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The Design and Implementation of a Comprehensive Back Injury Prevention Program and Development of a Vo2max Non-Exercise Regression Model for Emergency Services Personnel

Tamer Hatem Elattar
University of Miami, telattar@hotmail.com

UNIVERSITY OF MIAMI

THE DESIGN AND IMPLEMENTATION OF A COMPREHENSIVE BACK INJURY PREVENTION PROGRAM AND DEVELOPMENT OF A $VO2_{max}$ NON-EXERCISE REGRESSION MODEL FOR EMERGENCY SERVICES PERSONNEL

By

Tamer Hatem Elattar

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Tamer Hatem Elattar

Approved:

____
Shihab Asfour, Ph.D.
Professor and Associate Dean
College of Engineering

____
Moiez Tapia, Ph.D.
Professor of Electrical and
Computer Engineering

____
Sara J. Czaja, Ph.D.
Professor and Co-Director
Department of Psychiatry and
Behavioral Sciences

____
Guillermo Prado, Ph.D.
Dean of the Graduate School

____
Chad Brocato, DHSc.
Adjunct Professor of Anatomy and
Physiology, Kaplan University

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Back injury prevention programs are cost efficient typically by reducing the number of work-related injuries and lost work days in both fire fighters. Injury rates and sick leave usage can be reduced, thereby controlling overtime costs associated with filling vacant positions or utilizing other agencies for response. The measurement of fitness using exercise models is an important part of any fitness program and also the firefighters' annual fitness evaluation. Those exercise models require cost, time and expose firefighters to risks of injury.

We examined the difference in perceptions and knowledge about musculoskeletal injuries among emergency workers personnel with an emphasis on back injuries. Taking into consideration age groups, years of experience and measured fitness levels. We also gathered some input about topics for injury prevention programs. We used the results of the assessment to help design, implement and evaluate an eight weeks, comprehensive and easy to implement calisthenics exercise back injury prevention program that best fit the needs of emergency services personnel utilizing the basic resources that any emergency response facility and any emergency personnel has access to without the need of complicated equipment for exercise or fitness measurement. The program also included an education session with an overall goal of educating and strengthening

uniformed personnel so that their mental, physical, and emotional capabilities are resilient enough to withstand the stresses and strains of life and the workplace.

We used the exercise aerobic fitness data collected for our participants to validate the use of current non-exercise models developed before for different populations. Then used our firefighter's data to develop a model for firefighters specifically given their unique age and fitness distribution with the goal to reduce costs, resources allocated and injury risks that can result from the current methods used for aerobic fitness measurement during annual physicals or measurement of fitness as a part of fitness program for firefighters.

DEDICATION

I would like to dedicate this work to my father Hatem, mother Thana, wife Amira sister Amani and brother Ihab. I thank them kindly for their unconditional support, resolute understanding, and steadfast patience during the coursework, research, and writing of this dissertation.

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Injuries among emergency workers personnel

The fire service's greatest asset is not equipment, apparatus or stations, but rather its personnel. It is through personnel that the fire departments serve the public, accomplish their mission and are able to make a difference in their communities (International Association of Fire Fighters [IAFF], 1997).

Firefighting is among one of the most stressful, physically demanding and dangerous occupations in the world. Because of the long hours associated with firefighting, the shift type of schedule, the sporadic and unpredictable high intensity workload, the above average strength needed to rescue victims, place ladders, handle hose lines, and force entry with heavy tools, the high levels of aerobic fitness essential to conduct other such fire ground activities as rapidly moving down hallways, climbing ladders, or fighting fires on steep hillsides, strong emotional involvement, and excessive exposure to human suffering. Workers responding to emergency situations face unique and sometimes unknown risks, and must often rely upon personal protective equipment, well-practiced standard operating procedures and protocols, effective communications, and especially one another, to protect themselves. (NIOSH, 2007)

The National Fire Protection Association (NFPA) Estimates that the number of firefighters working in the U.S. in 2010 was 1,148,100. Of that number, 335,950 are career firefighters and 812,150 are volunteers. Which means that the United States currently depends on approximately 1.1 million fire fighters—three out of four are volunteers—to protect its citizens and property from losses caused by fire.

From 1998 through 2005, 863 fire fighters died in the line of duty, excluding the 343 fatalities in the World Trade Center tragedy, (U.S. Fire Administration [USFA], 2006). Each year, approximately 100 fire fighters die in the line of duty, approximately 54 fire fighters die each year from fatal traumatic injuries and another 48 die from cardiovascular-related disease in the line-of-duty. Approximately 95,000 fire fighters are injured at work each year (NIOSH, 2007).

There is growing concern with the number fire fighters who suffer disabling injuries and conditions that often have debilitating or fatal consequences and force them to discontinue their fire service activities. USFA maintains statistics on fire fighter injuries over several years through a national voluntary reporting system. Surprisingly, only 20% of fire fighter injuries are from burns and smoke inhalation. NFPA estimates that 71.875 firefighter injuries occurred in the line of duty in 2010. An estimated 32,675 or two-fifths (45.4%) of the all firefighter injuries occurred during fire ground operations. An estimated 14,190 occurred during other on duty activities, while 13,355 occurred at non-fire emergency incidents. The leading type of injury received during fire ground operations was strain, sprain or muscular pain (52.8%), followed by wound, cut, bleeding and bruise (14.2%). This pattern of injuries conclusively shows that fire fighters are more likely to receive sprains, strains, and other muscular pain injuries than other types of injuries. Certainly fire fighters must carry heavy equipment and be well protected, however, less attention may be given to aspects of the work environment not traditionally thought to be serious hazards. The high incidence of strains and sprains should be an indication that the application of ergonomics is strongly needed in the fire and emergency medical services to avoid more of these injuries (NFPA, 2011)

Workplace injuries consume an immense amount of resources. The Bureau of Labor Statistics (stats.bls.gov/) recorded approximately one million, three hundred thousand injuries in 2004. Approximately one third, or 400,000 of those reported injuries were related to the back. The average amount of days lost from back injuries was seven days. Back injuries cost $30-$50 billion dollars each year in the United States affecting 15%-20% (31 million) of the entire population (Bray, 2001). Employers also spend an additional $50 billion on indirect costs--such as finding and training substitute workers, and running work-hardening (physical conditioning) and reduced-work programs that help ease employees back into their jobs (Grossman, 2001). Total cost of low-back pain in the United States is $100 to $200 billion per year. Two-thirds of these costs are indirect costs, principally due to lost wages. This is paralleled by a patient burden of pain, disability, and psychological and social consequences (Katz, 2006).

The fire service is by every definition a dangerous profession (Peterson, 2002, Clark, 2002, Occupational Handbook, 1998-1999, 2000-2001). The estimated costs to the fire service of firefighter injuries and their prevention is 2.8 to 7.8 billion dollars per year (TriData, 2004). The direct costs in workers' compensation, medical treatment and vocational rehabilitation are very high. Additionally, indirect costs such as lost production, retraining and sick or administrative time can be at least four times the direct costs. An indirect cost of particular concern is the disruption of the professional integrity of services provided. In 2004, there were 24,000,000 calls for service to fire departments in the United States. One million firefighters handled those calls for service. Fire calls and medical aid accounted for almost 70% of those calls (NFPA, 2004). In such calls for service, the potential for back injuries is enormous.

Firefighter statistics categorized by age group in 2010 where coinciding: Age 16-19 (3%), Age 20-29 (21%), Age 30-39 (28%), Age 40-49 (26%), Age 50-59 (16%), Age 60 and over (6%). Firefighters over the age of 40 comprise 48% of the fire service, with those over 50 accounting for 22% of firefighters (NFPA, 2011).

Although older firefighters possess a wealth of invaluable knowledge and experience, they are killed while on duty at a rate disproportionate to their representation in the fire service. Firefighter fatality retrospective study 1990-2000 reported that approximately 60 percent of firefighter fatalities were over the age of 40 when they were killed and one-third were over 50.

Age and experience play a key role in firefighters' injuries. Injuries to career firefighters are the largest share (66 percent) of the reported injuries. Nationally, only 28 percent of the fire service is career firefighters. Injuries to career firefighters tend to occur in midcareer (ages 30–45) with the peak between ages 35 and 39. Injuries to volunteers, on the other hand, are sustained predominately by the younger members of the organization. Firefighters under the age of 25 account for 29 percent of injuries in the volunteer service. Career firefighters also experience proportionally more lost-time injuries than their volunteer counterparts (approximately 2 to 1). Volunteer firefighters, on the other hand, receive far more no lost-time injuries. (NFIRS, 2011)

The age characteristics of firefighters' population are a key factor in designing, testing or implementing any fitness tests or programs. The all have to be designed and tested on the wide range of age and appropriate to the older majority of the population.

We have taken age and years of experience into consideration in all phases of our research study with an effort to understand how age and experience in firefighters affects their prospective and understanding of all factors associated with injuries starting from their history of injury to their knowledge of causes of injuries and key practices to avoid and deal with injuries. Age was also taken into consideration when developed our $VO2_{max}$ Non-Exercise regression model.

Fitness and wellness programs and injury risk reduction

Fire departments with members who are medically, physically, and mentally fit will provide better service to their communities year after year while realizing reductions in disability retirements by their uniformed personnel (IAFF, 1997).

In 1998, NIOSH implemented the NIOSH Fire Fighter Fatality Investigation and Prevention Program FFFIPP to conduct independent, onsite investigations of fire fighter line-of-duty deaths. They investigated 44 percent of all fire fighter line-of-duty deaths for the period 1998 to 2004 (excluding fire fighter deaths associated with the 2001 World Trade Center attacks). Out of 366 deaths investigated, traumatic injury incidents accounted for 51% of the investigations (81 structure fires, 65 motor-vehicle-related, 15 training, nine wild fires, six explosions, and 11 other incidents—e.g., helicopter crash, homicide, drowning, etc.). Cardiovascular incidents accounted for the other 179 investigations (49%).

Fire fighters have elevated heart rates and blood pressures when responding to alarms conducting fire suppression tasks on the fire ground or during physically demanding training exercises (Gledhill, 1992). A case-control study using the NIOSH on-duty cardiovascular fatality data on fire fighters showed that participation in fire suppression and training and response to an alarm were significantly associated with fatalities from coronary heart disease (Kales et al. 2003, 2007). In addition, NIOSH found that most victims had multiple risk factors for coronary artery disease. Despite these findings, only 48 (31%) of the 154 departments where NIOSH investigated fatalities from cardiovascular disease conducted annual screening programs on all fire fighters to identify risk factors for coronary artery disease. Of the 48 departments conducting screening, only 16 (33%) conducted exercise stress tests on those at increased risk for coronary artery disease and sudden cardiac death (NIOSH, 2007).

In 2009, FFFIPP published recommendations based on seven years investigation. FFFIPP recommended that departments develop individualized fitness and wellness programs for all fire fighters. They also recommended that departments conduct annual medical evaluations to screen all fire fighters for risk factors for coronary artery disease (e.g., smoking, diabetes mellitus, high blood pressure, high blood cholesterol, physical inactivity, obesity, and a family history of coronary artery disease).More importantly, FFFIPP recommended that departments conduct exercise stress tests on fire fighters who have coronary artery disease or who are at increased risk (males older than 45 and females older than 55) of this disease and sudden cardiac death. They also recommended that fire fighters are medically cleared by physicians who are knowledgeable about the cardiovascular demands of firefighting and aware of published medical guidelines for fire fighters (NIOSH, 2009).

Fitness and wellness programs can reduce modifiable coronary artery disease risk factors like high blood cholesterol, cigarette smoking, high blood pressure, diabetes mellitus, obesity and physical inactivity (American Heart Association 2010) and can be cost effective, typically by reducing the number of work-related injuries and lost workdays in both fire fighters (Garfi et al., 1996, Harger et al., 1999, Dempsey et al., 2002, Stevens et al., 2002, Womack et al., 2005, Blevins et al., 2005, Kuehl, 2007) and other workers (Maniscalco et al., 1999, Stein et al., 2000, Aldana, 2001).

