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Does the Pre-employment Screening Process influence Health Status of Probationary Firefighters?

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ABSTRACT

Aim

Variation exists in the hiring process by human resource departments within the fire service in the province of Ontario, Canada. This study sought to examine the association between the sequence of hiring practices and biophysical health status in screening for probationary firefighters.

Methods

A biophysical health assessment was conducted on 134 male probationary firefighter applicants hired by one of two different Ontario cities. Prior to being hired as probationary firefighters, City A applicants (N=58) passed a biophysical health assessment at the beginning of a screening appointment before successfully completing a psychological aptitude exam conducted on the same day. Conversely, City B applicants (N=76) passed a biophysical health assessments several weeks following the successful completion of a psychological aptitude exam as part of a longer screening process (range=28-56 days, mean=39±7.3). Following resting heart rate (RHR) and blood pressure (BP) measurements, and a vision and hearing exam, biophysical health measures including waist-to-hip ratio, body fat percentage (BF%), maximum aerobic capacity, 60-second sit-up, and trunk flexibility (TF) as well as completion of an occupational assessment using the Candidate Physical Ability Test were conducted.

RESULTS

City A applicants demonstrated significantly lower RHR, resting diastolic BP, BF% and higher z-scores for BF, TF and overall biophysical health assessment ($p<0.05$). Multiple regression analysis identified candidate increased age and hiring sequence whereby positioning the biophysical health assessment at the end of the hiring process reflective of City B contributing to poorer BF% (R^2=21%), BF z-score (R^2=22%), TF z-score (R^2=10%) and an overall biophysical health assessment z-score (R^2=7%).

CONCLUSION

These results suggest that sequentially positioning the biophysical health assessment at the beginning of a short screening process will result in hiring a healthier probationary firefighter.

Keywords: pre-employment screening, probationary firefighter, hiring sequence, health status

INTRODUCTION

In relation to physically demanding occupations involving public safety, such as firefighting, it has become common practice to institute an occupational assessment or functional capacity evaluation prior to hiring. The goal of pre-employment occupational assessments is to match a potential firefighter candidate's physiological capabilities, including fitness and occupational abilities, to the demands of the job. A study examining pre-employment functional capacity evaluations of employees found that those scoring low on such evaluations developed their first injury sooner than those that scored high. Legge and colleagues concluded that pre-employment screening could predict the likelihood of injury within the initial 14 months of employment. [1] Predicting employee health is advantageous as injuries and chronic illness can result in lost work time. A study of Arizona firefighters found that 30% of injuries resulted in missed work; these absences result in additional cost and inconvenience to the employer [2]. A pre-employment fitness is a popular form of physical evaluation designed to assess a candidates' current physical potential as well as health status in meeting the demands of the job over time. A current study conducted by Poplin and colleagues found that increases in a firefighter's age significantly correlates with a decrease in aerobic fitness and flexibility and an increase in relative body fat percentage. Furthermore, a decrease in firefighter fitness increases the risk of sprain and strain injuries. [3]

Similarly, it is regularly accepted that occupational assessments are a critical part in the evaluation process as the safety of the employee, coworkers, and general public depends on the employee's physical ability [4]. The Candidate Physical Ability Test (CPAT) is as a bona fide occupational assessment recognized across North American as a valuable tool for firefighter pre-employment screening. Therefore, the objective of the CPAT is to ensure probationary firefighters demonstrate the essential physical ability required to execute key tasks through a structured and consistent evaluation [5]. Both men and women who are not successful in completing the CPAT display diminished strength and endurance compared to successful candidates [6]. A growing number of municipalities across Ontario, Canada require successful completion of the CPAT as part of the pre-employment screening process.

While a physical assessment involving fitness and occupational components is characteristic of the pre-employment screening of probationary firefighters, other measures such as a medical examination and psychological aptitude are also important. Furthermore, the utility of both physical and psychological components are well documented [7, 8]. However, it is less implicit as to the positive or negative influence in which the order or sequence of these components during the hiring algorithm could have on the health status of probationary firefighters. Brownlie and colleagues examined the sequence in which firefighter recruits were assessed with respect to their physical, occupational and psychological abilities [9]. They reported that screening of physical and occupational abilities at the beginning of the recruitment process narrows the candidate pool to those who are physically qualified to perform the job. This approach resulted in considerable costs savings compared to screening for psychological aptitude in the initial phase since fewer resources are required for the physical training of a probationary firefighter. Conversely, initial screening using psychological aptitude constricts the applicant pool to those who are mentally qualified for the job. Aside from the cost benefits, it is not clear whether prioritizing a physical and occupational assessment before a psychological aptitude pre-screen will result in the hiring of a healthier firefighter because of the emphasis on biophysical attributes, thus serves as the impetus for the current study in addressing this gap in the literature.

AIM

The aim of this study was to determine if varying the sequence of biophysical and occupational assessments either before or after a psychological aptitude evaluation influences the health status of probationary firefighters.

