
Muscular Strength and Body Composition Comparison Between the Charlotte-Mecklenburg Fire and Police Departments

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ABSTRACT

Int J Exerc Sci 1(3) : 125-135, 2008. Firefighters and police have different physical job requirements and selection processes. Firefighters have on-duty exercise time and police do not. This could affect body composition and strength. The purpose of this investigation was to compare body composition and bench press strength between firefighters and police officers in the Charlotte-Mecklenburg departments. Current 2006 fitness records were analyzed to compare firefighters and police (N = 2330). Variables included: gender, age, body mass, percent body-fat, fat mass, lean mass, bench press strength, bench press/lean mass, bench press/body mass, and percent that were obese. Significant ($p \leq 0.05$) differences were found between male firefighters and police in age (37.7 vs. 36.9 yrs), body mass (91.5 vs. 93.2 kg), percent body-fat (17.8% vs. 18.5%), fat mass (16.9 vs. 18.0 kg), bench press strength (93.4 vs. 96.3 kg), bench press/body mass (1.03 vs. 1.05) and percent that were obese (10% vs. 17%), respectively. Significant differences between female firefighters and police were found in age (42.4 vs. 37.4 yrs), body mass (77.5 vs. 71.8 kg), lean mass (54.4 vs. 51.2 kg), bench press strength (52.3 vs. 43.9 kg), bench press/lean mass (0.99 vs. 0.86) and bench press/body mass (0.69 vs. 0.62), respectively. Male police were younger, weighed more, had higher percent body fat, higher percent of obesity, and had greater upper body strength than firefighters. Female police were younger, weighed less, had less lean mass and less upper body strength than their firefighter counterparts. Contributing factors might include pre-employment selection, recruit training, in-service physical fitness testing, and counseling provided by departments.

KEY WORDS: Occupation, physical fitness, pre-employment testing, public safety

INTRODUCTION

The firefighting and police occupations are demanding, frequently dangerous, and involve periods of high physical exertion. Strength is a critical factor in performance of their job duties. Increased muscular

strength is positively associated with health (13) and provides protective benefits against disability (6, 19) and chronic diseases such as heart disease (24), diabetes (16) and metabolic syndrome (29). Strength supports the ability of both fire and police personnel to safely perform critical

emergency functions (11, 23) while fulfilling the local government's legal responsibility to deliver adequate protection to the public.

Strength is an important criterion in the selection and hiring of both police officers and firefighters and it is the responsibility of these organizations to establish minimum requirements for officer selection and hiring in order to ensure that applicants are physically capable of performing the work. These selection criteria must also be in accordance with the applicable state and federal fair employment laws. There are legal ramifications regarding the potential adverse impact of pre-employment testing upon the hiring of legally protected groups such as females and minorities (7, 21, 23). Females, in particular, having lower upper body strength than males, are almost guaranteed an adverse impact in a test that demands upper body strength (23).

Different physical conditions and expectations apply to these two jobs. The occupation of police officer, though mentally challenging, is primarily sedentary, with occasional periods of maximal exertion (25). Some of the critical functions of the job of police officer include the use of firearms, restraining suspects, removing demonstrators, rescuing victims, running in pursuit, climbing stairs, and surmounting barriers (23). However, the routine physical demands of this job, such as riding in a patrol car and preparing paperwork, are often inadequate for maintaining necessary physical fitness to perform these infrequent but possibly life-saving critical functions (26). Low levels of physical activity have been shown to promote increases in weight, body fat, and

potential health issues (4, 20). Weight gain can also account for decline in an officer's physical performance (25) and is associated with decreases in cardiopulmonary fitness (8).

In contrast, a firefighter is required to execute a variety of physically challenging tasks, usually while wearing heavy protective gear and under extreme environmental conditions. Some of the critical job functions of a firefighter include rescuing victims, crawling through smoke, dragging or pulling a charged line, lifting victims on a stretcher, pulling ceilings, surmounting barriers, breaching a wall or door, climbing stairs with a pack, and raising or lowering a ladder (23). Another aspect of the job of a firefighter is the long work shifts and the waiting time between events. This time spent waiting can potentially result in a similar risk of weight gain, as in the job of police.