Programs that include individualized risk reduction for high-risk workers within the context of a comprehensive program seem to hold the most promise for positive clinical and cost outcome (Pelletier, 2001). In 1979, Cady et al showed a graded and statistically significant protective effect for added levels of fitness and conditioning (least fit, 7.1% injured, middle fit 3.2% injured, and most fit, 0.8% injured). The least fit group had a injury rate seven times that of the most fit group. In 1985, Cady et al reported that high levels of PWC (physical work capacity), strength, and spine flexibility were found to be inversely related to workers' compensation costs. Firefighters with below average PWC's subsequently experienced 2.6 times more myocardial infarctions than their above average counterparts. In 1997, Pipes et al. carried out a study that involved twenty recruits tested before and after 10 weeks of training. An average of 16.9% increase in strength and a 33.2% increase in maximum oxygen uptake was reported. In 2002, Melanie et al. implemented a fitness program for 115 firefighters, they concluded that aerobic capacity increased by 28%, decreased fat and increased lean tissue weight, and increased/tended to increase other components of physical fitness.

Many contemporary training methods have been devised to preferentially optimize adaptation of muscular components through strategic periodization and exercise prescription. Such adaptations draw on synergistic physiological mechanisms that lend to increased force production, power output, and fatigue resistance, and include neuromuscular, metabolic, and hormonal-capacity modifications. Typically, progressive training techniques are reserved for advanced trainees and/or competitive athletes. However, because firefighters routinely encounter dangerous environmental fire-suppression tasks and rigorous physical stimuli, progressive strategies for muscular fitness and performance enhancement may offer superior protection against intrinsic hazards and improve the execution of job-specific duties. (Peterson, 2008).

Occupation readiness for the fire service industry requires a balanced approach to physical functioning and reinforces the need for simultaneous development and/or maintenance of each muscular fitness component. ‘Emergency preparedness’’ is not only the ability to complete a required job task; it is also the capacity to repeatedly do so without experiencing excessive, undue stress. Thus, combined with an adequate degree of cardiovascular fitness and uninhibited joint range of motion, the acquisition of optimized muscular endurance, muscular strength, and muscular power are equally vital to facilitate comprehensive firefighter readiness (Davis 2002, Rhea 2004, Peterson, 2008).

Mandatory programs showing the most benefit reducing coronary artery disease risk factors and improving fitness levels (Garfi et al., 1996, Harger et al., 1999, Dempsey et al., 2002, Womack et al., 2005 and Blevins et al., 2006). One mandatory program was able to show a cost savings of $68,741 due to reduced absenteeism (Stein, 2000). A similar cost savings has been reported by the results of this study are similar to the findings of others with health and wellness programs. The Phoenix Fire Department’s (PFD) twelve (12) year history of providing a comprehensive health and wellness program indicates significant reductions in the cost of disability retirements. Comparing the PFD’s costs to other City of Phoenix employees indicates significant savings (Ken, 1999).

Epidemiological studies on the general population have shown that increased physical activity and aerobic fitness significantly decrease the risk of coronary artery disease. Finding ways to decrease such risk factors can promote the health of firefighters.

In 2016, Seyedmehdi, et al. conducted a study in a large industrial facility in Tehran where aerobic fitness assessment and submaximal aerobic fitness testing of participants were performed according to the guidelines of the American College of Sports Medicine

(ACSM). Aerobic fitness was determined using a bicycle ergometer. Other information was collected using a specifically designed questionnaire, physical examination and blood test. A total of 157 male firefighters were evaluated and the results of logistic regression analysis revealed that aerobic fitness was significantly correlated with age, body mass index (BMI), cigarette smoking, physical activity, hemoglobin level, low-density lipoprotein (LDL) level, high-density lipoprotein (HDL) level, resting systolic blood pressure (RSBP), diastolic blood pressure (RDBP) and heart rate (RHR) ($P<0.05$). They concluded that firefighters with greater aerobic fitness had lower cardiovascular disease (CVD) risk factors.

The guidelines developed by the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC), the National Volunteer Fire Council (NVFC)/United States Fire Administration (USFA) and the National Fire Protection Association (NFPA) involve comprehensive programs with individualized assessment for all fire fighters.

The IAFF/IAFC Wellness Initiative is an individualized program that requires the participation of all uniformed personnel in a no punitive manor. The Initiative includes a manual with information on fitness evaluation, medical evaluation, rehabilitation, behavioral health and data collection. The IAFF/IAFC Task Force has determined that successful implementation of the Wellness/Fitness Initiative requires a fire fighter in each department who can take the lead. This person must have the ability to design and implement fitness programs, improve the wellness and fitness of his or her department, and assist with the physical training of recruits. This need for a department-level leader led to the development of the Fire Service Peer Fitness Trainer certification program. (International Association of Fire Fighters website 2010)

The NVFC developed the Heart-Healthy Firefighter Program that promotes fitness, nutrition, and health awareness. The program includes Heart healthy fire fighter kit, Fired up for fitness challenge and Heart healthy resource guide. Additional publications developed by the NVFC in conjunction with the USFA include the Health and Wellness Guide for the Volunteer Fire Service (www.usfa.dhs.gov/) and the Emerging Health and Safety Issues in the Volunteer Fire Service.

The NFPA developed the Standard on Health-Related Fitness Programs for Fire Fighters. The program stipulates that fire departments establish and provide a health-related fitness program that enables members to develop and maintain a level of health and fitness to safely perform their assigned functions. Components of this program include educational program regarding description and benefits, individualized exercise prescription with warm-up, aerobic, muscular, flexibility, healthy back, and cool-down guidelines and safety and injury program.

NFPA encourages fire departments to implement an on-duty physical training program (NFPA, 2007). However, one challenge is that many fire departments lack exercise equipment. A study by Pawlak et al in 2015 demonstrated that proper use of existing fire equipment is adequate to improve occupational physical ability and anthropometric outcomes and thus provides all fire departments with an opportunity to enhance firefighter preparedness and health. It is important that qualified personnel design and implement an exercise program that uses fire equipment to enhance safety and promote health, fitness, and performance outcomes. The distinct physical demands of firefighting make it a unique profession in regards to developing an effective exercise program. Specificity circuit training with firefighter equipment seems to provide an adequate overload stimulus for improvements in fire ground tasks. However, it is likely that circuit training should be supplemented with traditional strength and power training to optimize all of the fitness components associated with firefighting tasks. More highly fit firefighters may require additional training stimuli, higher training intensities, and volume to maintain and improve physical ability levels. Although our outcomes offer good insight as to the role a novel specificity circuit training program can provide, additional research is needed to identify optimal periodization and training strategies. Overall, our results suggest that that implementing a supervised training program using firefighter equipment is safe, feasible, and improves performance outcomes for firefighters. The results from this study also demonstrated that participation in a supervised fitness program 2 $d.wk^{-1}$ produced significant improvements in absolute resting heart rate and relative $VO2_{max}$. However, changes in cardiorespiratory function have been found to be associated with changes in body mass. Thus, expressing aerobic capacity in absolute terms and resting heart rate relative to body mass demonstrated that the exercise program did not significantly improve cardiorespiratory function (Table 3). Instead, these changes were body mass dependent (Pawlak, 2015).

Unfortunately, most of the fire departments in which NIOSH investigated an on-duty fatality from cardiovascular disease did not have a comprehensive fitness and wellness program as recommended by NFPA 1583, the IAFF/IAFC, and the NVFC/USFA documents. From 1998 to 2005, 63 fire departments that experienced a fire fighter's death from cardiovascular disease, (41% of the 154 that NIOSH-investigated) had fitness programs, but only 16 of the 154 (10.4%) required participation.

Rates of overweight and obesity in the fire service (estimated at about 80% combined) (Poston 2011, Tsismenakis, 2009) are higher than those found among the general United States (US) public (68% are overweight or obese) (Flegal, 2010) Obesity is an even greater risk for firefighters given the duties they are required to perform at a moment's notice, often in suboptimal conditions such as heat, smoke, and chemical exposure (Soteriades, 2011). Previous studies documented that overweight and obese firefighters have elevated rates of hypertension, low High-density lipoprotein (HDL) cholesterol, high Low-density lipoprotein (LDL) cholesterol, high triglycerides, significant yearly weight gain, lower cardiorespiratory fitness, reduced muscle strength, and more frequent fatal cardiac events (Soteriades 2011, Kales 2007). In turn, cardiovascular disease (CVD) is the leading cause of line of duty deaths (LODDs) among firefighters, implicated in nearly half of LODDs, with the majority occurring during fire suppression activities (CDC, 2007). In addition to serving as a risk factor for CVD, a study by Jahnke et al in 2013 found that obese firefighters were 5.2 times more likely to incur a musculoskeletal injury than their healthy weight peers. In addition, obesity has been found to be related to low rates of fitness in firefighters (Poston, 2011). Evidence suggests that firefighting duties require approximately 12 metabolic equivalent units of effort (METs) (Glendhill, 1992) which is recommended by national standards as a return to work standard for firefighters following a cardiac event (NFPA, 2013). In a population-based sample of firefighters, nearly all of whom were obese (80% career, 95% volunteer) by body mass index (BMI) standards would not be able to meet this fitness recommendation (Poston, 2011). Given the risks firefighters face and the need for high levels of fitness, high rates of overweight and obesity are of particular concern (Jahnke, 2015)

In 2014, Poplin et al. published a study they conducted to understand the risk of injury in relation to fitness in a retrospective occupational cohort of firefighters in

Tucson, Arizona, from 2005 to 2009. Annual medical evaluations and injury surveillance data were linked to compare levels of aerobic fitness in injured employees with those in non-injured employees. The individual outcomes evaluated included all injuries, exercise-related injuries, and sprains and strains. Time-to-event analyses were conducted to determine the association between levels of fitness and injury likelihood. Fitness, defined by relative aerobic capacity ($VO2_{max}$), was associated with injury risk. Persons in the lowest fitness level category ($VO2_{max}$ <43 mL/kg/minute) were 2.2 times more likely to sustain injury than were those in the highest fitness level category (VO2max >48 mL/kg/minute). Those with a $VO2_{max}$ between 43 and 48 mL/kg/minute were 1.38 times more likely to incur injury. Hazard ratios were found to be greater for sprains and strains.

These results suggest that improving relative aerobic capacity by 1 metabolic equivalent of task (approximately 3.5 mL/kg/minute) reduces the risk of any injury by 14%. These findings illustrate the importance of fitness in reducing the risk of injury in physically demanding occupations, such as the fire service, and support the need to provide dedicated resources for structured fitness programming and the promotion of injury prevention strategies to people in those fields (Poplin, 2014)

National Fire Protection Association (NFPA) needs assessment continued to emphasize the need for health and wellness programs and also reported that 70% of fire departments still have no such programs (NFPA, 2011). Consistent with this finding, Soteriades et al. in 2011 reported that infrequent amounts of physical activity are common in the fire service and that most departments do not mandate regular exercise training regimens or require maintenance of important fitness parameters. The reasons for lack of participation in medical assessment and wellness/fitness programs are complex, but guidelines for their development and implementation are available through NFPA standards for medical (NFPA 1582) (NFPA, 2013) and health-related fitness programs (NFPA 1583) (NFPA, 2007) and the Wellness-Fitness Initiative (WFI) developed by a Fire Service Joint Labor Management group. Despite these comprehensive guidelines, only 30% of U.S. fire departments have successfully implemented these programs (NFPA, 2011).

Physical fitness assessment using cardio respiratory testing

Cardio respiratory fitness (CRF) is the ability to perform moderate to high intensity dynamic exercise with the large muscle groups for prolonged periods of time. The assessment of Cardio respiratory fitness is valuable when educating individuals about their overall fitness status, developing exercise programs, and stratifying cardiovascular risk (ACSM, 2000).

The amount of oxygen we consume is directly related to the amount of energy we are burning, a measurement of oxygen consumption is actually a measure of aerobic fitness. Maximal oxygen uptake $VO2_{max}$ is the maximal amount of oxygen an individual can utilize during exercise and is the best measure of CRF (American College of Sports Medicine [ACSM], 2000). Highly fit individuals have a greater capacity to transport oxygen to the body's active tissues and therefore have high $VO2_{max}$ values (Noakes, 1988). Individuals who are sedentary or less active have lower $VO2_{max}$ values, and are at greater risk for cardiovascular disease and all-cause mortality (Blair,1989). Thus, $VO2_{max}$ is a useful criterion in assessing one's fitness level and risk for cardiovascular disease. Knowledge of $VO2_{max}$ can also be used to make appropriate recommendations to improve individual health, functional capacity and athletic performance (ACSM, 2000).

There is a variety of physical fitness tests used to establish a person's fitness level. The goal of these tests is to get the person to engage in some form of aerobic exercise, increase their heart rate and then perform some measurement to evaluate their fitness level. Test include running on treadmills, stationary bikes, walking, step tests and other aerobic activities. People who are more aerobically fit have higher $VO2_{max}$ values. The direct measurement of $VO2_{max}$ is expensive, time-consuming, requires high motivation from the test subjects and trained personnel to administer the test. Maximal GXTs are unappealing to some individuals because the test requires strenuous exercise to the point of volitional exhaustion.