METHODS

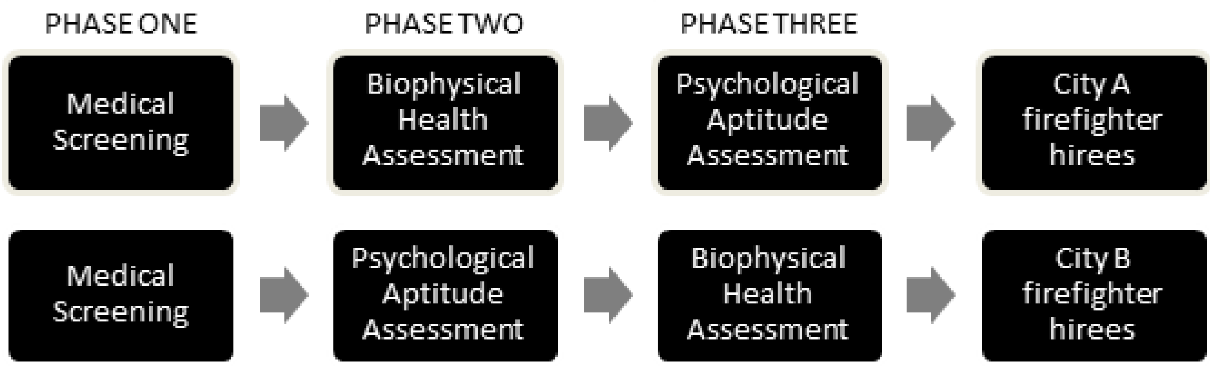
Research design:

This study incorporated an epidemiologic approach to investigation using a cross-sectional design. Male firefighter applicants selected from this database were identified as being hired as probationary firefighters for one of two large metropolitan cities in Ontario, Canada. All participants from both cities were selected based on being recent entry-level hires proximately following the successful completion of their pre-employment firefighter screening assessment. All subjects provided written consent prior to data collection. This study was granted approval through the Brock University Research Ethics Board prior to conducting any research.

Pre-employment screening algorithm:

Figure 1 outlines the two different pre-employment screening algorithms administered by *Firefighter Services of Ontario* for cities A and B. While both algorithms included three phases, only the first phase medical screening was consistent for both cities. Upon successful completion of phase one, City A firefighter applicants completed a biophysical health assessment including fitness and occupational components (phase two). Applicants that successfully passed the biophysical health assessment were eligible to write the phase three psychological aptitude assessment. City A applicants completed their entire three phase pre-employment screening over one day (approximately 6 hours). Conversely, City B applicants completed a written psychological aptitude exam as part of phase two hiring sequence. Applicants that successfully passed the written aptitude exam were eligible to complete the phase three biophysical health assessment at a later date (range=28-56 days, mean=39±7.3 days). Despite the difference in assessment order between both cities, the medical, biophysical and psychological assessments were the same. The final sample of firefighter applicants for City A (N=58) and City B (N=76) included 134 probationary firefighters.

Figure 1: Pre-employment screening algorithm for cities A and B



Note: City A applicants assessed over one day.
City B applicants assessed over multiple weeks (range=4-8 weeks).

Medical screening:

Phase one included a medical screening of all candidates, including resting heart rate and blood pressure as well as vision and hearing as outlined by the National Fire Protection Association 1582 medical evaluation standards [10]. Firefighter Services of Ontario have previously published details of this assessment [11]. Applicants were advised to adhere to several guidelines before their medical screening including, no vigorous exercise within 12 hours, no alcohol consumption within 48 hours, no diuretic medication consumption within seven days, no caffeine consumption within 12 hours, and no food or drink consumption within four hours. Furthermore, all applicants were required to complete a PAR-Q questionnaire or PARMED-X, where appropriate, to ensure they could safely perform the required physical tasks. Finally, all medical staff were required to complete proficiency training of each medical component to ensure accuracy of measurements.

Biophysical health assessment:

The biophysical health assessment included evaluations of fitness and occupational components.

The fitness component included assessments for body composition, muscular endurance, maximum aerobic capacity and flexibility, and were administered consistently in this sequential order to all candidates. Each candidate was required to attain a score ≥18 of 30 points (60%) in order to pass the fitness component. The protocol and scoring breakdown of each fitness components is outlined below.

Body composition:

Ten points were reserved for determining an applicant's body composition. Specifically, body fat percent (BF%) and waist-to-hip ratio (WHR) were each allotted 1-5 points. A dual-purpose medical weight scale with height stadiometer was employed for the initial body composition measures. The candidate's height was measured without footwear and heels together. The subject was required to stand vertically erect, shoulders relaxed and the arms downward. Height was measured and recorded to the nearest 0.2 cm from the highest point on the top of the subject's head. Body weight was measured and recorded to the nearest 0.1 kg. Measured height in kilograms and weight in metres were used to calculate body mass index (BMI) using the formula kg/m^2 [12]. Again, the subject was without footwear and wearing only clothing required for regular physical activity. Each applicant's height and weight were measured to determine BF% by bioelectrical impedance analysis using the Bodystat 1500 [13]. Measurements were conducted using a "whole body method", whereby 2 electrodes are placed on each of the right hand and right foot of the subject. A small electrical current was applied at the proximal electrodes at the right hand and the distal electrodes at the right foot detected the voltage drop due to impedance. A resistance index (height^2/resistance) was calculated using predetermined adult equations programmed into the Bodystat 1500 and used to predict the candidate's BF%. The BF% was compared to age and gender specific normative data to determine a score out of five with 1 being poor and 5 being excellent [12].