Comparative research identifying the relationship of body composition and strength of firefighters to police officers is dearth. Nor were any fire and police comparison studies found that included females. The number of females is especially low in firefighting and therefore, under represented in the literature. A need exists in these occupations to investigate body composition to gain insight into the numerous factors affecting body composition and strength. This information can aid administrators regarding program design to foster strength development, weight management, and the health of these public safety personnel.

A large metropolitan fire and police department in the Southeastern United

States has had an on-going physical fitness training and testing of personnel for over twenty-five years. This provided a unique opportunity to contrast these two occupations strengthened by the fact that the same test administrator performed identical evaluations of body composition and bench press strength for both departments over the time period covered by this report.

This study sought to determine whether there were differences in body composition and strength scores between firefighters and police officers. The hypothesis was that no significant differences would be found in body composition and strength variables between the two occupations within genders and between genders within the occupations.

METHOD

Comparisons were made between the occupations within genders and between genders within the occupations. Body composition variables included body mass, percent body fat, fat mass, lean mass, and percent that were obese. Strength scores were comprised of bench press, bench press/lean mass, and bench press/body mass. Body composition and strength mean scores with standard deviations and statistical comparisons between groups were described.

Subjects

The retrospectively studied sample included 922 firefighters (885 males, 37 females) and 1408 police officers (1208 males, 200 females). Their 2006 physical fitness test records were obtained from the Charlotte Mecklenburg Fire and Police Departments which represent large

metropolitan organizations in the Southeastern United States of America. Mean values with their standard deviations (SD) are provided in the text as mean \pm SD. The mean age of the subjects was 37.4 ± 7.5 years with a range from 20 years to 65 years. The University of North Carolina at Wilmington Institutional Review Board approved this study following the Office of Human Research Protection Requirements. Because this research involved existing and unidentifiable data it was exempt from applicable human subject regulation. The tests and measurements were required as a part of conditions of their employment.

Procedures

Age, gender, body mass, percent body fat, and bench press strength data were retrieved for each firefighter and police officer from their most recent test on the 2006 in-service fitness record. The same physical fitness coordinator, certified by the American College of Sports Medicine (ACSM), administered these tests.

Included in the physical fitness test battery were body mass, percent body fat using a skinfold caliper (12), and a one repetition maximum (1RM) bench press test (18) using a Smith Bench Press Machine (Atlantis Angled Smith Machine E-155, Quebec, Canada). This machine was selected because the framework served to prevent the possibility of the weights dropping on the subject. The skinfold test utilized a three-site formula. The sites for males were chest, abdomen, and thigh. The sites for females were triceps, suprailiac, and thigh (12). The testing protocol was based upon ACSM's Guidelines for Exercise Testing and Prescription (28). The testing sequence for the in-service officers was body fat,

bench press (18), treadmill (10), muscle endurance (either curl-ups or push-ups), and sit and reach (28). Subjects were allowed to warm up on the bench press to prepare for that test. Subjects could make multiple bench press attempts until they felt they had achieved their best score and that score was recorded. The tests selected for this study were body mass, percent body fat and the bench press. Test protocols were identical for firefighters and police officers.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS, Inc) version 15.0 was used to analyze the data. Analysis of variance (ANOVA) procedures compared differences between the firefighters and police officers within genders and the differences between genders within each department. The variables of interest were age, body mass,

percent body fat, fat mass, lean mass, bench press, bench press/lean mass, and bench press/body mass. A Fisher’s exact test was used to evaluate the differences in the percentage that were obese between the firefighters and police officers within genders, and between genders within each department. A male was classified as obese with a percent body fat $\geq 25\%$ and a female with a percent body fat $\geq 30\%$. The p-value used to define significance was $p \leq 0.05$.