While there is discussion as to what constitutes $VO2_{max}$ three generally accepted methods are used:(1) the plateau, (2) respiratory quotient, and (3) perceived exertion (Wisen and Wohlfart, 1999). Maximal effort is usually indicated by the test subject indication of fatigue or pain. Researchers need to specify which method is to be used to define $VO2_{max}$. The idea behind the MAX is that you are trying to measure the amount of oxygen you are consuming while exercising at your maximum capacity. $VO2_{max}$ is expressed as the amount of oxygen in milliliters you consume in one minute per kilogram of your body weight (ml/kg/min) while exercising at near maximum capacity.

The most accurate way to assess and quantify cardio respiratory fitness is to measure maximal oxygen uptake $VO2_{max}$ during the performance of a maximal graded exercise test (GXT). There are several maximal exercise test protocols available for use on treadmills (George, 1996, ACSM, 2000, Maud, 2006). All protocols advance the participant from a walking pace to a vigorous intensity of exercise as speed and/or grade of the treadmill is incrementally increased until the point of volitional fatigue or the appearance of significant adverse signs or symptoms. Each exercise stage typically lasts one to three minutes. Protocols differ by the length of the stages, initial workload, and the magnitude of the work increments between stages. Each protocol is suitable for specific purposes and few protocols are appropriate for all individuals. The Bruce or Ellestad protocols are most appropriate for younger and/or physically active individuals, while the Naughton or Balke-Ware protocols are most appropriate for older participants and patients with disease (ACSM, 2000).

A well-known maximal treadmill protocol is the Bruce multistage exercise test (Bruce, 1973). This test consists of six, three minute stages in which participants exercise to the point of volitional fatigue. The Bruce protocol starts with participants walking 1.7 mph at a 10% grade and imposes large increments in the metabolic cost of exercise throughout test with each 3-min stage. The Bruce protocol demonstrates relatively high predictive accuracy (r = .93, SEE = 3.13 $mL \cdot kg^{-1} \cdot min^{-1}$). However, the test is unappealing to many individuals because of large increases in workload, the Bruce protocol is best suited for younger, healthy, physically active individuals (ASCM, 2000).

Although each of the maximal tests has its advantages, performing a maximal GXT is not practical in many situations. The process involves inconvenient methods that require costly equipment, space, trained personnel and exercise to the point of volitional fatigue. Therefore, alternative methods have been devised to estimate $VO2_{max}$. These include a variety of maximal and submaximal exercise tests and non-exercise protocols.

Submaximal clinical tests are similar to maximal tests in that they both involve methods that require costly equipment, space, and trained personnel. Although submaximal tests are not as precise as maximal tests they are recognized as valid predictors of $VO2_{max}$ and CRF (ACSM, 2000). Moreover, submaximal tests offer many advantages to maximal tests in that they are performed at a lower cost, reduced risk, and require less time and effort from the participant (ACSM, 2000). Submaximal laboratory tests use a variety of exercise modes including cycle ergometry, and walking, jogging or running on a treadmill. Submaximal tests are not as accurate as maximal tests. When submaximal testing is to be used as a means to predict maximal effort ±15% is usually considered the best accuracy that can be obtained [Wisen and Wohlfart, 1999].

Submaximal aerobic capacity tests like Gerkin protocol where recommended by The Fire Service Joint Labor Management Wellness-Fitness Initiative. However, In 2004 Constance M. Mier et al. tried to evaluate the use of a treadmill test for predicting the aerobic capacity of emergency services personnel, in the study fifty-four healthy men and women (age range 19–58 years) performed the Gerkin test and a treadmill run test to maximal exhaustion. Their heart rates were monitored continuously with an electrocardiogram during each test. During the $VO2_{max}$ test, the subjects' $\dot{V}O_2$ was measured continuously using indirect calorimetry. They concluded that the Gerkin treadmill protocol **over predicts** $VO2_{max}$ in healthy men and women and, therefore, should not be used for predicting $VO2_{max}$ in individual emergency services personnel.

Field-based exercise tests are often used to assess the CRF of an individual or group and can be performed outside of the traditional laboratory without the need of expensive equipment. Field-based tests often use performance as a predictor of CRF and consist of walking or running for either a certain distance or a given amount of time (ACSM, 2000). These tests are based on the premise that participants who complete the prescribed distance in the least amount of time or a longer distance in the prescribed amount of time have the highest levels of CRF. The 12-minute run test (Balke, 1963, Cooper, 1968) requires sustained vigorous exercise since the objective is to complete the furthest distance as possible in 12 minutes. The 1.5 mile (Cooper, 1963) run also requires sustained vigorous exercise while the participant completes the 1.5 mile distance in as little time as possible. Because high exercise intensity is required, the 12-minute and 1.5 mile run tests are not considered submaximal tests. Submaximal tests, such as the one mile walk (Kline et al., 1987), require participants to walk one mile as fast as possible and use heart rate recorded at the end of the mile in a regression equation to predict CRF. The 1-mile track jog test (George et al., 1993) requires participants to jog at a self-selected submaximal pace for 1 mile then uses the steady state heart rate in a regression equation to predict CRF. Tests which use heart rate response to a submaximal workload to predict CRF are based on the fact that regular exercise results in a lower heart rate response to a given submaximal workload. Therefore, participants who have lower heart rates during the submaximal exercise tests have higher levels of CRF. Field based tests should be selected based on the appropriateness for the individual being tested.

Non-exercise (N-EX) tests

N-EX protocols provide an estimate of CRF without the need to perform a maximal or submaximal exercise test. These protocols are inexpensive, time-efficient, realistic for large groups, and accommodate all levels of fitness. N-EX protocols use information about the physical characteristics of an individual and his/her current physical activity levels to predict CRF (Jackson et al., 1990, Heil et al., 1995, George et al., 1997). Using simple questionnaires, self-reported N-EX predictor variables can be assessed and used in regression equations to predict $VO2_{max}$. N-EX predictor variables include age, gender, BMI, percent body fat, self-reported physical activity ratings (PA-R, Jackson et al., 1990) and perceived functional ability (PFA, George et al., 1997). Studies have validated the accuracy of N-EX equations, and suggest that they provide a quick and useful prediction of $VO2_{max}$ (Jackson et al., 1990, Heil et al., 1995, George et al., 1997).

There are however, limitations involved in the self-reporting of physical activity and body measurements. Generally individuals tend to underestimate their weight and overestimate their height and physical activity level.

In 1985, Siconolfi et al. studied the validity between two indices developed by Paffenbarger. They assessed Paffenbarger's Physical Activity Index Questionnaire and the reported number of times per week that vigorous activity caused sweating to occur (Paffenbarger et al., 1966). Participants responded to the questionnaires and performed a $VO2_{max}$ test on a cycle ergometer. The study population included 36 men and 32 women between the ages of 20 and 70 years old. The study concluded that the frequency of activity, sufficient to generate sweat, related closer to $VO2_{max}$ than the Physical Activity Index.

In 1987, Kohl et al. investigated the association between self-reported responses to physical activity and an objective measure of physical fitness. The study included 375 men of an average age of 47 years. All participants responded to a numeric physical activity questionnaire and completed a maximal treadmill protocol. Participants' reported exercise values were converted to estimates of energy expenditure and combined into overall indices of physical activity participation. The variables that proved to be significant predictors of physical fitness were age (β = -0.34), an index of running, walking, and jogging participation (β = 0.31) and the frequency of sweating response (β =

0.35). The study reported a multiple correlation coefficient of 0.65 between these variables and total treadmill time.

In 1990, Jackson and colleagues developed a N-EX prediction model based on 2,009 individuals between 18 and 70 years old. The predictor variables included self-reported PAR, age, body composition and gender. Participants $VO2_{max}$ was measured during the first three walking stages of the Bruce treadmill protocol. Self-reported PAR was the most highly correlated variable with measured $VO2_{max}$. The multiple regression equation developed by Jackson et al in 1990, ($VO2_{max}$ = 56.363 + 1.921(PAR) – 0.381(Age) – 0.754(BMI) + 10.987(F = 0, M = 1)) can be generalized to men and women. The study confirmed that the N-EX model including self-reported PA-R, age, BMI, and gender provided a valid estimate (R = 0.783, SEE = 5.70 ml· $kg^{-1}\cdot min^{-1}$) of $VO2_{max}$. Results also illustrated that the N-EX model was more accurate than estimated $VO2_{max}$ from Astrand bicycle tests and established submaximal treadmill prediction models. Although the N-EX prediction model proved to be an accurate method for predicting $VO2_{max}$, Jackson mentioned that predictions of CRF were less accurate in individuals who had high aerobic capacities ($VO2 \geq 55$ ml· $kg^{-1}\cdot min^{-1}$).

In 1995, Heil et al. conducted a study to determine if a more precise N-EX model could be developed for predicting $VO2_{max}$ than the model presented by Jackson et al. in 1990. The study included 439 participants between the ages of 20 and 79 years. Each participant performed a maximal walking treadmill test to determine $VO2_{max}$. Independent variables included both age and age-squared, percent body fat, gender, and the same self-reported activity rating used by Jackson et al. (1990). Self-reported activity demonstrated to be a valuable variable in predicting $VO2_{max}$. The standard error of estimate and multiple correlation coefficient (4.90 $mL \cdot kg^{-1} \cdot min^{-1}$ and .88, respectively) reported by Heil et al (1995) were similar to those reported by Jackson et al. (1990). Heil concluded that their N-EX model was at least as accurate, stable, and generalizable as the N-EX model reported by Jackson et al. (1990) and the one-mile walk test (Kline et al. 1987).

In 1997, George et al. developed an N-EX regression model using self-reported perceived functional ability (PFA) to walk, jog, or run given distances, a modified PA-R, BMI, and gender. One hundred college students (50 males and 50 females) aged 18-29 years, participated in the study. Compared to other studies using NEX regression models, the N-EX regression model reported by George et al. (1997) had a higher correlation coefficient (R = 0.85) and a lower SEE (3.44 $mL \cdot kg^{-1} \cdot min^{-1}$). The George N-EX regression model provides valid $VO2_{max}$ estimates for college aged students. The linear regression equation developed by George et al. (1997) was: $VO2_{max}$ ($mL \cdot kg^{-1} \cdot min^{-1}$) = 44.895 + (7.042 x gender) – (0.823 x BMI) + (0.738 x PFA) + (0.688 x PA-R). A disadvantage inherent in this study is that it is not age-generalized. Since the population consisted of only college aged participants, the N-EX model cannot be generalized to a broad population. Thus, there is a need to evaluate PFA as an independent variable in predicting CRF in a more diverse age.

Other studies were done to test and validate or develop similar models on different kinds of populations like college students, (Fred (1994), George (1996), Williford (1996), George (1997), Danielle (2005)) based on the results of those studies, non-exercise models showed very promising results for the estimation of VO_{2max}.

In 2006, Wier, Jackson et al. conducted a study to investigate the use of waist girth (WG) as a body composition surrogate in the non-exercise models and to compare the accuracy of non-exercise models that include WG, %fat, or BMI. A total of 2417 men and 384 women were measured for VO_{2max} by indirect calorimetry (RER > 1.1), age (yr), gender by M = 1, W = 0, self-report activity habit by the 11-point (0–10) NASA physical activity status scale (PASS), WG at the apex of the umbilicus, %fat by skinfolds, and BMI by weight (kg) divided by height squared (m2). Three models were developed by multiple regression to estimate VO_{2max} from age, gender, PASS, and either WG %fat, or BMI .Cross-validation by the PRESS technique confirmed these statistics. Accuracy of the models for predicting VO_{2max} of sub samples was supported by constant errors for subgroups of gender, age, PASS, and VO_{2max} between 30 and 50 (70% of the sample). CE were > 1 for VO_{2max} < 30 and > 50.

The study concluded that Waist girth is an acceptable surrogate for body composition in the non-exercise models. More importantly All models were similar inaccuracy and valid for estimating VO_{2max} of most adults, but with reduced accuracy at the extremes of fitness (V˙O2max < 30 and > 50). This was another validation for the non-exercise models developed in 1990, taking into consideration that more female subjects were included this time in the study compared to the initial models, which gives the results more scientific validity.

The NASA/Johnson space center physical activity rating (PA-R)

The NASA/Johnson Space Center Physical Activity Rating (PA-R) scale was developed to provide an assessment score of 0-7 on a person's level of regular physical activity. PA-R has been validated in a large sample of 18-70 year-old men and women, but PFA has only been validated in a sample of college-aged men and women.