Waist and hip circumference was measured using the Canadian Society for Exercise Physiology protocol. Waist girth was measured at the umbilicus and hip girth was measured around the widest portion of the buttocks using a flexible measuring tape. Each measure was recorded three times and the average of these three measures to the nearest 0.1 cm was recorded. These measurements were used to calculate the candidate's WHR with a score out of 5 based on age and gender specific normative data with 1 being poor and 5 being excellent [12].

Muscular endurance:

The 60 seconds sit-up test was used to assess muscular endurance of the torso region. Candidates were required to lie in a supine position while resting their head on the mat, arms folded across their chest and legs bent at the knees to a 90° angle. While a research assistant anchored the feet, the candidate bent their hips and moved from the down position to a full sit-up position performing at maximal rate. The total number of sit-ups completed in one minute was recorded and compared to normative data based on age and gender specific normative data and a score out of five was assigned with 1 being poor and 5 being excellent [12].

Maximum aerobic capacity:

Maximal aerobic capacity (VO_{2max}) was measured using a graded exercise test on a motor-driven treadmill using the Bruce protocol. This protocol is a continuous, multi-stage test that gradually increases speed and grade of the treadmill every 3 minutes [14]. The candidate continued until he reached volitional fatigue and voluntarily terminated the assessment, or symptoms dictated that the assessment be terminated. Heart rate was recorded using a Timex heart rate monitor. Breath by breath gas analysis was recorded using a Vacumed Vista Mini CPX metabolic cart and the candidate's relative VO_{2max} was recorded in ml/kg/min. The candidate's score was compared to normative data relative to age and gender [14]. A score based on a 10-point scale was assigned with 1 being poor and 10 being excellent.

Flexibility:

A standard sit-and-reach test was used to assess flexibility primarily of the hamstrings and lower torso. Candidates were required to remove their shoes and sit with legs fully extended and soles of their feet placed flat against a flexometer. The candidate placed one hand on top of the other, flexing at the hip while knees and legs remain straight, and extended their arms as far as possible while pushing the flexometer measurement curser. The candidate was required to hold the position for two seconds and the maximum trunk flexion was recorded to the nearest 0.5cm. The trunk flexibility assessment was performed three times. Maximum length was compared to normative data based on age and gender and a score out of 5 was appointed with 1 being poor and 5 being excellent [15].

The occupational component was evaluated using the Candidate Physical Ability Test (CPAT), which is designed to measure a pre-employment firefighter candidate's ability to perform the physical expectations of a suppression firefighter. The CPAT was designed as a firefighter-specific obstacle course that simulates a fire scene. Each candidate was required to complete eight events in succession, including: 1) stair climb, 2) hose drag, 3) equipment carry, 4) ladder raise and extension, 5) forcible entry, 6) search, 7) rescue, and 8) ceiling breach [5]. During this test, applicants were required to wear a 50-pound vest to simulate the weight of a self-contained breathing apparatus and firefighter protective clothing. An additional 25 pounds was added to the candidate's shoulders using two 12.5-pound weights to simulate a high-rise pack for the stair climb event. Long pants, hardhat with chinstrap, work gloves and footwear with a closed heel and toe were required of all candidates. The CPAT is a pass/fail test based on a validated maximum allotted total time of 10 minutes and 20 seconds. Candidates failed if any of the eight events are not completed correctly, or if the maximum time was exceeded.

Psychological aptitude assessment:

The psychological assessment was conducted using the Cooperative Personnel Services firefighter entry-level aptitude exam [16]. The test format was multiple choice and a metric version of this exam was provided for the two Ontario city fire services. Description of the types of questions include: 1) understanding oral information, 2) reading comprehension, 3) arithmetic reasoning, and 4) maps, diagrams and mechanical drawings. The aptitude exam terminology was constructed to not discriminate based on gender or race. All test materials were provided, including pencils and eraser. Calculators are not permitted. Candidates are not permitted to leave the examination room throughout the duration of the test. Candidates were required to attain an overall score of $\geq$70% on the aptitude exam in order to receive a pass grade [11].

Statistical analyses:

All statistical analyses were performed using SPSS, V.20 [17]. Descriptive statistics were calculated for mean and standard deviation for subject age, height, weight, resting heart rate (RHR), BMI, resting systolic blood pressure (RSBP), resting diastolic blood pressure (RDBP) and all biophysical health component scores to compare sample characteristics between both cities. Health risk classifications according to BMI and blood pressure categories were also examined. Z-scores were calculated to standardize the scores for all categorical variables representing biophysical health assessment scores based on candidate age. All z-scores were summed to create a sum of z-scores variable. Z-scores for each age category within the component scores were also created. A t-test was used to determine significant differences between City A and City B firefighter characteristics and all continuous variables. Chi square analysis was conducted to determine significant difference for categorical variables.

