circumference (post)	102.22	4.50			
	W/H ratio (pre)	0.95	0.05	5.184	20	.00*
	W/H ratio (post)	0.91	0.04			
Control group (*n*=20)	Weight (pre)	87.60	14.19	-2.131	19	.04**
	Weight (post)	88.73	13.87			
	BMI (pre)	29.53	4.46	-2.087	19	.04**
	BMI (post)	29.91	4.34			
	Waist circumference (pre)	102.58	9.94	0.453	19	.66
	Waist circumference (post)	102.35	10.87			
	Hip circumference (pre)	104.23	7.24	-3.213	19	.00*
	Hip circumference (post)	106.58	7.71			
	W/H ratio (pre)	0.98	0.05	2.781	19	.01**
	W/H ratio (post)	0.96	0.06			

* p<.01, ** p<.05.

Table 4. Analysis of differences between performance tests (pre- and post-tests).

Variables		Mean	*SD*	*t*	*df*	*p*
Experiment group (*n*=21)	VO_2max (pre)	30.83	5.34	-9.131	20	.00*
	VO_2max (post)	43.39	4.71			
	Push-up (pre)	16.11	10.53	-10.059	20	.00*
	Push-up (post)	24.61	10.21			
	Sit-up (pre)	33.89	10.12	-3.036	20	.00*
	Sit-up (post)	40.39	10.19			
	Relative HG strength (pre)	0.57	0.08	-3.446	20	.00*
	Relative HG strength (post)	0.61	0.08			
	Med ball throw (pre)	4.74	0.71	-4.260	20	.00*
	Med ball throw (post)	5.02	0.71			
	Flexibility (pre)	21.33	5.33	-6.630	20	.00*
	Flexibility (post)	28.81	5.46			
Control group (*n*=20)	VO_2max (pre)	31.10	2.84	5.245	19	.00*
	VO_2max (post)	29.74	2.82			
	Push-up (pre)	15.26	9.53	-0.705	19	.49
	Push-up (post)	14.37	7.56			
	Sit-up (pre)	23.79	10.85	0.246	19	.80
	Sit-up (post)	23.26	7.87			
	Relative HG strength (pre)	0.51	0.10	-0.070	19	.94
	Relative HG strength (post)	0.50	0.12			
	Med ball throw (pre)	4.64	0.51	2.171	19	.04**
	Med ball throw (post)	4.51	0.52			
	Flexibility (pre)	19.53	6.40	1.325	19	.20
	Flexibility (post)	18.38	7.70			

* *p*<.01, ** *p*<.05.

Table 4. Analysis of differences between performance tests (pre- and post-tests).

Variables		Mean	*SD*	*t*	*df*	*p*
Experiment group (*n*=21)	VO_2max (pre)	30.83	5.34	-9.131	20	.00*
	VO_2max (post)	43.39	4.71			
	Push-up (pre)	16.11	10.53	-10.059	20	.00*
	Push-up (post)	24.61	10.21			
	Sit-up (pre)	33.89	10.12	-3.036	20	.00*
	Sit-up (post)	40.39	10.19			
	Relative HG strength (pre)	0.57	0.08	-3.446	20	.00*
	Relative HG strength (post)	0.61	0.08			
	Med ball throw (pre)	4.74	0.71	-4.260	20	.00*
	Med ball throw (post)	5.02	0.71			
	Flexibility (pre)	21.33	5.33	-6.630	20	.00*
	Flexibility (post)	28.81	5.46			
Control group (*n*=20)	VO_2max (pre)	31.10	2.84	5.245	19	.00*
	VO_2max (post)	29.74	2.82			
	Push-up (pre)	15.26	9.53	-0.705	19	.49
	Push-up (post)	14.37	7.56			
	Sit-up (pre)	23.79	10.85	0.246	19	.80
	Sit-up (post)	23.26	7.87			
	Relative HG strength (pre)	0.51	0.10	-0.070	19	.94
	Relative HG strength (post)	0.50	0.12			
	Med ball throw (pre)	4.64	0.51	2.171	19	.04**
	Med ball throw (post)	4.51	0.52			
	Flexibility (pre)	19.53	6.40	1.325	19	.20
	Flexibility (post)	18.38	7.70			

* $p<.01$, ** $p<.05$.

Table 5. Analysis of differences between Performance Related Physical Fitness Test (PRPFT) performances.