There are a series of eight statements about routine physical activity. Participants are to select only one response that best describes their physical activity level. Each response is given a numerical value. To use the scale, simply give the person the scale and ask them to select the number that best represents their level of physical activity for the past 30 days. Often, some will respond with two numbers. In these instances, the highest value is used. see Figure 1.

Based on the research N-Ex % Body Fat approach is slightly more accurate but still requires a physical measurement of percent body fat. Since this would be hard for most programs to get participants to do pre-course. We decided to use the N-Ex BMI model to measure the person's $VO2_{max}$.

A limitation of the study was that the sample size of females was considerably smaller than males. However, additional research with a much larger sample of women (Jackson et al., 1996b) was done by the same team, and the models still showed validity. In 1990, Jackson et al. developed a model for prediction of aerobic capacity without exercise testing, In this study, the authors decided to use VO2max as their index of aerobic capacity and hence a measurement of physical fitness level. These models did not require exercise testing, and the accuracy of these models were equal to or better than the accuracy of the submaximal exercise models. Derived from several thousand measurements of $VO2_{max}$ furnished by the NASA/Johnson Space Center (JSC), Jackson's non-exercise models estimated VO2max from a combination of age, gender, self-assessments of activity habit, and either %fat or body mass index (BMI).

NASA CODE FOR PHYSICAL ACTIVITY

Use the appropriate number (0 to 7) which best describes your general ACTIVITY LEVEL for the PREVIOUS MONTH.

DO NOT PARTICIPATE REGULARLY IN PROGRAMMED RECREATION SPORT OR HEAVY PHYSICAL ACTIVITY.

0 - Avoid walking or exertion, e.g., always use elevator, drive whenever possible instead of walking.

1 - Walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration.

PARTICIPATED REGULARLY IN RECREATION OR WORK REQUIRING MODEST PHYSICAL ACTIVITY, SUCH AS GOLF, HORSEBACK RIDING, CALISTHENICS, GYMNASTICS, TABLE TENNIS, BOWLING, WEIGHT LIFTING, YARD WORK.

2 - 10 to 60 minutes per week.

3 - Over one hour per week.

PARTICIPATE REGULARLY IN HEAVY PHYSICAL EXERCISE SUCH AS RUNNING OR JOGGING, SWIMMING, CYCLING, ROWING, SKIPPING ROPE, RUNNING IN PLACE OR ENGAGING IN VIGOROUS AEROBIC ACTIVITY TYPE EXERCISE SUCH AS TENNIS, BASKETBALL OR HANDBALL.

4 -Run less than one mile per week or spend less than 30 minutes per week in comparable physical activity.

5 - Run 1 to 5 miles per week or spend 30 to 60 minutes per week in comparable physical activity.

6 -Run 5 to 10 miles per week or spend 1 to 3 hours per week in comparable physical activity.

7 -Run over 10 miles per week or spend over 3 hours per week in comparable physical activity.

Figure 1. NASA/JSC Physical Activity Rating (PA-R) scale.

In the study they compared two different Non-exercise based assessments against the actual $VO2_{max}$ levels of their test subjects. The goal of their study was to see if they could develop a predictive formula for VO2max without requiring an actual exercise test. They identified a number of important factors that are determinants of physical condition, age, gender, BMI or % body fat, and a ranking of the person's regular physical activity. For this ranking they used a Physical Activity Rating questionnaire (PA-R) developed by NASA and the Johnson Space Center for evaluating the physical condition of employees (Figure 1). Using data from 2,009 employees of NASA and the Johnson Space Center, they developed two different formulas which predicted $VO2_{max}$ without an exercise test, see table 1.

N-Ex BMI model	
Female:	$VO2_{max}$ = 56.363 + 1.921 (PA-R) - 0.381 (age) - 0.754 (BMI)
Male:	$VO2_{max}$ = 67.350 + 1.921 (PA-R) - 0.381 (age) - 0.754 (BMI)
N-Ex % Body Fat	
Female:	$VO2_{max}$ = 50.513 + 1.589 (PA-R) - 0.289 (age) - 0.552 (% body fat)
Male:	$VO2_{max}$ = 56.376 + 1.589 (PA-R) - 0.289 (age) - 0.552 (% body fat)

Table 1 Models used to predict VO2max without an exercise test

The variables needed to use the non-exercise test and the relationship of each with aerobic capacity is

1. **Age in Years.** Research (Buskirk et al., 1987, Jackson et al., 1995, Jackson et al., 1996b, Kasch el al. 1990, Kasch et al., 1985) shows that aerobic capacity decreases with age.
2. **Gender.** Separate equations are used for men and women. The aerobic capacity of women is about 80% of men (Buskirk et al., 1987, Jackson et al., 1995, Jackson et al., 1996b, Kasch el al. 1990, Kasch et al., 1985).
3. **Self-report Level of Physical Activity.** Figure 2 gives the NASA scale used to rate level of physical activity. This rating has been found to be significantly correlated with measured VO_{2max} (Jackson et al., 1995, Jackson et al., 1990a, Jackson et al., 1996b). Changes in self-report exercise ratings have been shown to be related with aerobic capacity (Blair et al., 1995, Jackson et al., 1995, Jackson, 1996b).
4. **Body Mass Index (BMI).** The BMI (kg/m^2) is computed from the person's height and weight. BMI is inversely related to $VO2_{max}$ (Jackson et al., 1990a).

$$\textbf{BMI} \; (kg/m^2) = \frac{\textbf{(weight in pounds * 703)}}{\textbf{height in inches}^2}$$

In the first model the formula which they developed used the score from the PA-R, measured percentage of body fat, age, and gender to predict $VO2_{max}$. This was called the N-Ex % Body Fat model. The second model, referred to as the N-Ex BMI model, uses the score from the PA-R, Body Mass Index (BMI), age and gender to predict VO2max. In order to calculate the predicted $VO2_{max}$ all that is needed is weight and height (for BMI), age, gender, and the score from the PA-R questionnaire. Based on the study results both the N-Ex BMI model and the N-Ex % Body Fat model are valid predictors of $VO2_{max}$. The formulas are shown in table 1 (note that there is a different formula for women and men). The first number in each formula is a constant that was developed based on the person's gender which standardizes the results into the normal VO2max values.

Chapter 2: Objectives

Back injury prevention programs are cost efficient typically by reducing the number of work-related injuries and lost work days in both fire fighters (Blevins et al., 2006, Dempsey et al., 2002, Garfi et al., 1996, Harger et al., 1999, Ken, 1999, Kuehl, 2007, Stevens et al., 2002, Stein, 2000 and Womack et al., 2005) and other workers (Aldana, 2001, Maniscalco et al., 1999, Stein et al., 2000). Injury rates and sick leave usage can be reduced, thereby controlling overtime costs associated with filling vacant positions or utilizing other agencies for response. Emergency services with members who are medically, physically, and mentally fit will provide better service to their communities year after year while realizing reductions in disability retirements by their uniformed personnel.

The measurement of fitness using exercise models is an important part of any fitness program and also the firefighters' annual fitness evaluation. Those exercise models require cost, time and expose firefighters to risks of injury. Non-exercise models are used to measure aerobic fitness with the goal to reduce costs, resources allocated and injury risks that can result from the current methods used for aerobic fitness measurement. Current non-exercise models were developed for different populations with different physical characteristics. There was no research done to develop a specific non-exercise model for firefighters.

The first objective of this study was to examine the difference in perceptions and knowledge about musculoskeletal injuries among emergency workers personnel with an emphasis on back injuries. Taking into consideration age groups, years of experience and measured fitness levels. We also gathered some input about topics for injury prevention programs. Data was gathered using a paper and pencil knowledge test and survey instruments discussed in details in the protocol.

The second objective was to use the results of the assessment to help design, implement and evaluate an eight weeks, comprehensive and easy to implement, calisthenics exercise back injury prevention program that best fit the needs of emergency services personnel utilizing the basic resources that any emergency response facility and any emergency personnel has access to without the need of complicated equipment for exercise or fitness measurement. The program would also include an education session with an overall goal of educating and strengthening uniformed personnel so that their mental, physical, and emotional capabilities are resilient enough to withstand the stresses and strains of life and the workplace.

The third objective was to use the exercise aerobic fitness data collected for our participants to validate the use of current non-exercise models developed before for different populations. Then use our firefighter's data to develop a model for firefighters specifically given their unique age and fitness distribution with the goal to reduce costs, resources allocated and injury risks that can result from the current methods used for aerobic fitness measurement during annual physicals or measurement of fitness as a part of fitness program for firefighters.

Chapter 3: Methodology

Protocol

The study was reviewed and approved by University of Miami Institutional review board (IRB) (HSRO number 20070169, 6/19/07)

Participants were introduced to the study team during a pre-scheduled mandatory training session at the Deerfield Beach Fire Rescue training facility. Training participants were given a brief description of the study and were asked to volunteer.

Volunteers where then given the informed consent explaining details of study.

The study was divided into three main parts

Part 1: Musculoskeletal and back injuries knowledge and perception assessment

The goal of the assessment was to examine perceptions and knowledge about musculoskeletal injuries among emergency workers personnel, with an emphasis on back injuries. Data was gathered using paper and pencil knowledge survey instruments. The results were to be used to guide back injury prevention programs so that they best fit the needs of emergency workers personnel.

Participants that showed interest signed the informed consent and were given three questionnaires.

a) **Physical Activity Readiness Questionnaire (PAR-Q)** which was introduced by Thomas et al. in 1992 (Appendix D) and was recommended as a minimal standard for screening to assess participants' physical readiness to participate in physical activities prior to beginning an exercise program.

b) **The Spinal Health Questionnaire** designed to assess participants' general knowledge of safe practices related to avoiding musculoskeletal injuries. This questionnaire was administered on orientation day before the educational session and then was re administered 8 weeks later.

c) **Emergency Services Personnel Back Injuries Questionnaire** designed to assess participants' opinion on where back injuries stand among other musculoskeletal injuries in terms of occurrence, expense of treatment, and controllability, the causes of back injuries, what their action(s) were if they experienced back injuries while either on or off duty, and whether they currently participate or would wish to participate in any strength, physical fitness and/or back injury prevention activities/programs.

After the instruments were administered, the session was concluded with a one hour back injury prevention educational session presented by Deerfield beach fire fighting chief Dr. Chad Brocato. This session introduced participants to the best practices for back injury prevention and discussed the misconceptions and practices that lead to musculoskeletal injuries in general with particular emphasis on back injuries.

Part 2: Eight weeks calisthenics exercise back injury prevention fitness pilot program

The goal was to evaluate the impact of an eight weeks physical fitness program on the strength, endurance, fitness and physical work capacity of participants. The easy to implement program consisted of calisthenics exercises aimed to strengthen the core and back muscles and increase the endurance, fitness and physical work capacity of emergency services personnel utilizing the basic resources that any emergency response facility and any emergency personnel has access to without the need of complicated equipment for exercise or fitness measurement.

All participants agreed to follow an eight weeks, twice per week, pre-defined set of exercises based on the guidelines developed by the International Association of Fire Fighters (IAFF).

Participants were introduced to the various exercises and researchers explained the safe and correct ways of performing those exercises. Participants were given various materials to help them perform the exercises correctly and safely, they were also asked to document their progress for the eight weeks in a worksheet provided by researchers.

Participants then attended a strength, endurance, fitness and physical work capacity measurement pre-program baseline session where standard exercise tests were used to measure their strength, endurance, fitness and physical work capacity. Throughout the eight weeks to follow, researchers stayed in touch with participants through visits to Deerfield fire department and through a 2, 4 and 6 weeks follow-up phone calls. Eight weeks after the baseline session, Participants attended a post-program follow up session to measure their strength, endurance, fitness and physical work capacity where they also brought back their progress worksheets to the researchers.

Part 3: Development of $VO2_{max}$ Non-Exercise regression model

We used the exercise aerobic fitness data collected for our participants to validate the use of current non-exercise models developed before for different populations. Then use our firefighter's data to develop a model for firefighters specifically given their unique age and fitness distribution with the goal to reduce costs, resources allocated and injury risks that can result from the current methods used for aerobic fitness measurement during annual physicals or measurement of fitness as a part of fitness program for firefighters.

Participants

All participants were employed as emergency services personnel by Deerfield Beach Fire Rescue. Participants were all attending a pre-scheduled mandatory training session at Deerfield beach firefighting department, they were given a brief description of the study and were asked to volunteer, participants that showed interest signed the informed consent and were given the study questionnaires to answer onsite.