Linear regression analysis was conducted to establish if differences in the sequence of hiring practice within the two cities was associated with the biophysical health assessment results. Age was considered a confounding variable and was controlled for in the linear regression analysis. Unadjusted R^2 values were examined to identify the explained variance of the predictor variables and standardized β-weights were assessed to report contributions of the independent variables. Age adjusted means were also tested to account for the impact of age on the regression model. Pairwise comparisons verified if significant differences remained in a predictor variable after adjusting for age. Level of significance was established at two-tailed α=0.05.

RESULTS

Subject Characteristics:

A cohort of 134 firefighter applicants, including 58 from City A and 76 from City B, was included in this study. Table 1 presents the subject descriptive characteristics for each city relative to age, height, weight, resting heart rate, resting systolic and diastolic blood pressures and BMI. Variables revealed normal distribution except resting systolic and diastolic blood pressures for City B, which demonstrated kurtosis. In addition, equal variance between groups did not exist for resting diastolic blood pressure. City B applicants were older (30.5 vs. 27.3, p=0.001) and demonstrated significantly higher resting heart rates (75.3 vs. 70.6, p=0.007) and resting diastolic blood pressure (77.8 vs. 72.7, p=0.001). There were no significant differences in height, weight, and resting systolic blood pressure between city subjects (p>0.05). BMI differences approached significance (p=0.07). As normal distribution was not found in all variables, non-parametric analyses were conducted and results were confirmed.

Although health risk classifications for BMI and blood pressure were not statistically significant, results revealed 35% of firefighters from City A had normal BMI compared to 30% of firefighters in City B. Over 60% of City A applicants were overweight according to their BMI, while 2% were considered obese compared to 55% and 14% respectively in City B. 17% of City A candidates had normal blood pressure compared to 12% of subjects from City B. 72% of candidates from City A were pre-hypertensive and 10% were hypertensive. Although fewer City B applicants (68%) were pre-hypertensive, 20% were identified as hypertensive (Table 1).

Table 1. Probationary firefighter baseline characteristics

Variable	City A (N = 58)	City B (N = 76)
	mean, [SD]	mean, [SD]
Age (years)	27.3 [5.0]	30.5 [5.7]†
Height (cm)	180.0 [6.7]	179.9 [5.9]
Weight (kg)	82.9 [9.5]	85.5 [11.0]
RHR (bpm)	70.6 [8.6]	75.3 [10.8]*
SBP (mmHg)	125.3 [9.8]	127.1 [9.1]
DBP (mmHg)	72.7 [10.2]	77.8 [7.7]†
BMI (kg/m^2)	25.6 [2.2]	26.4[3.0]
	%	%
Normal BP	17	12
Pre-hypertensive	72	68
Hypertensive	10	20
Healthy BMI	35	30
Overweight BMI	64	55
Obese BMI	2	14

Note: † = $p \leq 0.001$; * = $p<0.05$
RHR = Resting Heart Rate; BP = Blood Pressure; SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure; BMI = Body Mass Index

Biophysical fitness and health scores:

Table 2 presents the raw and component scores for the biophysical health status, including fitness and CPAT occupational assessment for City A and B. Significant differences in fitness measures were present in body fat percentage, 60-second sit-up raw scores, and sit-up and body fat component scores for ages 30-39. Body fat percentage raw score was higher in City B (18.4 vs. 15.61, $p<0.001$), and the corresponding component scores were lower for the 30-39 age group (2.1 vs. 2.7, $p=0.05$). City B subjects completed significantly fewer sit-ups than City A subjects did (47.6 vs. 50.5, $p=0.03$) and the 60 second sit-up component score was also significantly higher in the City A subjects age 30-39 years (2.7 vs. 2.1, $p=0.03$). There were no significant differences between cities with respect to waist-to-hip ratio, trunk flexibility and VO_{2max} raw and component scores or CPAT time ($p>0.05$). The examination of histograms revealed body fat percentage, trunk flexibility and VO_{2max} raw score demonstrated kurtosis and waist-to-hip-ratio and CPAT time had positive skewness in City A. City B descriptive statistics presented kurtosis in the VO_{2max} raw score. Equal variance between groups was not found in the VO_{2max} raw score. As normal distribution was not found in all variables, non-parametric analysis confirmed similar results. Overall, results revealed City B performed poorer on all fitness measures except for VO_{2max} and WHR component scores for those ages 20-29 years.

Mean z-scores were calculated for each biophysical measure. After converting the biophysical measures to z-scores, it was found that body fat percentage remained significantly different between City A and B as well as the z-score for the entire fitness assessment score. However, sit-up component scores were no longer significant when converted. When z-scores were examined for each age category it was found that body fat and trunk flexibility scores were significantly different between City A and B for those aged 20-29. The sum of z-scores for City A was significantly higher for those 30-39 years old. Overall, City A's z-scores were above the mean for all fitness measures, in all age groups, except for WHR and VO_{2max} for the 20-29 age group (analysis not shown).