Variables		Mean	*SD*	*t*	*df*	*p*
Experiment group (*n*=21)	PRPFT (pre)	341.96	47.59	10.916	20	.00*
	PRPFT (post)	273.69	39.12			
	PFPFT HR (pre)	172.50	17.32	-0.634	20	.54
	PFPFT HR (post)	175.25	7.83			
	PFPFT load (pre)	94.48	9.03	-0.755	20	.46
	PRPFT load (post)	96.06	5.10			
Control group (*n*=20)	PRPFT (pre)	383.76	56.02	2.354	19	.03**
	PRPFT (post)	344.47	79.35			
	PFPFT HR (pre)	168.32	12.72	0.908	19	.38
	PFPFT HR (post)	164.63	19.83			
	PFPFT load (pre)	95.42	6.75	0.879	19	.39
	PRPFT load (post)	93.35	11.58			

* $p<.01$; ** $p<.05$.

found to have moderate negative correlations with PRPFT ($p < .05$).

Linear regression analysis was conducted to assess the predictive powers of the variables on PRPFT scores. The results were given in Table 7. It was seen that sit-up, push-up, VO2max, waist circumference, and relative HG strength were top-five predictors of PRPFT, with predictive powers .256, .245, .245, .183 and .175,

Table 6. Correlations between PRPFT and other variables.

Variables	PRPFT (s.)	
	r	*p*
Sit-up (reps)	-.528	.00*
VO_2max (ml/kg/min)	-.519	.00*
Push-up (reps)	-.519	.00*
Waist circumference (cm)	.457	.01**
Relative HG strength	-.449	.01**
Waist/hip ratio	.442	.01**
Med ball throw (m)	-.430	.01**
Flexibility (cm)	-.392	.02**
BMI (kg/m^2)	.360	.03**

* $p < 0.01$; ** $p < 0.05$.

Table 7. Linear regression analysis results to assess predictive powers of the variables on PRPFT performance.

Variable	*R*	R^2	Adjusted R^2	Standard Error of Estimate
Sit-up	0.528	0.279	0.256	64.05
Push-up	0.519	0.269	0.245	64.49
VO_2max	0.519	0.269	0.245	50.69
Waist circumference	0.457	0.209	0.183	67.10
Relative HG strength	0.449	0.201	0.175	67.41

respectively.

DISCUSSION AND CONCLUSION

The purpose of this study was to examine the effects of attending to planned exercise sessions for 12 weeks on firefighters' anthropometric measurements, physical fitness and readiness levels. It is well-known that firefighting is physically demanding and hazardous task (Abel et al., 2015) that is characterized by prolonged periods of low-intensity work and occasional bouts of moderate to high-intensity efforts (Barr et al., 2010). To meet the physiological requirements of these demanding tasks, firefighters should always be physically fit and ready. Although it was desired that the firefighters would have good level of fitness, some researchers have proven that this was not the case.

According to the National Fire Protection Association (NFPA), firefighters' minimum acceptable aerobic capacity standard should be 42 ml/kg/min (NFPA, 2007). Since NFPA is not a governing body for the firefighters in the United States, only one third of the administrators in fire services take their advice (Barry et al., 2019). Some other researchers suggested to have an aerobic capacity about 45 ml/kg/min to perform firefighting tasks safely (Elsner and Kolkhorst, 2008; Holmer and Gavhed, 2007). In the current study, the firefighters' BMI values were over the healthy range and aerobic capacities were much lower than the recommended 42 ml/kg/min level. Attending to the exercise sessions improved firefighters' aerobic fitness levels positively and raised it from 30.83 ± 5.34 ml/kg/min to 43.89 ± 4.71 ml/kg/min, which is over the recommended minimum level. However, in a review by Barr et al., it was clearly demonstrated that firefighters had different levels of aerobic capacities worldwide but the average was around 45.0±5.0 ml/kg/min and it was stated that the firefighters with values about 31.5 ml/kg/min and a bit over that would not be able to perform well during the firefighting tasks (Barr et al., 2010). Even though the importance of the aerobic capacity is well-known, many firefighters had lower aerobic fitness levels below the recommended level. In a study conducted on the Brazilian firefighters, it was reported that 60% of the personnel had cardiorespiratory fitness levels lower than 42 ml/kg/min (Abel et al., 2015). It should be kept in mind that aerobic fitness is very important for the firefighters because tasks such as victim drag, ladder climbs, hose carrying and performing in stressed environment puts a very heavy load on the firefighters aerobic system and this energy cost can be up to 80-100% of the firefighters' aerobic capacities (Elsner and Kolkhorst, 2008). In a study it was concluded that aerobic capacity had a severe impact on firefighting tasks and it was reported that 22% of the firefighters who were exposed to a series of firefighting tasks could not finish the course due to excess fatigue, moreover, all of those who quit the physical readiness course had VO_2max values lower than 35 ml/kg/min (Sothmann et al., 1990).