The first part of the study which included Musculoskeletal and back injuries knowledge and perception assessment and the educational session included 125 participants, 116 of which were males. Participants ages mean was 36 (SD=10) with a mean of 11 years of experience (SD=9). Ninety six (76.8%) of the participants had an associate degree or higher and 29 had a high school degree (23.2%).

Fifty three of those 125 participants showed interest in participating in the second part of the study (the pilot strength and fitness program). Participants that agreed to participate in the program were required to have no history of major musculoskeletal injuries, heart problems, high blood pressure, or conditions that restrict participating in strength and fitness improvement testing and exercise. Forty participants (all male) with a mean age of 36 years (SD=9) and mean years of experience of 11 (SD=8.4) eventually participated in the pilot fitness program and thirty made it till the end of the program (there were challenges in scheduling participants for the fitness assessments due to their personal and work commitments and schedules).

Instruments

Informed consent

The form contained a summary of the purpose, procedures, risks and benefits of the study and their full right to withdraw. Most importantly it reserves the rights of participants for privacy, confidentiality and the right to be compensated for injuries sustained due to participating in the study through employer's insurance benefits and workers' compensation as it has occurred while on the job (Appendix A).

Spinal Health Questionnaire

The Spinal Health questionnaire (Appendix B) was designed to assess the emergency workers personnel general knowledge of spinal health and safety. The questionnaire was developed based on a collaborative effort of the fire chiefs at Deerfield fire department and the research team at university of Miami, trying to identify the common misconceptions related to back injuries and safety then quantify that knowledge in to a knowledge score. Participants were then offered an educational session as part of the program to correct those misconceptions and educate them about injury prevention best practices. The questionnaire was re-administered at the end of the program (after 8 weeks) to test whether there is a significant change in their knowledge.

The questionnaire started with questions inquiring about whether participants have received training on back injury prevention before or not, how they would rate their department ergonomics and instructions related to back injury prevention.

The questionnaire then queried respondents about safe or un-safe back practices. The questionnaire included 29 likert scale questions in which participants were asked to agree or disagree with the statements about spinal health like “It is safer to pull a stretcher rather than pushing it”, “Using heat immediately after a back strain is beneficial for quick recovery” and “Reaching above shoulder height to move an object is harmful to spinal health”. Scores could range from 0 – 29 with a higher score indicating more knowledge.

In questions from 25 to 29, they were asked to evaluate five pictures and indicate the extent to which you agree that the sitting, standing, or exercising postures are Beneficial to spinal health.

Musculoskeletal Injuries Questionnaire

The Musculoskeletal Injuries questionnaire included five main sections, the first was a brief demographic assessment (categorical) including gender, age, ethnicity (African- American, Asian, Hispanic/Latin, White or Other), marital status and highest level of education (High School, Associate, Bachelors, Masters or higher) and finally how many years they have been in the profession.

The second section included three level likert type questions assessing perceptions regarding prevalence, cost of treatment and controllability of back injuries relative to other types of musculoskeletal injuries. They were asked how prevalent they thought shoulder/back/neck/knee/ankle/elbow injuries where, how costly in terms of treatment and loss of working time they thought shoulder/back/neck/knee/ankle/elbow injuries where and how controllable shoulder/back/neck/knee/ankle/elbow injuries where for emergency services personnel?

The third section gathered information about factors they considered the main causes for back injuries among emergency services personnel, external environment factors (e.g. weather, rescue in confined spaces), workplace factors (e.g. night shifts, equipment used) and/or personal factors (e.g. commitment, experience, age), this section included categorical and likert scale “Yes” and ”No” type questions where they indicate whether they believe those factors can lead to severe and/or frequent back injuries or not.

They were first asked in general, in their opinion, which of those main three groups of factors lead to more frequent/more severe back injuries. They were then asked about each group of factors in more details. They were asked whether they thought external factors that included extreme weather, large scale emergencies, collapsing structures that all can force them to lift and/or handle victims/objects in an unsafe way can lead to severe and/or frequent back injuries.

They were asked whether they thought workplace factors that included Shifts (24hrs. on / 48 hrs. off) or night shifts, staffing levels, systems for personnel selection, protective equipment and appropriate training on how to use them, emergency nature of work support from local authorities, safety training, availability of fitness/back strengthening/back injury prevention education nutrition counseling programs can lead to severe and/or frequent back injuries.

They were asked whether they thought personal factors that included age, experience, stress (physical, mental or emotional), fitness, fatigue, knowledge of back injury prevention methods, pre-existing conditions and commitment to the team can lead to severe and/or frequent back injuries.

The fourth section included categorical and likert scale “Yes” and “No” type questions assessing their history of musculoskeletal injuries, location of injury (e.g. back, knee etc.), type of injury (fracture, dislocation, sprain, strain), severity of injury (mild, moderate, severe). Participants were also asked if they had experienced an injury whether on duty or off duty and did not report/document it because they under estimated its severity/out of fear they will be assigned to light duty/they did not want to jeopardize promotions or assignments only to realize later it was severe and should have been reported so it would be treated.

The last section of the questionnaire gathered information on their exercise routines such as current involvement in exercise programs, their desire to participate in physical fitness and/or back injury prevention activities/programs and their opinions on how such a program should be designed and implemented and what goals should be set for such a program.

They were asked to review a list of goals and help us identify which ones they thought should be the primary goals for the back injury prevention program by selecting which ones they consider important and which ones they consider not important (likert scale “Important” and “Not important” type questions). Those goals included improving cardiovascular fitness, reducing risks of sprains and strains, emphasizing on best practices to avoid back injury, improving moods and ability to cope with stress, improving flexibility and back strength, increasing energy level, correcting misconceptions that lead to back injuries, losing weight, training on the use of personal protective equipment, enjoyment, reshaping and feeling better.

In the last section of the questionnaire they were asked whether they would recommend it to be mandatory and/or be included in their working hours and whether it should have meaningful incentives to encourage participation, whether they think their department needs to acquire more adequate facilities, whether it should include periodic testing to measure their back, whether they think it should include nutrition supervision and guidance, educational sessions on safe exercise and work practices and online education follow-up sessions.

Physical Activity Readiness Questionnaire (PAR-Q)

Exercising and exercise testing places increased demands on the body, thus it is essential that participants know or determine their current health status and physical condition prior to participation in this fitness program. The American College of Sports Medicine (ACSM) recommends that if a participant is male age 40 or greater or a female age 50 or greater, participants should have a medical examination prior to participating in this exercise program. If participants were younger, active, and free of symptoms of coronary heart disease and at low risk for heart disease, they can probably start the program immediately. If they have a pre-existing medical condition or musculoskeletal injury, they should consult physician before beginning the program.

The Physical Activity Readiness Questionnaire (PAR-Q) introduced by Thomas et al. in 1992 (Appendix D) is recommended as a minimal standard for screening prior to beginning an exercise program or, if some activity is already underway, to exercising more vigorously. The PAR-Q is designed to identify the small number of adults for whom physical activity might be inappropriate and those who should have medical clearance prior to exercise.

Strength and fitness testing pre and post fitness program

To evaluate the effectiveness of the eight weeks calisthenics exercise back injury prevention fitness pilot program, it was important to measure participants' strength and fitness pre and post program to quantify the effectiveness of the program.

In both sessions, participants performed various strength and fitness tasks based on the Fire Service Joint Labor Management Wellness-Fitness Initiative guidelines. The Fire Service Joint Labor Management Wellness-Fitness Initiative is a historic partnership between the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) to improve the wellness of fire department uniformed personnel. It is intended to be implemented as a positive individualized program that is not punitive.

All activities were done with the availability of medical personnel under the supervision of the Medical Director. Testing was conducted in a medical care setting with Adult Cardiac Life Support (ACLS) equipment and the ability to implement ACLS protocols.

The strength and fitness sessions included the measurement of participants'

A. **Physical Work Capacity (PWC)**
B. **Back strength**
C. **Endurance**
D. **Flexibility**
E. **Cardiovascular fitness**

The Physical Work Capacity (PWC) test is a standard test is based on various standard series of strength tests which were designed to isolate different muscle groups in the body. These tests measure the Grip, arm, shoulder and torso strength statically System input included the person's physical ability test results and demographic data. For each test, participants performed three trials, one warm-up trial at fifty percent (50%) effort and two trials at voluntary maximum.

Muscle strength is a measure of the greatest amount of force a muscle can apply, that is, the most weight a muscle group can move one time. In addition to its importance in many job-related tasks improving muscular strength also helps prevent injuries to the muscles and makes bones and tendons stronger.

Muscular endurance is a measure of a muscle's ability to maintain a submaximal force or repeatedly apply a submaximal force without a rest, that is, the number of times you can lift a certain amount of weight. Adequate levels of muscular endurance allow muscles to perform a task for a longer period of time before the muscles get tired. Poor endurance of the back and abdominal muscles have been implicated as the cause of much of the low back pain suffered by American adults.

Flexibility is a measure of the range of motion at a joint. Adequate levels of flexibility are necessary in order to make daily movements with ease and to help prevent injuries to muscles and joints. In addition, there is evidence to suggest that inadequate flexibility of the back and legs is related to low back pain.

Cardiovascular fitness is the ability of the heart and lungs (i.e., cardio respiratory system) to supply the working muscles with adequate amounts of oxygen and fuel during endurance activities that last for more than 5 minutes.

The main objective of pre and post program physical work capacity, strength, endurance, flexibility and physical fitness tests was to provide some measure of actual physical gains made by the participant due to the training provided.

Participants that chose to be part of the eight weeks calisthenics exercise back injury prevention fitness pilot program were scheduled to attend a baseline strength and fitness testing session before they start the program and a follow-up strength and fitness testing session after finishing the 8 weeks program.

During the strength and fitness assessment session, a list of the tests was provided to participants with the consent form. An experimenter was on hand to answer any questions participants may have about the tests.

Physical work capacity testing using Jackson Strength Evaluation System (JSES)

The Physical Work Capacity (PWC) score is a calculated score based on a series of strength tests designed to isolate different muscle groups in the body. These tests measure the grip, arm, shoulder and torso strength statically. It evaluates an individual's capacity to perform physically demanding work tasks. System input includes the person's physical ability test results and demographic data. Output is a report that assesses the person's Physical Work Capacity.

The JSES was developed by Dr. Andrew S. Jackson of the University of Houston. It features an electronic load cell to ensure accurate and reproducible readings of isometric strength. Large readouts allow determination of both peak and average strength in pounds. The system includes the control and load cell, a hand dynamometer fixture for the measurement of grip strength, and a heavy duty lifting platform, bar and chain (Figure 2). The manufacturer reports that the JSES is widely used to measure static strength using the National Institute of Occupational Safety and Health (NIOSH) protocol.

The JSES has three qualities that make it ideal for employment testing. It has been shown to be safe, reliable (**r** = .90), and practical. The JSES is widely recognized as a reliable and valid indicator of the amount of static strength possessed by individuals. The test is relatively inexpensive, it is practical, safe and portable.

Figure 2. Jackson Strength Evaluation System (JSES) that was used for testing

Physical work capacity testing procedures

To be able to calculate the PWC score, we measured participants'

- **Grip strength,**
- **Arm lifting strength,**
- **Shoulder lifting strength,**
- **Torso pull and**
- **Leg lifting strength.**

The general procedures that were followed for all tests were:

- Prior to administering the first test, instructions were given about what is being measured and how they will be doing three attempts, with the first attempt at only half (50%) effort and that the final score with be the average of the other two.
- For each test, the participants were given three trials, one warm-up trial at 50% effort and two trials at voluntary maximum. We first administered a "warm-up" trial where the participants exerted force at 50% effort and corrected any problems. Once

participants understood what to do, we administered two trials for score. The trials were at maximum, voluntary effort.

- To insure a maximum voluntary effort, participants were not tested in the presence of others, were not subjected to any form of external motivation and were not given their score at the completion of the trial.
- The Jackson Strength Evaluation System provided the applicant with a stimuli (beep) to apply force and a second stimuli (flutter beep) to end the trial. Prior to administering the first test, applicants will be given instructions to exert max effort as soon as they hear the first beep, apply a consistent, maximum effort during this period and not to jerk. They will be instructed to relax at final beep.