Table 2. Biophysical health assessment raw and component scores (mean [SD]).

Variable	City A (N=58)	City B (N=76)
Waist-to-Hip ratio	0.82 [0.04]	0.83 [0.04]
Waist-to-Hip ratio score		
20-29 years (n=38; n=38)	4.1 [0.86]	4.3 [0.80]
30-39 years (n=19; n=34)	4.0 [0.85]	3.7 [0.82]
40-49 years (n=1; n=4)	4.0 [0]	4.0 [0.82]
Body Fat (%)	15.6 [4.1]	18.4 [4.0]†
Body Fat score		
20-29 years (n=38; n=38)	3.3 [0.98]	2.7 [1.2]
30-39 years (n=19; n=34)	2.7 [1.4]	2.1 [0.93]*
40-49 years (n=1; n=34)	3.0 [0]	1.0 [0]
VO_{2max} (ml/kg/min)	52.5 [3.5]	51.7 [4.2]
VO_{2max} score		
20-29 years (n=38; n=38)	8.7 [2.0]	8.8 [1.7]
30-39 years (n=19; n=34)	9.2 [1.4]	8.8 [1.6]
40-49 years (n=1; n=4)	10.0 [0]	8.5 [1.7]
60 Second Sit-Up (#)	50.5 [6.9]	47.6 [8.1]*
60 Second Sit-Up score		
20-29 years (n=38; n=38)	4.1 [0.90]	3.9 [1.2]
30-39 years (n=19; n=34)	4.1 [1.1]	3.8 [0.99]*
40-49 years (n=1; n=4)	5.0 [0]	3.5 [1.3]
Trunk Flexibility (cm)	38.8 [5.3]	37.2 [5.7]
Trunk Flexibility score		
20-29 years (n=38; n=38)	4.3 [0.93]	3.8 [1.1]
30-39 years (n=19; n=34)	4.58 [.61]	4.4 [0.82]
40-49 years (n=1; n=4)	5.0 [0]	5.0 [0]
Occupational assessment time / CPAT (sec)	526.7 [36.3]	533.5 [32.5]

Note: * = $p \leq 0.05$

Estimated marginal means:

We controlled for age as work capacity is found to decrease with age [18, 19]. City hiring practice significantly predicted resting heart rate, resting diastolic blood pressure, body fat percentage, body fat and trunk flexibility z-score and sum of z-score for the entire fitness assessment. Age was found to be the only significant contributor to resting systolic blood pressure and blood pressure categories, BMI and BMI classification, WHR, sit-up, VO_{2max} raw scores and CPAT time. Estimated marginal means confirmed significance in resting heart rate, resting diastolic blood pressure, body fat percentage, body fat and trunk flexibility z-score and sum of z-scores after adjusting for age ($p<0.05$). Overall, City A performed better on all variables after adjusting for age, except WHR z-score (Table 3).

Age and hiring sequence explain 6% of the variation in resting heart rate in firefighter subjects. The model was significant ($F(2, 131)=3.8$, $p<0.03$) and standardized β-weights revealed city hiring sequence to have a greater loading compared to age ($\beta=0.23$, $t=2.54$, $p=0.01$). In relation to resting diastolic blood pressure, the two predictor variables explained 16% of the variance in firefighter candidates and demonstrated a significant model ($F(2, 131)=12.31$, $p<0.001$). City hiring sequence was a significant contributor ($\beta=0.19$, $t=2.28$, $p=0.02$), however, age had a stronger impact ($\beta=0.30$, $t=3.58$, $p<0.001$) (analysis not shown). Age and hiring sequence explained 21% ($R2=0.21$) of the variation in body fat percentage raw scores for firefighters. This model was significant ($F(2, 131)=17.19$, $p<0.001$) and standardized β-weights revealed age to have greater loading compared to city hiring sequence ($\beta=0.33$, $t=4.11$, $p<0.001$). The predictor variables also accounted for 22% ($R2=0.22$) of the variance found in body fat z-score between City A and B. This model was significant ($F(2, 131)=18.05$, $p<0.001$) and similar to body fat percentage results, age demonstrated a greater standardized β-weight compared to the city hiring sequence predictor ($\beta=-0.36$, $t=-4.5$, $p<0.001$). Finally, 7% of the variance in the sum of z-score for the entire fitness assessment was explained by age and hiring sequence ($R2=0.07$). This model was significant ($F(2, 131)=4.88$, $p=0.009$) and city hiring sequence revealed a greater standardized β-weight $= -0.19$ ($t = -2.1$, $p = 0.04$) compared to age (analysis not shown).