Aerobic fitness, which has been recognized as one of the fundamental components of physical performance (Astrand and Rodahl, 1986; Johnson, 1991), is directly related to firefighting tasks (Sothmann et al., 1992) and it is an important aspect of firefighters' health (Donovan et al., 2009). A high level of aerobic fitness was reported to be the key to quality in firefighters' performances (Rhea et al., 2004). Aerobic fitness delays the onset of fatigue and therefore a good aerobic fitness level may contribute to prevent the firefighters from injuries and fatal errors (Barr et al., 2010). Along with these, Barry et al. (2019) reported that waist circumference was a good predictor of VO_2max which was associated to firefighting tasks. The correlation between physical performance test and the hip circumference in the current study was found to be statistically significant and the PRPFT times worsened as the waist circumference increased. It can be told that high aerobic capacity is essential for a firefighter and attending to regular exercises has positive effects on the aerobic capacity and the exercise sessions should be extended throughout the year. I will help the firefighters be fit and lower the risk of cardiorespiratory problems due to increased ventilation and lowered fat mass.

In the current study, obesity levels of the firefighters were assessed by using BMI categories. It was found that the firefighters were all overweight and the control group subjects were nearly obese. BMI values in the experiment group did not change significantly as a result of regularly participating into the 12-week exercise sessions but attending to exercises prevented the experimental group subjects from getting worse. The control group's BMI values were negatively affected and the deterioration was statistically significant. No changes were observed in the experiment group's hip circumferences but the control's pre- and post-test comparisons revealed that not attending to regular exercises increased their hip circumferences significantly. In a study conducted by Damacena et al. (2020), more than half of the firefighters were at overweight and obese categories.

Most of the firefighters in the U.S., as much as 75%, were reported to be overweight and 40% of them were obese (Baur et al., 2012). Fat mass adversely affects firefighters' performances by acting as an insulator in hot environments thereby increasing the core temperature (McLellan, 1998) and by adding extra weight to be carried thereby disrupting the tasks such as climbing, hose pulling and victim drag (Williford et al., 1999). It was also shown earlier that heavier firefighters climbed the stairs slower and climbing time was prolonged as fatness increased (Lyons et al., 2005). Previous studies clearly revealed the negative effects of higher BMI values on firefighting tasks ant those were supported the results of the current study. It was found that BMI level had a significant positive correlation with performance related physical fitness test results. It was proven that higher BMI levels caused extended PRPFT times.

Firefighting is not only an aerobic work but includes anaerobic efforts. As 40% of the energy expenditure of the firefighting tasks demanded on anaerobic system, firefighters required to have a good anaerobic capacity and a greater power is a predictor for better performance as a strong correlation between anaerobic capacity and firefighters' performance was reported earlier (Rhea et al., 2004). It was reported that high level of strength reflected success on firefighting tasks. Handgrip strength and simple field tests for muscular strength such as push-ups and sit-ups were recommended to predict firefighting performance (Henderson et al., 2007; Sothmann et al., 2004). As firefighting is a demanding job and is a hard work, firefighters will need strength which is directly related to muscle mass; otherwise the firefighters will struggle to perform their tasks (Barr et al., 2010). In the current study, it was found that performance related physical fitness test was mostly related to the sit-up performance. There was a negative significant correlation and PRPFT times decreased as the sit-up performances increased. Push-up was also found to have similar correlation with the PRPFT. Linear regression analysis results were revealed that both sit-up and push-up performances were very good predictors of the PRPFT. Sit-up was found to explain 25.6% of the variance and push-up was found to have a level of 24.5%. Relative handgrip explained 17.5% of the variance. As it can be seen from the results of the analysis, strength has a very high predictive power on the performance related physical fitness test scores. Experiment group's sit-up, push-up, and relative handgrip strength performances were affected significantly by attending to the 12-week exercise program. Control group's scores were decreased but the levels of the deterioration were not enough to have significant differences. It can be seen from the results that strength had a positive effect on performance related physical fitness test and attending to exercises regularly increased the strength levels of the firefighters. It can be concluded that exercising regularly will increase the muscular fitness levels of the firefighters and therefore their performance related physical performance will get better.