Grip strength testing

The grip strength test measured the grip of both hands. The JAMAR hand dynamometer was used and it utilizes a hydraulic gauge with a peak-hold needle to record the highest strength effort. JAMAR displayed grip force in pound/ kilogram. The maximum grip strength was recorded by a special peak-hold needle. After each test trial, we reset the needle to "0". Participants stood comfortably with their shoulder adducted and neutrally rotated. The elbow was flexed to 90° and the forearm and wrist were in neutral position. When in the correct position, they were instructed to apply force by gripping the handle with a single, forceful effort as soon as they hear the first beep and relax at second beep. A 50% effort trial should was before doing the 2 scored trials. The two trials for a score for the right grip were then administered. The participant's score in pounds was recorded. This value was recorded by the peak-hold needle. The peak-hold needle was then reset to zero after each trial. Once the right and left grip were tested, the participant's grip strength was then calculated as the average of the four maximum-voluntary effort trial.

Arms lift testing

The arm lift test was administered with the Jackson Evaluation System with the load cell attached to platform. Figure 3 shows the arm lift test position. In proper position, the participant stood on the platform with arms at his side and elbows at a right angle (90° flexion). Administrator un snapped the bar from chain and raised or lowered the chain to the appropriate height.

Participants were instructed to assume a hand placement width (about shoulder-width apart) that is comfortable holding their handle with the palms up. The cable had to be tight and at a right angle to the base. This is done by having the participant pull up and by moving forward or backward. The participants were instructed not to lean back or use his legs (e.g., bending the knees and generating force with the legs). The force was exerted by lifting with the arms with the elbows at 90° flexion.

Figure 3. The arm lifts test position.

When in the correct position, they were instructed to lift up with arms without leaning back. Rather, lift up. 50% effort trials then the two trials for score were administered. The participant's score was the average of the two maximum voluntary-effort trials.

Shoulder lift testing

This test measured the lifting strength of the shoulders. The force was correctly exerted by lifting with shoulders while the elbows point outward (without leaning back or using legs).The same bar setting used for the arm lift test was used for the shoulder lift. To assume the correct position, the participant moved forward until the bar touches his body. The cable had to be tight and at a right angle to the base. With the palms facing the rear, the participant grabbed the bar so that the inside of their hands was on the inside of the black handle. In this position the elbows were pointing out, away from the body. Figure 4 shows the shoulder lift test position.

Figure 4. The shoulders lift test position

The participant was not allowed to lean back or uses his legs (e.g., bending the knees and generating force with the legs). The force was correctly exerted by lifting with shoulders while the elbows point outward. The participant's score was the average of the two maximum voluntary-effort trials.

Torso pull testing

The lift bar was attached to a chain link that places the bar 17 inches from the base of the platform. The same chain setting was used for all participants. The handle was attached to the 8th link in the chain. The platform was placed against the wall with the cable-chain unit at the bottom of the platform. The braces were connected to the side of the platform to provide stability. The participant sat on the floor with feet firmly against the platform and straight see figure 5.

In this sitting position, the participant bent at the waist and grips the handle with the palms facing down. The hands were held about shoulder-width apart and the arms were straight. In the test position, force was exerted by pulling and leaning back. The participant was instructed not to jerk, but rather apply force in a consistent, forceful manner. Once participant was in the correct test position, they were instructed to grip the bar with palms facing down, then lean back and pull, applying a steady, forceful effort. The participant's score was the average of the two maximum voluntary-effort trials.

Figure 5. The test position to test torso pull strength

Leg lift testing

The same bar setting used for the torso pull test was used for the leg lift test, i.e., 17- inch height from the base. The participant stood on the platform with their feet spread a comfortable distance. The bar was rotated 90° so the end of the bar faced the front and back of the platform, i.e., the bar was between the person's legs see figure 6.

The participant griped the bar with the palms facing each other. The hands were as close to the center of the bar as possible. In this position the bar was between the legs with the arms as close to the body as possible. The participant bent their knees, keeping the arms as close to the body as possible to minimize low back compression forces. Once in position, participant was instructed to look up. This makes him assume the correct position.

In the test position, force was produced by exerting force with the legs. This duplicates lifting with the legs. The participant was instructed not to jerk, instead apply force in a consistent, forceful manner. The participant's score was the average of the two maximum voluntary-effort trials.

Figure 6. The test position to test leg lift

Back strength tests

This group of tests were done examine back strength. They were asked to do as much repetitions as they can in one minute. The tests included Bridge test, Wall squat test and Partial sit-up test. Administrator instructed them on the correct and safe way to do each test.

Bridge test

Participants were asked to lie on back with knees bent, feet flat on the floor and arms at his sides. With knees slightly parted, Participants slowly raised buttocks from the floor, keeping stomach tight and abdomen in line with thighs. Participants were asked to hold this position for five seconds and return to the starting position.

Wall squat test

Participants were asked to lean against a smooth wall with feet pointing straight ahead and heels 18 inches from the wall. Participants slowly lowered upper body down the wall until knees were bent to 90°. Participants were asked to hold this position for five seconds then return to the starting position.

Partial sit-up test

Participants were asked to lie on back with knees bent, feet flat on the floor and arms at sides. First tuck chin into chest. While holding this position, raise head and shoulders up until shoulder blades were off the floor. Hold this position briefly before returning to the starting position.

Flexibility - sit and reach test

Flexibility is the range of movement about a joint. Individual differences in flexibility depend on physiological characteristics that influence the extensibility of the muscles and ligaments surrounding a joint. It is generally believed that a degree of flexibility in the back and hamstring muscle groups is essential for the prevention of lower back disorders.

It is for this reason that the sit-and-reach test is a common test used to measure physical fitness of adults (Golding et al., 1989). Provided next are the procedures we followed for measuring flexibility. The objective of the sit and reach test was to evaluate the flexibility of the lower back and posterior thighs. Figure 7 shows the correct test procedure.

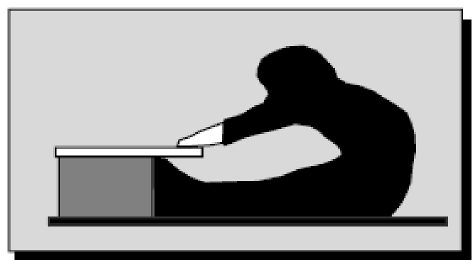

Figure 7. Test position for testing flexibility

With the shoes removed, the participant sat with feet flat against the test apparatus. With their knees fully extended, participants extended their arms forward with their hands placed on top of each other. The participant reached forward, palms down, along the measuring scale. The tips of the fingers were against the maximum indicator.

They stretched as far as possible and held the position for one second. The score was the farthest point reached measured to the nearest 0.25 inch. The distance was obtained from the maximum indicator.

Muscular endurance test

Muscular endurance is the ability of a muscle group to perform repeated contractions. Several studies and job analysis have shown a strong association between muscular endurance and the essential job tasks of firefighting. Low levels of muscular endurance precipitate many preventable fire service injuries.

Abdominal muscles endurance is necessary to stabilize the torso and support the lower back during exertion. Weak abdominal muscles may contribute to low back pain and low back injury. To measure muscle endurance, we performed two tests, the Push-up test to measure anterior chest girdle and triceps endurance and the Curl-up test to measure the abdominal endurance

The push-up test

The push-up test is a measure of the muscular endurance of the anterior chest girdle and the triceps. Participants were instructed to do push-ups in a two- minute time period. Tests initiated from the "up" position (hands were at shoulder width apart, back was straight, and head was in neutral position). Their feet were not against a wall or other stationary item and their back was to stay straight at all times.

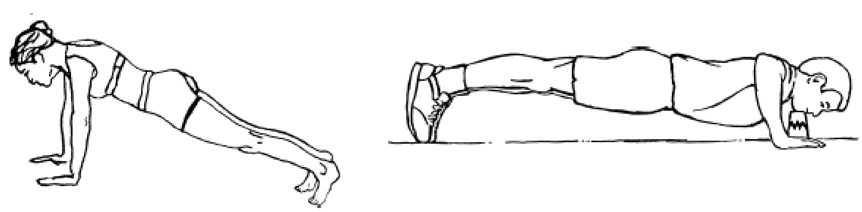

Figure 8. Test position for push-ups

They were asked to push up to a straight arm position (figure 8). Participants were asked to stop that if at any time during the evaluation they experienced chest pain, light-headedness, ataxia, confusion, nausea, or clamminess.

We stopped the evaluation when the individual performed three consecutive incorrect push-ups or did not maintain continuous motion then recorded the highest number of successfully completed push-ups during those two minutes.

The curl-up test

Curl-up test was used to measure muscular endurance of the abdominal muscles. Participants were asked to perform a series of curl-ups in a 3-minute time period.

Evaluation was initiated from the supine position with knees bent at a 90 degree angle, hands cupped over the ears or at the temples and with hand and arm position maintained for the entire duration of the evaluation. The feet were secured by administrator, but the holding or bracing of the knees and or ankles was not allowed. The curl-up was initiated by flattening the lower back followed by actively contracting the abdominal muscles and then continuing the movement until the trunk reaches a 45-degree angle with respect to the floor. This was followed by curling down of the trunk with the lower back fully contacting the mat before the upper back and shoulders. A rocking or bouncing movement was not permitted and the buttocks had to remain in contact with the mat at all times. Participants were instructed to continue performing curl-ups in time with the cadence of the metronome, one beat up and one beat down. Inform the individual that if at any time during the evaluation they experience back pain, chest pain, light-headedness, ataxia, confusion, or nausea, they should terminate the evaluation.

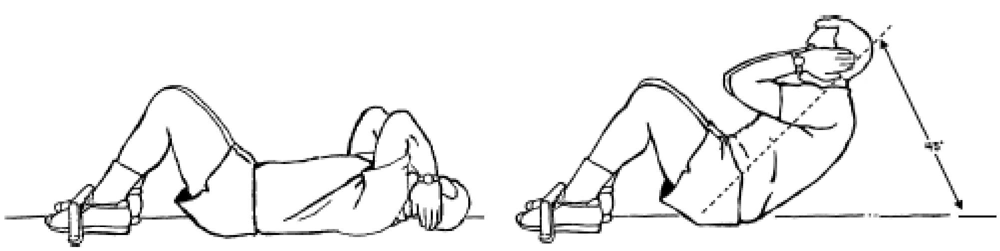

Figure 9. The curl-up test

The metronome was set at a speed of 60, allowing for 30 curl-ups per minute. Participants were given a 3-minute time limit to complete a maximum of 90 curl-ups. We observed the evaluation from the side to ensure that each curl-up was performed correctly and we recorded the highest number of successfully completed curl-ups. We stopped the evaluation when the individual reached 90 curl-ups or performed three consecutive incorrect curl-ups or did not maintain continuous motion with the metronome cadence.

Cardiovascular fitness test

We used Maximal graded exercise test (GXT) using Oxycon Mobile systems and applied Ellestad Protocol (Stress testing : principles and practice Myrvin H. Ellestad, 1986). We used a treadmill as our mode of testing, treadmill tests are preferred over bicycle tests because of higher VO2max values and heart rates are achieved on a treadmill test, leg strength and early fatigue are less of a problem compared to bicycle ergometer.

There are several protocols used with treadmill tests. Some common known tests are Bruce, Balke, Naughton, Ellestad and Astrand just to name a few. Ellestad Protocols were known for being short – 8-12 minutes and ideal for more fit participants. The protocol started with a warm-up session where participants started walking on the treadmill for 2 to 4 minutes, then the first stage started at 10% grade and 1.7 mph speed for 3 minutes, the second stage was for 2 minutes (10% grade and 3 mph), third stage for 2 minutes (10% grade and 4 mph), fourth stage was 3 minutes (10% grade and 5 mph), fifth stage was 3 minutes (15% grade and 6 mph) then all next stages were 3 minutes at grade 15% with increase of 1 mph per stage.

Oxycon Mobile was used to monitor cardio respiratory functions during the maximal GXT (figure 10). The Oxycon Mobile is a mobile lung function testing system that monitors cardio respiratory functions during exercise tests, which are performed in the field of sports medicine, rehabilitation, and during other activities. Furthermore the

Oxycon Mobile allows the telemetric monitoring of metabolic parameters and can be used for measurements in adults and children from the age of 14 up.

Oxycon Mobile offers on-the-spot measurements of all relevant ergospirometry parameters. The small, sophisticated unit is fixed to a comfortable belt system which is carried like a harness so that the measurement can be performed via a face mask without any impairment by cables. The measured data are telemetrically transferred to the PC or saved on a small replaceable flash card.

Oxycon Mobile measures important ergospirometric key parameters such as ventilation, VO2, VCO2, anaerobic threshold, RER, HR, EQO2, EQCO2. The system acquires data breath by breath in the so-called "open system".