Table 3. Biophysical health assessment age adjusted means

Variable	City A	City B
RHR	70.7	75.3*
RSBP	126.2	126.6
RDBP	73.6	77.2*
Blood Pressure category	2.0	2.1
BMI	25.8	26.2
BMI category	1.7	1.8
Waist-to-Hip Ratio	0.82	0.82
Z-score: Waist-to-Hip Ratio score	-0.06	0.04
Body Fat%	16.1	18.0*
Z-score: Body Fat score	0.23	-0.18*
VO_{2max}	52.3	51.7
Z-score: VO_{2max} score	0.02	-0.01
Sit-ups	49.7	48.1
Z-score: Sit-ups score	0.18	-0.09
Trunk Flexibility	38.9	37.1
Z-score: Trunk Flexibility	0.24	-0.18*
Z-score: Sum of fitness assessment scores	0.55	-0.43*
Occupational assessment score / CPAT	529.3	531.5

Note: * = $p<0.05$

DISCUSSION

Biophysical scores and impact on health performance:

Our study examined the effect of employee hiring sequence on health status in probationary firefighters. Age and hiring sequence explained the largest variance in the differences found between the two cities with regard to resting diastolic blood pressure, body fat percentage, body fat z-score and flexibility z-score. Hiring sequence was only found to contribute to the variation in resting heart rate and sum of z-score for the entire fitness assessment. Furthermore, a hiring sequence incorporating biophysical health measures at the beginning of employee screening process revealed predominantly healthier probationary firefighter for all age groups. Significant differences were found in BF%, BF and trunk flexibility z-score and sum of z-scores after adjusting for age. It is also important to note that pre-screening measures of resting heart rate and diastolic blood pressure were significantly higher in firefighters who underwent a biophysical health assessment at the end of the screening process (City B). These findings reflect a poorer health status of City B firefighters. These biophysical health determinants are associated with increased risk for cardiovascular disease [20, 21].

The significantly higher amount of body fat demonstrated by City B firefighters is of concern due to the negative impact it has on general health. Firefighters with excess amounts of fat are more likely to exhibit increased CVD risk factors such as hypertension [22-25], decreased high density lipoproteins [24, 26] and chronic conditions such as type II diabetes, osteoarthritis [27, 28], and asthma [27]. Cardiovascular disease is of primary concern in the fire service as sudden cardiac death is the leading cause of on-duty firefighter deaths [29]. Yang and colleagues examined sudden cardiac death causation in firefighters ≤ 45 years and found that 63% of cases were obese [30]. In addition to sudden cardiac death risk, firefighters who are obese have reduced core and back muscular endurance, which puts them at greater risk for musculoskeletal injury [3, 31]. Obesity in firefighters predicts job disability as every one unit increase in BMI was found to increase the risk of job disability by 5% [32] and the chance of filing a worker's compensation claim is nearly three times greater for firefighters with a BMI greater than 30 [33]. Poston and colleagues found that firefighters with BMIs of ≥35.0 had almost five times the number of missed workdays due to injury in comparison to those of normal weight [34]. Brown et al. indicate that individuals with increased amounts of body fat have an increased number of self-perceived poor health days, which may affect job performance [35]. To make matters worse, obese firefighters also report greater weight gain and hypertension over five years compared to those of normal weight [24].

Hypertension is the most common risk factor in firefighters, with adverse events being 2 to three times more likely to occur in those with stage II hypertension [22, 36]. While our study did not find statistical significance in blood pressure classification, a greater percentage of City B candidates was identified as hypertensive and demonstrated a significantly higher resting diastolic blood pressure. It is possible that elevations in blood pressure did not have sufficient time to produce the physical manifestations expected of hypertension in City B subjects despite the older age of these firefighter applicants. Overall, our findings suggest that significantly higher amounts of body fat found in City B candidates place them at a greater risk for cardiovascular disease and on duty fatality. It is advantageous to hire firefighter applicants with no or low risk, as seen in City A applicants, to limit the impact of these consequences on health and vocational performance over both short and long term.

Researchers calculated the cost of firefighter absenteeism due to non-fatal injury and concluded yearly costs escalated over 220 time from an overweight firefighter to an obese firefighter [37]. Mean BMI of City A and City B candidates in our study approached significance (p=0.07) and a greater percentage of City B applicants were found to be in the combined overweight/obese categories. However, these expenses do not account for additional factors contributing to lost work. Furthermore, as weight gain is found to increase in firefighters over their career, [38] it is expected these costs are associated with their first year of service and would continue to escalate over time. Therefore, hiring a greater portion of firefighters classified as normal weight would decrease the financial burden to the fire service as projected in City A applicants.

Screening process of hiring firefighters:

Our findings suggest City A's hiring sequence results in employing healthier firefighters as demonstrated by significantly lower relative body fat, higher absolute body fat and trunk flexibility z-scores and sum of z-score for the fitness assessment. It is also important to note that the City A hiring sequence may have additional benefits such as saved time and resources to the city corporation. City B's process involves a number of steps such as written aptitude and knowledge tests, application review, and an applicant interview prior to the conditional offer of employment. All of these steps precede the candidate's biophysical assessment. As a result, City B is expending needless time and human resources by administering each step of the hiring sequence prior to knowing a candidate's overall biophysical health. Furthermore, City B would be required to restart the hiring process if the applicant does not pass the biophysical assessment.