RESULTS

Table 1 presents the means and standard deviations of age, body mass, percent body fat, and bench press strength scores for male and female firefighters and police officers. The male police were significantly ($p \leq 0.05$) younger, weighed more, had a higher body-fat percentage, and had

Table 1. Comparison of firefighters and police officers for age, body mass, percent body fat and strength

		Female				Male			
		N	Mean	SD	p-value	N	Mean	SD	p-value
Age	Fire	37	42.4	6.4		885	37.7	8.4	
	Police	200	37.4	7.2		1208	36.9	6.7	
	Total	237	38.2	7.3	0.000 †††	2093	37.3	7.5	0.019 †
Body Mass (kg)	Fire	37	77.5	14.0		870	91.5	14.8	
	Police	200	71.8	14.6		1208	93.2	16.2	
	Total	237	72.7	14.6	0.031 †	2078	92.5	15.7	0.013 †
% Body Fat	Fire	37	28.8	8.1		870	17.8	5.7	
	Police	200	27.6	7.2		1208	18.5	6.2	
	Total	237	27.7	7.3	0.347	2078	18.2	6.0	0.014 †
Bench Press (kg)	Fire	36	52.3	10.4		818	93.4	18.9	
	Police	195	43.9	9.4		1181	96.3	20.9	
	Total	231	45.2	10.0	0.000 †††	1999	95.1	20.2	0.002 ††

ANOVA comparison between departments: † $p \leq 0.05$, †† $p \leq 0.01$, ††† $p \leq 0.001$

SD = Standard Deviation

greater upper body strength than male firefighters. Female police were significantly ($p \leq 0.05$) younger, weighed less and had less upper body strength than female firefighters. However, their percentage of body fat was similar.

Figure 1 features box plots which compare the body mass of firefighters and police officers. When comparing the males, the inter-quartile ranges, the boxes, were roughly similar between firefighters and police officers. However, the overall spread in scores, as illustrated by the whiskers of the plot, was greater in police and they showed a lower minimum and greater maximum data values than male firefighters. In females, the police officers also demonstrated a greater spread in body mass. The inter-quartile range of female police was shifted lower than that of the female firefighters.

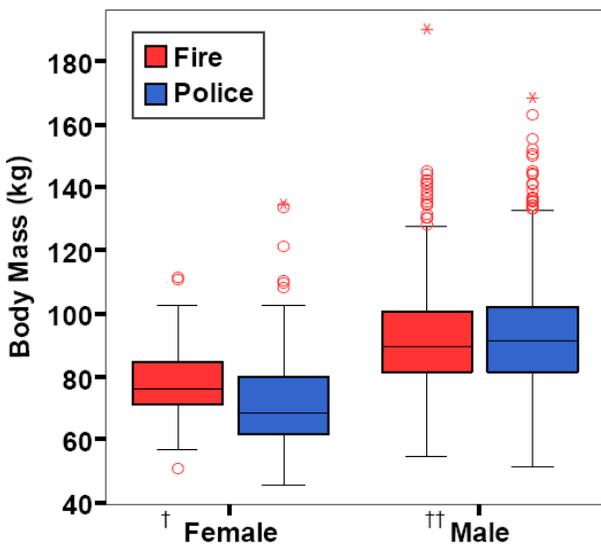


Figure 1. Box plots for comparing body mass of firefighters and police officers. ANOVA comparisons between departments: † $p \leq 0.05$, †† $p \leq 0.01$

The box plots in Figure 2 compare the percent body fat of firefighters and police. The spread of scores was greater for male police than the male firefighters. Even though the median scores for female police were lower than the firefighters, the maximum and minimum data values for police were higher.

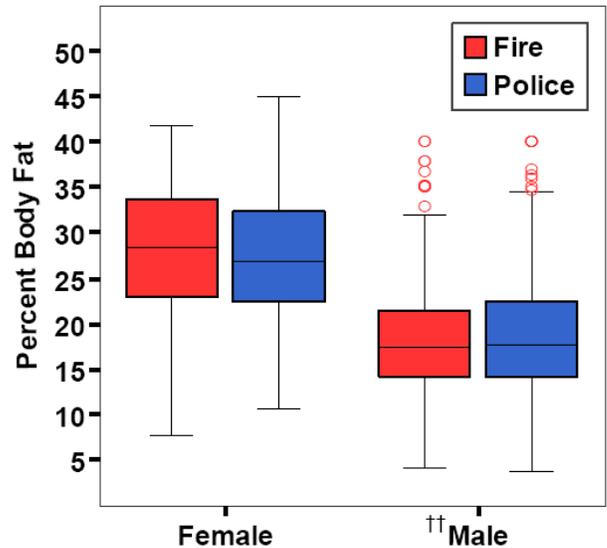


Figure 2. Box plots for comparing percent body fat of firefighters and police officers. ANOVA comparisons between departments: †† $p \leq 0.01$