As a result of this study, it was concluded that firefighters' general physical fitness level was not at the desirable level but it can be improved by attending to regular exercise sessions. The most important components that affected the performance related physical fitness test were found to be sit-up, push-up, and VO_2max, revealing the importance of muscular strength and cardiorespiratory fitness. It can be concluded that firefighters should continue exercising throughout the year and performance related physical fitness tests should be regularly carried out by the supervisors to check the readiness levels of the firefighters.

ACKNOWLEDGEMENT

This study was funded by Corum Municipality.

REFERENCES

Abel, M. G., and Palmer, T. G., and Trubee, N. (**2015**). Exercise program design for structural firefighters. Strength and Conditioning Journal, 27(4): 8-18.

ACSM's Guidelines for Exercise Testing and Prescription (**2014**). American College of Sports Medicine. 9th ed. China: Lippincott Williams & Wilkins. p. 96-108.

Astrand, P. O., **Rodahl**, K. (**1986**). Textbook of Work Physiology. New York: McGraw-Hill Book Company. p. 291-304.

Barr, D., Gregson, W., and Reilly, T. (**2010**). The thermal ergonomics of firefighting reviewed. Applied Ergonomics, 41(1):161-172.

Barry, A. M., Lyman, K. J., Dicks, N. D., Landin, K. D., McGeorge, C. R., Hackney, K. J., and Walch, T. J. (**2019**). Firefighters' physical activity and waist circumference as predictors of VO_2max. Journal of Occupational and Environmental Medicine; 61(10):849-853.

Baur, D. M., Christophi, C. A., Cook, E. F., and Kales, S. N. (**2012**). Age-related decline in cardiorespiratory fitness among career firefighters: modification by physical activity and adiposity. Journal of Obesity, 2012:1-6.

Baur, D. M., Christophi, C. A., Tsismenakis, A. J., Cook, E. F., and Kales, S. N. (**2011**). Cardiorespiratory fitness predicts cardiovascular risk profiles in career firefighters. Journal of Occupational and Environmental Medicine, 5: 1155-1160.

Calcagno, C. (**2012**). Physical fitness in the fire service. Fire Engineering; December:77-80.

Centers for Disease Control and Prevention (**CDCP**) (**2020**). Fire Fighter Fatality Investigation and Prevention. Accessed at: https://www.cdc.gov/niosh/fire/default.html Accessed on: 14 March 2020.

Corbin, B. C., Welk, G. J., Corbin, W. R., and Welk, K. A. (**2019**). Concepts of fitness and wellness: a comprehensive lifestyle approach. 12th Ed. New York: McGraw-Hill Education. p. 9-10.

Damacena, F. C., Batista, T. J., Ayres, L. R., Zandonade, E., and Sampaio, K. N. (**2020**). Obesity prevalence in Brazilian firefighters and the association of central obesity with personal, occupational and cardiovascular risk factors: a cross-sectional study. BMJ Open; 10: e032933.

Deng, T. J., Hsieh, C. H., Yang, C., and Sheu, H. J. (**2001**). A conceptual framework for improving fire-fighting service quality of a public fire department. International Journal of Public Management, 24(4): 405-422.

Donovan, R., Nelson, T., Peel, J., Lipsey, T., Voyles, W., Israel, R. G. (**2009**). Cardiorespiratory fitness and the metabolic syndrome in firefighters. Journal of Occupational Medicine, 59(7): 487-492.

Elsner, K. L., and **Kolkhorst**, F. W (**2008**). Metabolic demands of simulated firefighting. Ergonomics, 51(9): 1418-1425.

Fahy, R. F., LeBlanc, P. R., and Molis, J. L. (**2015**). Firefighter fatalities in the United State. National Fire Protection Association Research. 1–24. Accessed at: https://www.nfpa.org/News-and-Research/Data-research-and-tools/Emergency-Responders/Firefighter-fatalities-in-the-United-States. Accessed on: 21 November 2019.

Gatt, I., Smith-Moore, S., Steggles, C., and Loosemore, M. (**2018**). The Takei handheld dynamometer: an effective clinical outcome measure tool for hand and wrist function in boxing. Hand, 13(3): 319-324.

Heimburg, E. D., Rasmussen, A. K., and Medbo, J. I. (**2006**). Physiological responses of firefighters and performance predictors during a simulated rescue of hospital patients. Ergonomics, 49: 111-126.