Brownlie and colleagues support the findings of this study as their conclusion regarding the optimal hiring sequence for entry-level firefighters reflected that of our investigation [9]. They were able to show a cost savings associated with executing the biophysical assessment sequentially at the beginning of the hiring process. They found initial pre-screening of biophysical capabilities was effective in narrowing the applicant pool to a viable group of firefighter candidates. Furthermore, they credited a biophysical pre-screening approach with a significant cost savings over time. For example, pre-screening reduced the time required for the training and physical conditioning of probationary firefighters. As a result, fire service personnel could invest more time in advanced firefighting training for their new recruits.

Although our study reported that City A firefighters demonstrated a healthier profile, it is not entirely understood why early use of biophysical screening is preferred in the hiring process. Ostensibly, City A may attract candidates with a more favourable health profile because applicants are required to pass all testing components prior to applying to a city's human resources department. Therefore, these applicants reflect an enhanced health status. As a result, these applicants are more likely to ensure that they exhibit an optimal health profile in order to continue in the hiring process. Conversely, City B applicants may invest more in preparing for the written and interview components, as these are the primary assessments required. City B applicants are merely required to pass the physical assessment prior to an offer of employment, whereas a City A applicant has to demonstrate their biophysical superiority compared to other applicants before being granted an interview. Research has demonstrated that probationary firefighter recruits selected through the competitive hiring process tend to feel they have achieved an elite status because of their success in the biophysical screening [9]. Furthermore, these firefighter gain confidence in their ability to perform occupational duties compared to those hired without the new assessment. These qualities are more likely to be demonstrated with the hiring sequence implemented by City A's fire service and may be important in the maintenance of enhanced health status as a firefighter over their career.

Some limitations existed within this study and warrant discussion. First, only male subject data was investigated due to the limited number of females hired in City A and City B. Further investigation should include female subjects that are increasingly employed by fire services. While two large fire departments were included in this study, future research should examine if similar results can be reproduced in smaller departments as well as volunteer fire services. Finally, future longitudinal research should examine how biophysical and occupational measures from different hiring sequences impact work-related factors such as absenteeism rates, work related injuries or long-term physical and psychological health. Furthermore, the relationship of biophysical components to number of lives saved by firefighters is also an area to be considered [9]. This information would provide support for the importance of hiring sequence on long-term outcomes of firefighter recruits.

CONCLUSION

The results of this study demonstrate that the sequence of firefighter hiring procedures influences the type of candidate hired. While both City A and City B's selection processes resulted in the hiring of presumably capable probationary firefighters, City A's candidates demonstrated superior health status in terms of RHR, RDBP, BF, and trunk flexibility. Positioning the biophysical assessment at the beginning of the hiring process reveals a more favourable probationary firefighter candidate compared to screening protocol that places this assessment at the end of screening process.

REFERENCES

1. Legge J, Burgess-Limerick R, Peeters G. New pre-employment functional capacity evaluation predicts longer-term risk of musculoskeletal injury in healthy workers. Spine 2013;38:2208-15

2. Poplin GS, Roe DJ, Peate W, Harris RB, Burgess, JL. The association of aerobic fitness with injuries in the fire service. Am J Epidemiol 2014;179(2):149-55

3. Poplin GS, Roe DJ, Burgess JL, Peate WF, Harris RB. Fire fit: assessing comprehensive fitness and injury risk in the fire service. Int Arch Occup Environ Health 2016;89(2):251-59

4. Gumieniak R, Jamnik V, Gledhill N. Physical fitness bona fide occupational requirements for safety-related physically demanding occupations: test development considerations. Health Fit J Can 2011;4(2):47-52

5. International Association of Fire Fighters 2012 Candidate Physical Ability Test Program Summary [Internet]. http://www.iaff.org/hs/CPAT/cpat_index.htmlon 07/10/2017

6. Williams-Bell F, Villar R, Sharratt M, Hughson R. Physiological demands of the firefighter candidate physical ability test. Med Sci Sport Exer 2009;3:653-62

7. Pachman J. Evidence base for pre-employment medical screening. Bull World Health Organ 2009;87:529-34

8. JacksonA. Preemployment physical evaluation. Exer & Sport Sci Rev 1994;22(1):53-90

9. Brownlie L, Brown S, Diewert G, Good P, Holman G, Laue G, Banister E. Cost effective selection of firefighter recruits. Med Sci Sports Exerc 1985;17(6):661-666

10. National Fire Protection Association 2013 NFPA 1582: Standards on comprehensive occupational medical program for fire departments [Internet]. http://www.nfpa.org/codes-and-standards/document-information-pages?-mode=code&code=1582.On 07/10/2017.

11. Firefighter Services of Ontario 2014 Pre-appraisal screening [Internet]. http://fireontario.com/services/clinical-assessment/pre-appraisal-screening/on 07/10/2017.

12. Klentrou P, Montelpare WJ, Faught, BE. Clinical Exercise Physiology Lab Manual. Dubuque: Kendall-Hunt Publishing; 2000.