In Figure 3 the box plots compare bench press strength. The male police officers had higher median scores than the firefighters. Once again, the spread of scores was greater in male police officers and they had higher maximum data values. The spread in scores between the females was similar. The inter-quartile range of female police, as well as their minimum and maximum data values, was shifted lower than the firefighters.

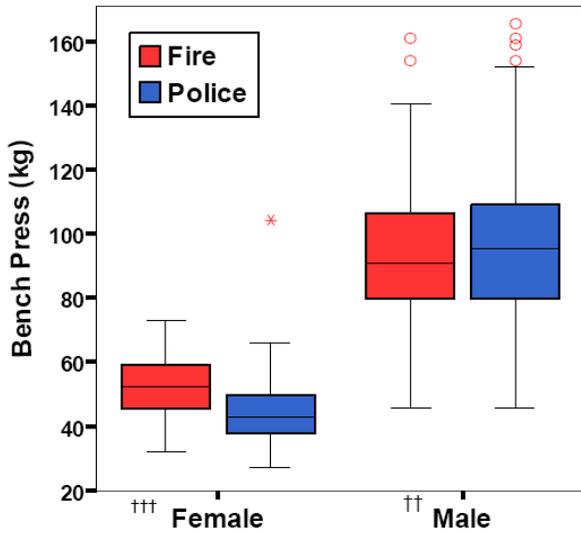


Figure 3. Box plots comparing firefighters and police officer bench press strength. ANOVA comparisons between departments: †† $p \leq 0.01$ and ††† $p \leq 0.001$

Figure 4 compares the percentage of firefighters and police officers that were obese. The percentage of obese within the male police officers was significantly higher than the firefighters. However, there was no significant difference between the females.

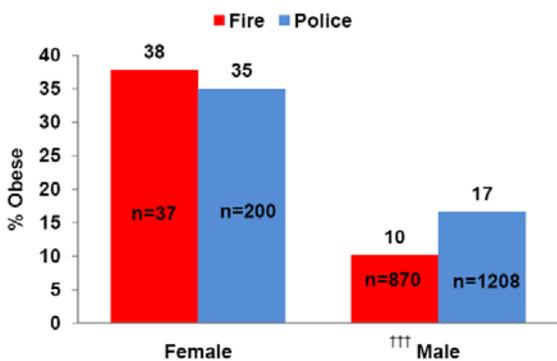


Figure 4. Comparison of percentage of firefighters and police officers that are obese. Fisher's exact test comparisons between departments: ††† $p \leq 0.001$
Female obesity $\geq 30\%$ body fat. Male obesity $\geq 25\%$ body fat

Male firefighters had significantly less mean fat mass than police officers, $16.9 \pm$

7.8 kg vs. $18.0 \pm 8.9 \text{ kg}$, respectively. However, there were no significant differences in the males' mean lean mass, $74.6 \pm 9.3 \text{ kg}$ vs. $75.2 \pm 9.3 \text{ kg}$ for firefighters and police officers, respectively. The opposite occurred in the females, there were no significant differences in their fat mass, $23.0 \pm 9.9 \text{ kg}$ vs. 20.6 ± 9.4 for firefighters and police officers, respectively. However, the female firefighters were significantly higher in lean mass, $54.5 \pm 7.3 \text{ kg}$, than the female police officers, $51.2 \pm 6.5 \text{ kg}$. Figure 5 demonstrates that the spread of scores was relatively consistent between females in both fat and lean mass. The scores were also consistent between the males for both fat and lean mass.