Henderson, N. D., Berry, M. W., and Matic, T. (**2007**). Field measures of strength and fitness predict firefighting performance on physically demanding tasks. Personnel Psychology, 60(2): 431-473.

Holmer, I., and **Gavhed**, D. (**2007**). Classification of metabolic and respiratory demands in fire fighting activity with extreme workloads. Applied Ergonomics, 38: 45-52.

Hunter, A. L., Shah, A. S. V., Langrish, J. P., Raftis, J. B., Lucking, A. J., and Mills, N. L. (**2017**). Fire simulation and cardiovascular health in firefighters. Circulation, 135: 1284-1295.

International Society for the Advancement of Kinoanthropometry (**ISAK**) (**2001**). International Standards for Anthropometric Assessment. Underdale; p. 53-84.

Johnson, A. T. (**1991**). Biomechanics and Exercise Physiology. New York: Wiley. p. 12-15.

Kales, S. N., Polyhronopoulos, G. N., Aldrich, J. M., Leitao, E. O., Christiani, D. C. (**1999**). Correlates of body mass index in hazardous materials firefighters. Journal of Occupational and Environmental Medicine, 41: 589–595.

Leger, L. A., Mercier, D., Gadoury, C., and Lambert, J. (**1988**). The multistage 20 metre shuttle run test for aerobic fitness. Journal of Sports Sciences, 6:93-101.

Lyons, J., Allsopp, A., and Bilzon, J. (**2005**). Influences of body composition upon the relative metabolic and cardiovascular demands of load-carriage. Occupational Medicine, 55: 380-384.

McLellan, T. M. (**1998**). Sex-related differences in thermoregulatory responses while wearing protective clothing. European Journal of Applied Physiology and Occupational Physiology, 78: 28–37.

Mullen, M. (**2010**). On total force fitness in war and peace. Military Medicine, 175(8):1-2.

National Fire Protection Association (**NFPA**) (**2007**). NFPA Association 1582: Standard on Comprehensive Occupational Medical Program for Fire Departments. Quincy, MA: National Fire Protection Association. p. 66.

Preparation for Fire Fighter Physical Fitness Maintenance Program Evaluation (**1998**). **Canada National Defence**. Canada: DGPA Creative Services. p. 3-8.

Rhea, M. R., Alvar, B. A., Gray, R. (**2004**). Physical fitness and job performance of firefighters. Journal of Strength and Conditioning Research; 18(2): 348-352.

Smith, D. L. (**2011**). Firefighter fitness: improving performance and preventing injuries and fatalities. Firefighter Fitness, 10(3): 167-172.

Smith, D. L., Manning, T., and Petruzzello, S. J. (**2001**). Effect of strenuous live-fire drills on cardiovascular and psychological responses of recruit firefighters. Ergonomics, 44(3): 244-254.

Sothmann, M. S., Gebhardt, D. L., Baker, T. A., Kastello, G. M., and Sheppard, V. A. (**2004**). Performance requirements of physically strenuous occupations: Validating minimum standards for muscular strength and endurance. Ergonomics, 47(8): 864-875.

Sothmann, M. S., Landy, F., and Saupe, K. (**1992**). Age as a bona fide occupational qualification for firefighting: a review on the importance of measuring aerobic power. Journal of Occupational Medicine, 34(1): 26-33.

Sothmann, M., Saupe, K., and Jasnof, D. (**1990**). Advancing age and the cardiorespiratory stress of fire suppression: determining the minimal standards for cardiorespiratory fitness. Human Performance, 3: 217-236.

Thorndyke, M. A. (**1995**). Evaluating flexibility with the sit and reach test. Strength and Conditioning; December: 12-15.

U.S. Forest Service (**2020**). Work Capacity Test. Accessed at: https://www.fs.usda.gov/Internet/ FSE_DOCUMENTS/stelprdb5112313.pdf, Accessed on: 06 January 2020.

Williford, H. N., Duey, W. J., Olson, M. S., Howard, R., and Wang, N. (**1999**). Relationship between fire fighting suppression tasks and physical fitness. Ergonomics, 42(9): 1179-1186.

Wyss, T. (**2010**). Physical activities and demands in Swiss soldiers. Doctoral Thesis. Zurich: Eidgenössiche Technische Hochschule.

Citation: Kamuk, Y. U. (2020). Effects of training on firefighters' physical readiness, fitness and BMI levels. African Educational Research Journal, 8(1): S17-S25.