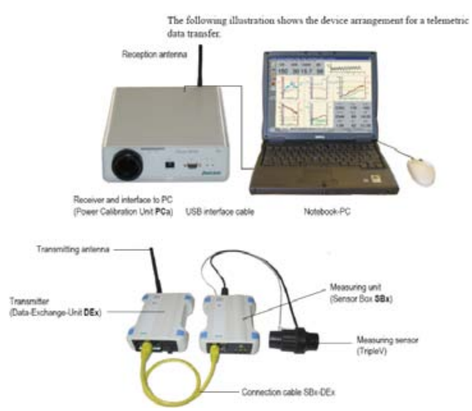

Figure 10. The Oxycon Mobile system

Figure 11. Participant in warm-up stage with Oxycon mobile system on.

Oxycon Mobile measurement procedure

Check ambient conditions

The ambient conditions were checked once a day and corrected if considered necessary. During this check, the SBx has to be connected to the DEx unit.

Calibration

A calibration had to be carried out before every measurement. Before the actual calibration was started, we waited till the warm-up period is over. We performed a volume calibration 15 minutes after switching on the unit at the earliest.

Performing ergospirometry measurement

Participants were fitted with the belt carrying the transmitter and the measurement units, the face mask was fitted comfortably and once participants were ready, the measuring sensor was attached to the face mask. The transmission was then tested and participants were asked to step on the treadmill.

The protocol started with a warm-up session where participants started walking on the treadmill for 2 to 4 minutes, then the first stage started at 10% grade and 1.7 mph speed for 3 minutes, the second stage was for 2 minutes (10% grade and 3 mph), third stage for 2 minutes (10% grade and 4 mph), fourth stage was 3 minutes (10% grade and 5 mph), fifth stage was 3 minutes (15% grade and 6 mph) then all next stages were 3 minutes at grade 15% with increase of 1 mph per stage. Medical personnel under the supervision of the medical director of Deerfield fire department were available throughout the testing. Testing was conducted in a medical care setting with Adult Cardiac Life Support (ACLS) equipment and the ability to implement ACLS protocols.

Participants were asked to keep going till tire and to immediately inform us if at any time during the evaluation they experience back pain, chest pain, light-headedness, ataxia, confusion, or nausea.

The VO2max was recorded by the system and saved on the participants profile along with the stage they peaked at the heart rate.

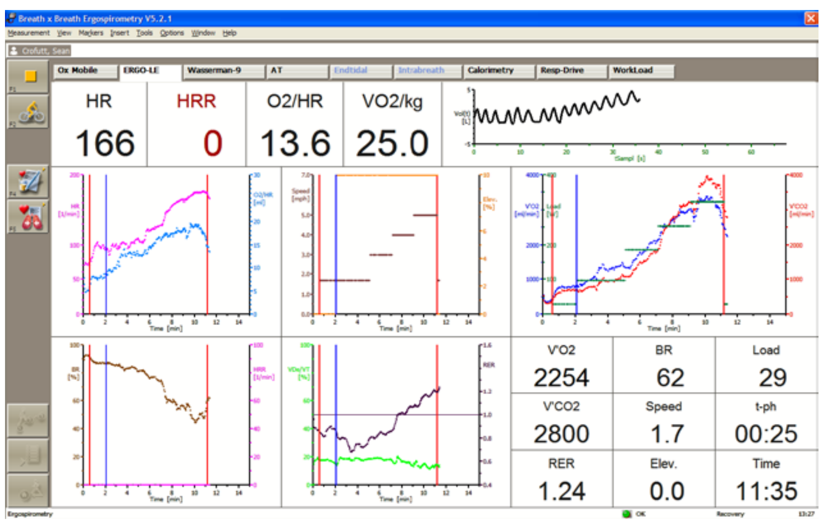

Figure 12. Participant Oxycon mobile system screen output.

Training program

The goal was to evaluate the impact of an eight weeks physical fitness program on the strength, endurance, fitness and physical work capacity of participants. The easy to implement program consisted of calisthenics exercises aimed to strengthen the core and back muscles and increase the endurance, fitness and physical work capacity of emergency services personnel utilizing the basic resources that any emergency response facility and any emergency personnel has access to without the need of complicated equipment for exercise or fitness measurement.

All participants agreed to follow an eight weeks, twice per week, pre-defined set of exercises based on the guidelines developed by the International Association of Fire Fighters (IAFF).

Following baseline assessment, the 8 weeks 1.5 $h \cdot d^{-1}$, 3 $d \cdot wk^{-1}$ program started. The program was designed to improve muscle strength, endurance, flexibility, aerobic capacity, and body composition. Each 1.5 hour workout was segmented as follows: 15 minutes warm-up and stretching, 20-30 minutes aerobic conditioning, 50-60 minutes upper-/lower-body, abdominal and back strengthening exercises 15 minutes cool down and stretching. Training periods (initial conditioning/strength I/strength II) were instituted so that progressive improvement would be made during the entire course of the training period. For upper-/lower-body, abdominal and back strengthening calisthenics exercises recommended where Chin-ups, dips, lunges, leg lifts, wall squats, bench steps and bridges (3 sets, 12 repetitions) were performed at an estimated 75% of 1RM for initial conditioning phase weeks (1–2); 80% of 1RM for basic strength phase (weeks 3–5); 85-90% of 1RM for strength phase II (weeks 6–8). Other optional calisthenics were recommended during strength phases including forward traveling lunges, opposite side and leg lifts , chair squats, rotational sit-up. For muscle endurance training exercises (push-ups, sit-ups, partial sit-ups and/or rotational sit-ups) were performed at an estimated 50–55% of 1RM for weeks 1–2, 55–60% of 1RM for weeks 3–5, and 60–65% of 1RM for weeks 6–8. For cardiovascular conditioning, exercises were performed at 65–75% of predicted maximal HR for the basic training period (weeks 1–2) where running was emphasized; 70–80% of predicted maximal HR for improvement stage I (weeks 3–5) where hill running was included; 75–85% of predicted maximal HR for improvement stage II (weeks 6–8) where speed/sprint work was added.

Participants were introduced to the various exercises and researchers explained the safe and correct ways of performing those exercises. Participants were given various materials to help them perform the exercises correctly and safely, they were also asked to document their progress for the eight weeks in a worksheet provided by researchers.

Throughout the eight weeks to follow, researchers stayed in touch with participants through visits to Deerfield fire department and through a 2, 4 and 6 weeks follow-up phone calls

The training program targeted specific muscles or muscle groups of the body. It involved having the muscle or muscles apply and maintain a force for a short time and/or repeatedly. The rate of improvement or adaptation is related to the Frequency, Intensity, or Time (FIT) parameters. Three FIT parameters were used for all exercises. These are: Frequency, Intensity, and Time. Frequency refers to the number of times that you exercise per week. For improvement in fitness level to take place via adaptation, a part of the body had to be subjected to more than it is accustomed.

Participants were asked to document their progress by logging their replications of each exercise in the exercise log sheet (appendix F), they were also advised to try to increase replications from a session to the next or from a week to week and record their progress.

They were advised not to eat, smoke, and drink alcohol or caffeinated beverages for at least one hour before an exercise session because eating a large meal prior to exercise results in less blood being available to carry oxygen to the skeletal muscles. In addition, eating, drinking alcohol, and/or smoking prior to exercise can increase their resting heart rate by as much as 10 beats per minute. This increase coupled with the exercise-related increase in heart rate may lead to dizziness or nausea. They were advised to drink water before, during, and after exercise. About 20 minutes prior to exercise, frequently (i.e., every 15-20 minutes) consume small amounts (i.e., 4-6 ounces) of water as opposed to large amounts infrequently.

The training program instructions were given to participants along with the log sheets and the instructions on how to perform each exercise and procedures were asked to do the following in each session:

A. Warm-up

B. Strength and muscular endurance exercises (Calisthenics)

C. Cool-down

A. Warm-up

The warm-up exercises were designed not only to get a person physically and mentally ready for the muscular and/or aerobic exercise sessions, but also to help develop flexibility in various joints. Participants were asked to do a 5-10 minute warm-up period allowing them to mentally prepare for exercise, increase body temperature slowly, stretch the muscles and joints and increase their heart rate and breathing gradually. Warm-up consists of low intensity aerobic activity such as walking or slow jogging followed by light stretching. Participants were given a list of warm-up and stretching exercises as part of the materials they were given during the eight weeks program (Appendix F)

B. Strength and muscular endurance exercises (Calisthenics)

Calisthenics are exercises that can be performed without equipment, although hand or ankle weights may be used. These types of exercises can be used to develop strength, muscular endurance, and flexibility. Calisthenics usually involve the repetitive lifting and lowering of a body segment as in push-ups, curl-ups, and arm circles.

When designing the strength and fitness program we chose a variety of exercises that would help strengthen various body muscles with a focus on core and back muscles (Abdominal muscles).

Participants were asked to record the number of repetitions performed for each exercise performed during a session try to increase the repetitions by at least 5 per week throughout the program.

Strength exercises

These were exercises targeting various body muscles with the aim to increase the total body strength and fitness. Participants were given a list of the exercises with detailed steps on how to do each exercise correctly and safely, they were also given a summary illustration sheet that had all the exercises and their starting and ending positions to be used as a reference.

The strength exercises included:

- **Push-ups**
- **Chin-ups**
- **Dips**
- **Chair squats**
- **Lunges and forward traveling lunges**
- **Standing side leg lifts**

Abdominal muscle strength is important for core stability and back support. Performing these exercises on a regular basis helps reduce or prevent back injuries. The following were the exercises we chose specifically to strengthen the back and abdominal muscles.

Bridges: Participants were asked to lie on back with knees bent, feet flat on the floor and arms at the sides. With knees slightly parted, Participants slowly raised buttocks from the floor, keeping stomach tight and abdomen in line with thighs. Participants were asked to hold this position for five seconds and return to the starting position.

Wall squat: Participants were asked to lean against a smooth wall with feet pointing straight ahead and heels 18 inches from the wall. Participants slowly lowered the upper body down the wall until knees were bent to 90°. Participants were asked to hold this position for five seconds then return to the starting position.

Partial sit-up: Participants were asked to lie on back with knees bent, feet flat on the floor and arms at sides. They were then asked to tuck chin into chest. While holding this position, raised head and shoulders up until shoulder blades are off the floor then hold this position briefly before returning to the starting position.

Rotational sit-up: Participants were asked to lie on back with the knees bent, feet flat on the floor and arms at sides. Keeping hips flat on the floor, they were asked to rotate upper body onto left shoulder. Keeping chin tucked in, curl head and right shoulder upward by stretching out arms and hands toward left knee. Hold briefly before returning to the starting position.

Bench steps: Participants were asked to step up onto a bench that is 8-12" high, bringing up both feet and then down again, one at a time, for 30 seconds (up-up-down-down). Switch the lead foot and repeat for 30 seconds. Increase the time for each lead foot by 10 seconds per week, up to a maximum of 60 seconds of stepping up and down with each lead foot.

Opposite arm and leg lifts: Participants were asked to lie face down on the floor with forehead resting on a towel. Arms were stretched overhead with hands shoulder-width apart. Raise the left arm and the right leg approximately 4-8 inches from the floor. Lower to starting position. Repeat on other side.

A picture illustration of how all previously mentioned exercises should be done were given (appendix E), this illustration sheet was provided to each participant as a reference along with a log sheet where they recorded how many repetitions from each exercise they did each session.

C. Cool-down

Participants were asked to take 5 – 10 minutes to cool to allow the heart rate to decrease gradually.

Chapter 4: Results

Musculoskeletal and back injuries knowledge and perception assessment

This section highlights the results of the first phase of the study where we examined perceptions and knowledge about musculoskeletal injuries among emergency workers personnel, with an emphasis on back injuries. We also gathered some input about topics for injury prevention programs. Data was gathered from a paper and pencil knowledge test and survey instruments. The results can be used to guide back injury prevention programs so that they best fit the needs of emergency workers personnel.

Participants

The assessment included 125 full-time paid, professional emergency workers personnel from Deerfield Beach firefighting department, table 2 represents the demographic information of participants

	Min.	Max.	Mean	Std. Dev.
Age	21	56	35.81	9.61
Years of Exp.	1	30	10.95	8.49

		N (%)
Gender	Male	116 (92.8)
	Female	9 (7.2)
Ethnicity	White	108 (86.4)
	Hispanic	10 (8)
	Other	7 (1.6)
Education	High school	29 (23.2)
	Associate or higher	96 (76.8)

Table 2. Participants demographics

For analysis purposes, we recoded age into two levels, 18-35 yrs (53.6%) and 36-60 yrs (46.4%). We recoded years of experience into two levels,≤ 10 years of experience

(48.8%) and > than 10 years of experience (51.2%). We recoded education to two levels, high school (23.2%) and associate or higher (76.8%). Chi-squared tests were used to test whether participants' responses differed by age levels, level of experience or educational level. Correlation was used to test degree of relationship between calculated scores and participants' responds.