Male police officers showed a tendency ($p \leq 0.07$) to be stronger, 1.28 ± 0.23 , in bench press/lean mass than firefighters, 1.26 ± 0.19 . Male police officers had a significantly ($p \leq 0.03$) higher bench press/body mass, 1.05 ± 9.22 , than firefighters, 1.03 ± 0.19 . The female firefighters were significantly ($p \leq 0.001$) stronger, 0.99 ± 0.21 than the female police officers, 0.86 ± 0.15 in bench press/lean mass. They were also significantly ($p \leq 0.009$) stronger in bench press/body mass, 0.69 ± 0.19 vs. 0.62 ± 0.14 for the female police. The box plots in Figure 6 depict the variability of the scores. The male police officers had the greatest variability of scores for both bench press/lean mass and bench press/body mass. The male police officer range of scores included both the lowest and highest values.

When comparing males to females within firefighters and police officers, males weighed significantly ($p \leq 0.001$) more, had less percent body fat, a lower percent of

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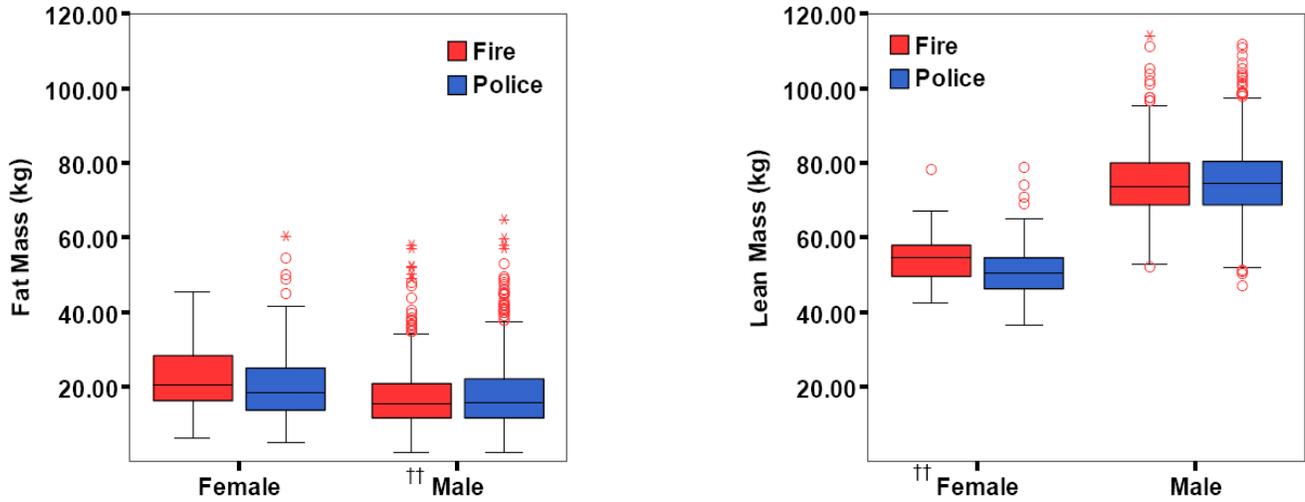


Figure 5. Box plot for comparing fat and lean weight of firefighters and police officers. ANOVA comparisons between department: †† $p \leq 0.01$