13. Faught B, Hay J, Cairney J, Flouris A. Increased risk for coronary vascular disease in children with developmental coordination disorder. J Adolescent Health 2005;37:376-80

14. Canadian Society for Exercise Physiology. The Professional Fitness and Consultant Manual. Ottawa: Canadian Society for Exercise Physiology Publishing; 1996.

15. Canadian Society for Exercise Physiology. The Canadian Physical Activity Fitness and Lifestyle Approach, 3rd Ed. Ottawa: Canadian Society for Exercise Physiology Publishing; 2004, pp. 7-48

16. Cooperative Personnel Services 2014. Fire services Entry-level tests [Internet]. http://www.cpshr.us/testrental/fs_entrylevel.html on 07/10/2017.

17. IBM. SPSS Statistics 19.0 User's Guide. Chicago: IBM Corporation; 2010.

18. Fleg J, Morrell C, Bos A, Brant L, Talbot

L, Wright J, Lakatta E. Accelerated longitudinal decline of aerobic capacity in healthy older adults. Circulation 2005;112:672-74

19. Sheppard RJ. Age and physical work capacity. Exp Aging Res 1999;25(4):331-43

20. Franklin S. The importance of diastolic blood pressure in predicting cardiovascular disease risk. J Am Soc Hypertens 2007;1(1):82-93

21. Kannel W, Kannel C, Paffenbarger R, Cupples L. Heart rate and cardiovascular mortality: The Framingham heart study. Am Heart J 1987;113(6):1489-94

22. Donovan R, Nelson T, Peel J, Lipsey T, Voyles W, Israel R. Cardiorespiratory fitness and the metabolic syndrome in firefighters. Occup Med 2009;59:487-92

23. Fahs C, Smith D, Horn G, Agiovlasitis S, Rossow L, Echols G, Heffernan K, Fernhall B. Impact of excess body weight on arterial structure, function and blood pressure in firefighters. Am J Cardiol 2009;104(10):1441-45

24. Soteriades E, Hauser R, Kawachi I, Liarokapis D, Christiani D, Kales S. Obesity and cardiovascular disease risk factors in firefighters: a prospective cohort study. Obes Res 2005;13(10):1756-63

25. Yoo H, Franke W. Prevalence of cardiovascular disease risk factors in volunteer firefighters. J Occup Environ Med 2009;51(8):958-62

26. Tsismenakis A, Christophi C, Burress J, Kinney A, Kim M, Kales S. The obesity epidemic and future emergency responders. Epidemiology 2009;17(8):1648-50

27. Mokdad A, Ford E, Bowman B, Dietz W, Vinicor F, Bales V, Marks J. Prevalence of obesity, diabetes and obesity related health risk factors. J Am Med Assoc 2003;289(1):76-79

28. Must A, Spadano J, Coakley E, Field A, Colditz G, Dietz W. The disease burden associated with overweight and obesity. J Am Med Assoc 1999;282(16): 1523-29

29. Fahy R, LeBlanc P, Molis J 2007. What's changed over the past 30 years? National Fire Protection Association [Internet]. http://www.nfpa.org on 07/16/2017.

30. Yang J, Teehan D, Farioli A, Baur DM, Smith D, Kales SN. Sudden cardiac death among firefighters ≤ 45 years of age in the United States. Am J of Cardiology 2013;112(12):1962-67

31. Kong PW, Suyama J, Hostler D. A review of risk factors of accidental slips, trips, and falls among firefighters. Safety Science 2013;60:203-09

32. Soteriades E, Hauser R, Kawachi I, Christiani D, Kales S. Obesity and risk of job disability in male firefighters. Occup Med 2008;58:245-50

33. Kuehl K, Kisbu-Sakarya Y, Elliot D, Moe E, DeFrancesco C, MacKinnon D, Lockhart G, Goldberg L, Kuehl H. Body mass index as a predictor of firefighter injury and workers' compensation claims. J Occup Environ Med 2012;54(5):579-82

34. Poston W, Haddock K, Jahnke S, Jitnarin N, Tuley B, Kales S. The prevalence of overweight, obesity and substandard fitness in a population-based firefighter cohort. J Occup Environ Med 2011;53(3):266-73

35. Brown AL, Wilkinson ML, Poston WSC, Haddok CK, Jahnke SA, Day RS. Adiposity predicts self-reported frequency of poor health days among male firefighters. J Occup Environ Med 2014;56(6):667-72

36. Kales S, Soteriades E, Christoudias S, Tucker S, Nicolaou M, Christiani D. Firefighters' blood pressure and

employment status on hazardous materials teams in Massachusetts: A prospective study. J Occup Environ Med 2002;44(7):669-76

37. Poston W, Jitnarin N, Haddock K, Jahnke S, Tuley C. Obesity and injury-related absenteeism in a population-based firefighter cohort. Obesity 2011;19(10):2076-81

38. Davis S, Jankovitz K, Rein S. Physical fitness and cardiac risk factors of professional firefighters across the career span. Res Q Exercise Sport 2002;73(3):363-70