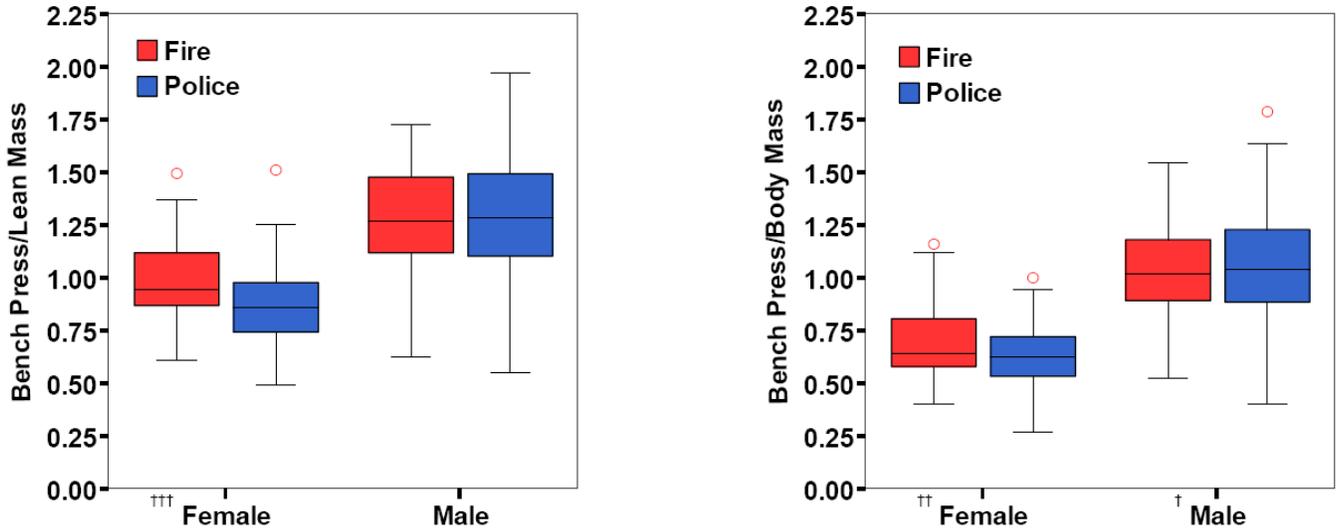


Figure 6. Box plot for comparing bench press/lean mass and bench press/body mass of firefighters and police officers.

ANOVA comparisons between departments: † $p \leq 0.05$, †† $p \leq 0.01$ and ††† $p \leq 0.001$

obesity, and lower fat mass than females. They also had significantly ($p \leq 0.001$) greater lean mass, higher bench press strength and higher bench press/lean mass and bench press/body mass than females. The male firefighters were significantly ($p \leq 0.001$) younger than the female firefighters and the ages were similar between male and female police. Refer to Table 1 for the

means and standard deviations of these variables.

DISCUSSION

The data considered in this study provided a unique opportunity to examine two similar, though different, occupations for the purpose of observing the affect these

occupations had upon body composition and strength. In this study, it appeared that the more sedentary aspects of the job of police, along with other factors, affected the higher amount of body fat in male officers, even though their lean mass remained approximately the same as their firefighter counterparts. While the firefighters had a more physically demanding job, on-duty exercise time, and a more rigorous job-related physical ability test as part of their pre-employment selection process, this study revealed that the male firefighters were not as strong, as measured by the bench press, as the male police officers. However, in the case of the females the firefighters were significantly stronger than the police officers.

There are substantial differences in the pre-employment physical ability testing requirements of the two departments which could influence body composition and strength factors. The current recruitment process for new firefighters is more strenuous than that for police in the Charlotte-Mecklenburg departments. Fire applicants are required to pass a CPAT (1, 2), which includes a battery of eight events to be completed in less than 10 minutes and 20 seconds. Tasks are performed wearing a 22.68 kg vest, protective clothing, a helmet, and a breathing apparatus. Two 5.67 kg weights, simulating a high-rise pack, are added for the stair-climb event. The events include stair climb, hose drag, equipment carry, ladder raise and extension, forcible entry, search, rescue, and ceiling breach and pull.

The current application process for police also includes a job related physical ability test (3). While this test requires physical

exertion it is not compounded with the specialized clothing or equipment involved in the firefighter's test. The tasks include running 200 yards, step up on an aerobic step bench 20 times, 15 push ups, 15 sit ups, step up on an aerobic step bench another 20 times, 15 push ups, 15 sit ups, run 200 yards, and recall a street address given at the beginning of the test. Applicants must complete this test in no more than 6 minutes and 18 seconds.

The more rigorous nature of the CPAT may be the reason for the small number of females in this fire department sample, only 37 out of a total of 922 firefighters. It may be reasonable to assume that the heavy equipment and strenuous physical tasks required in a fire department job had a greater impact on the recruitment of females than it did on males. This selection process along with the intense routine physical requirements of the job could also explain why the female firefighters were significantly stronger, heavier, and had more lean mass than their police counterparts. However, the small number of firefighters and disparity in sample size between the departments, 37 firefighters vs. 200 police, could have influenced these statistical outcomes. Further research is needed with larger samples of females.

This same selection process and job demands could have been expected to result in similar body composition and strength differences for the males. However, the male police were stronger than their fire counterparts. They also had higher body mass, percent body fat and percentage that were obese than the firefighters. One rationale for the differences might be the culture of police

work and their need to project authority. Another aspect may be the type of individuals attracted to employment in these two professions. Further research is needed to investigate if the occupation of police attracts people with different physical attributes or athletic backgrounds or career experience (such as the military) than that of the fire department.

The fact that the police occupation involves more sedentary activities than firefighting may have had an influence on their body composition results which could potentially increase their health risks. This corresponded with the literature regarding sedentary occupations (5, 17) and the affect of lower activity levels on weight gain, body fat and health issues (4, 20). The literature also suggested that weight gain was associated with decreases in cardiopulmonary fitness (8) and physical performance (25). Further research is recommended to investigate if the male police, with their higher body mass, percent body fat, fat mass, and percent that were obese, have less cardiopulmonary fitness than their firefighter counterparts.

The literature suggests that increases in body mass correspond with increases in lean mass by as much as 44% (9). Lean mass is also associated with increases in strength (9, 14, 15). Therefore, one would expect to see greater bench press strength related to greater lean mass alone. This was demonstrated in the female comparisons as the firefighters had higher body mass, lean mass, and bench press strength than the police officers. However, it is interesting to note that there were no significant differences in the lean mass of the males when comparing the two occupations.

Even though the police officers had higher body mass and higher fat mass, they had greater strength scores. Also, when adjusting the males' bench press strength scores by dividing it by their body mass, these police officers were still significantly stronger than the firefighters. It is important to note that lean mass alone does not necessarily translate into upper body strength, as measured by the bench press, as the lean mass may be in areas of the body that do not affect bench press strength.

More research is indicated to explore the multiple factors influencing body composition and strength, especially when considering the complexities of the firefighter and police occupations. In particular, research is needed concerning females for there is little or no published data regarding body composition and its relationship to the strength of females employed in these physically demanding jobs.

The role of the pre-employment selection process in combination with recruit training of these fire and police departments is another factor that might warrant further study. One earlier report contrasted a sample from these same departments just after the completion of recruit training and reported the male police officers had significantly higher bench press averages and higher strength ratios than male firefighters (27). This raises the possibility, when taking the results of this current study into consideration, the trend of greater upper body strength in male police as opposed to male firefighters began as early as recruit training and possibly earlier.

A recent longitudinal report examining the Charlotte-Mecklenburg police department, determined that after 12 years, when dividing the male officers into five groups by strength, the strongest groups remained the strongest over time (22). This implies the strength of firefighters and police over time could be considerably influenced by the pre-employment selection process. If an organization could identify the strongest candidates at hire, there is evidence that they will remain the strongest over time. This can, however, raise issues with protected groups, such as females, when considering fair hiring practices and appropriate pre-employment testing (7, 21, 23).

The strength disparity between these two occupations suggests further investigation into pre-employment selection testing may be warranted. This would involve administering the fire department's CPAT test to a sample of police officers and comparing the results to a similar sample of firefighters. This might serve to clarify potential issues about this intense job-related physical ability test and its capacity to predict job performance, especially when considering its impact upon female job applicants.

There are practical implications of this study regarding the administration of fire and police physical fitness programs. The police department may need to place more emphasis on weight management for the males and on strength training for the females. In regards to fire personnel, there appeared to be a need for increased focus upon building and maintaining strength for the males. Simply providing weight training equipment and on-duty exercise

time to the firefighters did not result in greater strength scores than the police, who did not have on-duty exercise time.

In conclusion, the results of this research suggest that the occupations of fire and police had an influence upon the body composition and strength of these emergency personnel. There appeared to be a complex blend of potential contributing factors and these factors impacted the females differently than the males.

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