A. Perceptions of prevalence, cost and preventability

Respondents were asked about their perceptions of how prevalent, costly and preventable musculoskeletal injuries are at different body locations (back, neck, shoulder, elbows, knees and ankles). To examine general perceptions of musculoskeletal injuries, we calculated three scores reflecting overall perceptions of preventability, cost and prevalence of musculoskeletal injuries based on summaries of responses to queries for injuries at the neck, shoulders, back, elbows, knees and ankles. The three scores could range from 6 to 18, where higher score corresponds to more prevalent, preventable, and costly injuries.

All participants indicated that back injuries were the most costly followed by knee injuries (95.2%). Ninety nine percent of participants indicated that back injuries were most prevalent followed by knee injuries (90.4%). Only 61 percent of participants indicated that back injuries were preventable followed by neck injuries (70.4%).

The overall score of their perception of prevalence of musculoskeletal injuries had a mean of 12.94 (*SD*=2.62). There were no differences in the perceptions regarding the prevalence of musculoskeletal injuries by age ($r(123) = .083$, $p > .01$), level of education ($r(123) = .018$, $p > .01$) or years of working experience ($r(123) = .098$, $p > .01$).

The overall score of their perception of preventability of musculoskeletal injuries had a mean of 11.25 (SD=2.65). There were no differences in the perceptions regarding preventability by age ($r(123) = .010$, $p > .01$), level of education ($r(123) = .024$, $p > .01$) or years of working experience ($r(123) = .011$, $p > .01$).

The overall score of their perception of costly of musculoskeletal injuries had a mean of 14.25 (SD=2.35). There were no differences in the perceptions regarding how costly musculoskeletal injuries were by age ($r(123) = .05$, $p > .01$), level of education ($r(123) = .03$, $p > .01$) or years of working experience ($r(123) = .027$, $p > .01$). There was a relationship between perceptions of cost and prevalence such that prevalent injuries were preserved as more costly $r(123) = .521$, $p < .01$.

There was no significant difference in perceptions about the potential for preventing back injuries according to level of education $\chi^2(1, 125) = 1.35$, $p > .01$, years of working experience $\chi^2(1, 125) = 0.49$, $p > .01$ or age . $\chi^2(1, 125) = 0.73$, $p > .01$.

B. Perceptions of causes of back injuries

Perceptions of causes of frequent and/or severe back injuries were categorized according to three factors: external factors (e.g. weather, terrain etc.), workplace factors (e.g. shifts, equipment etc.) and finally personal factors (e.g. commitment, experience etc). Overall participants indicated that work place factors are the leading cause of frequent (58.4%) and severe (51.2%) back injuries (Table 3) However, there was a difference in these perceptions according to amount of work experience ($\chi^2(2, 125) = 6.94$, $p < .05$). Thirty nine percent of participants with higher work experience indicated that external factors are the leading cause of severe back injuries whereas fifty seven percent of those with less experience indicated that workplace factors are the leading cause of severe back injuries.

Perceptions of causes of severe and frequent back injuries	Leads to severe back injuries			Leads to frequent back injuries		
	Years of experience		Total	Years of experience		Total
	<= 10 yrs	> 10 yrs		<= 10 yrs	> 10 yrs	
External Factors	11 (18)	25 (39)	36 (28.8)	14 (23)	14 (21.9)	28 (22.4)
Workplace Factors	35 (57.4)	29 (45.3)	64 (51.2)	34 (55.7)	39 (60.9)	73 (58.4)
Personal Factors	15 (24.6)	10 (15.7)	25 (20)	13 (21.3)	11 (17.2)	24 (19.2)

Table 3. Perceptions of causes of severe and frequent back injuries

Table 4 summarizes participants' perceptions of causes of severe and frequent back injuries. Participants indicated that being forced to lift objects/subjects in an unsafe way and pre-existing conditions were the highest causes of severe and frequent back injuries. Other factors perceived to be frequent contributors to injury included: fatigue, lack of experience, lack of fitness programs, lack of back injury prevention knowledge, and lack of back strengthening programs. We examined if perceptions regarding specific causes of back injuries varied according to participants' level of experience, the results indicated that participants with less work experience perceived lack of fitness programs (77%), lack of back injury prevention education programs (79%) and inadequate safety training (79%) contributed to back injuries.

Participants with higher levels of education indicated that frequent back injuries are caused by lack of back injury prevention knowledge (82.3%) and lack of experience (83.3%)

	Perceptions of causes of severe and frequent back injuries	Leads to severe back injuries			Leads to frequent back injuries		
		Years of experience		Total	Years of experience		Total
		<= 10 yrs	> 10 yrs		<= 10 yrs	> 10 yrs	
External	Forced to lift objects/subjects in an unsafe way	60 (98.4)	62 (96.9)	122 (97.6)	50 (82)	50 (78.1)	100 (80)
	Extreme weather	30 (49.2)	23 (35.9)	53 (42.4)	27 (44.3)	24 (37.5)	51 (40.8)
	Large scale emergencies	42 (68.9)	38 (59.4)	80 (64)	30 (49.2)	34 (53.1)	64 (51.2)
	Collapsing structures	55 (90.2)	54 (84.4)	109 (87.2)	35 (57.4)	38 (59.4)	73 (58.4)
Workplace	Lack of fitness programs	47 (77)	37 (57.8)	84 (67.2)	51 (83.6)	56 (87.5)	107 (85.6)
	Lack of protective equipment	46 (75.4)	40 (62.5)	86 (68.8)	44 (72.1)	47 (73.4)	91 (72.8)
	Lack of back injury prevention Education	48 (78.7)	39 (60.9)	87 (69.6)	46 (75.4)	51 (79.7)	97 (77.6)
	Lack of back strengthening programs	46 (75.4)	43 (67.2)	89 (71.2)	52 (85.2)	54 (84.4)	106 (84.8)
	Shifts (24hrs. on / 48 hrs. off) or night shifts	18 (29.5)	19 (29.7)	37 (29.6)	24 (39.3)	30 (46.9)	54 (43.2)
	Emergency nature of work	47 (77)	49 (76.6)	96 (76.8)	48 (78.7)	48 (75)	96 (76.8)
	Poor staffing level	42 (68.9)	47 (73.4)	89 (71.2)	40 (65.6)	49 (76.6)	89 (71.2)
	Inadequate safety training	48 (78.7)	40 (62.5)	88 (70.4)	46 (75.4)	53 (82.8)	99 (79.2)
	Lack of support from local authorities	26 (42.6)	25 (39.1)	51 (40.8)	28 (45.9)	36 (56.3)	64 (51.2)
	Lack of nutrition counseling	27 (44.3)	25 (39.1)	52 (41.6)	38 (62.3)	39 (60.9)	77 (61.6)
	Lack of training on use of protective equipment	47 (77)	40 (62.5)	87 (69.6)	49 (80.3)	45 (70.3)	94 (75.2)
	Systems for personnel selection and promotion	23 (37.7)	22 (34.4)	45 (36)	24 (39.3)	28 (43.8)	52 (41.6)
	Lack of commitment to the team	30 (49.2)	33 (51.6)	63 (50.4)	37 (60.7)	39 (60.9)	76 (60.8)
	Lack of back injury prevention knowledge	47 (77)	47 (73.4)	94 (75.2)	48 (78.7)	49 (76.6)	97 (77.6)
personal	Age	43 (70.5)	47 (73.4)	90 (72)	44 (72.1)	54 (84.4)	98 (78.4)
	Lack of experience	46 (75.4)	44 (68.8)	90 (72)	47 (77)	52 (81.3)	99 (79.2)
	Pre-existing conditions	52 (85.2)	51 (79.7)	103 (82.4)	47 (77)	55 (85.9)	102 (81.6)
	Fatigue due to repetition	46 (75.4)	51 (79.7)	97 (77.6)	52 (85.2)	53 (82.8)	105 (84)
	Bad eating habits	28 (45.9)	27 (42.2)	55 (44)	37 (60.7)	34 (53.1)	71 (56.8)
	Physical, mental or emotional stress	36 (59)	41 (64.1)	77 (61.6)	39 (63.9)	48 (75)	87 (69.6)
	Lack of self fitness/health awareness	48 (78.7)	48 (75)	96 (76.8)	51 (83.6)	56 (87.5)	107 (85.6)

Table 4. Perceptions of Causes of Back injuries by years of working experience

C. Musculoskeletal injuries history

Eighty percent of our participants reported having had previous musculoskeletal injuries. Back injuries were the most frequent reported injury. Fifty nine percent of the participants reported having a back injury, 28% reported having ankle injuries and 20% reported having knee injuries.

There was an age difference in back injury prevalence. As expected, 67.8% of the older participants reported having back injuries, whereas only 29% of younger participants reported having a back injury $\chi^2(2, \mathit{125}) = 25.4$, $p < .05$. The same trend was found for years of experience where 58% of the more experienced participants reported having a back injury, while 43% of the less experienced participants reported having a back injury $\chi^2(2, \mathit{125}) = 14.1$, $p < .05$.

Of those participants who reported having an injury, 26% indicated they underestimated the severity of the injuries and thus did not report it. However, 50% documented the injury in case it became serious and required coverage. Only 13% did not report it to avoid being assigned light duty and 7% did not report it to avoid jeopardizing promotions. Respondents in the older age group were more likely to underestimate the severity of an injury ($\chi^2(1, \mathit{125}) = 6.39$, $p < .05$).

D. Participants' recommendations regarding fitness program

In the last section of the questionnaire they were asked whether they would recommend it to be mandatory and/or be included in their working hours and whether it should have meaningful incentives to encourage participation, whether they think their department needs to acquire more adequate facilities, whether it should include periodic testing to measure their back, whether they think it should include nutrition supervision and guidance, educational sessions on safe exercise and work practices and online education follow-up sessions.

Participants recommended that a physical fitness program should be mandatory (79.2%), included within working hours (87.2%), having access to better fitness facilities (81.6%) and have periodic back strength testing (82.4%). They also suggested that workers should be provided with meaningful incentives for participation in fitness programs (88.8%), have nutrition supervision (92.8%), have training on safe exercising (94.4%) and safe work practices (92.8%). They also recommended including online education follow-up sessions (68%).

Finally, participants recommended that the programs should focus on improving cardiovascular fitness (92%), improving back strength and flexibility (92.8%) and reducing risks of strain and sprain (92.8%).

E. Spinal health questionnaire score

The Spinal Health questionnaire was designed to assess the emergency workers personnel general knowledge of spinal health and safety and trying to identify the common misconceptions related to back injuries and safety then quantify that knowledge in to a knowledge score. Participants were then offered an educational session as part of the program to correct those misconceptions and educate them about injury prevention best practices. The questionnaire was re-administered at the end of the program (after 8 weeks) to test whether there is a significant change in their knowledge.

The questionnaire then queried respondents about safe or un-safe back practices. The questionnaire included 29 likert scale questions in which participants were asked to agree or disagree with the statements about spinal health like “It is safer to pull a stretcher rather than pushing it", "Using heat immediately after a back strain is beneficial for quick recovery" and "Reaching above shoulder height to move an object is harmful to spinal health". Scores could range from 0 – 29 with a higher score indicating more knowledge.

Spinal health score at baseline

The average spinal health score based on 125 participants at baseline was 21.93 (*SD* = 2.57). We examined if spinal health score varied according to age, level of experience education or prior history of having back injury. The results indicated that spinal health score was correlated with age $r(123) = .285$, $p < .01$, years of experience $r(123) = .311$, $p < .01$ and education $r(123) = .177$, $p < .05$ such that those who were older, had more experience and education had more knowledge. Spinal health score was correlated to history of reported back injury $r(123) = 0.348$, $p < .01$ such that those that reported history of back injuries had more knowledge.

The most common misconceptions about spinal health were related to lifting belts, sleeping positions and the use of heat immediately after strains, Eighty eight participants (70.4%) believed that the use of lifting belts is beneficial, sixty eight (54.4%) participants believed that lying on their side while sleeping is ideal and forty four (35%) believed that the use of heat immediately after a back strain is beneficial to their spinal health. Among workers with less experience the most common misconceptions were benefits of back belts were 80% believed it was beneficial and use of heat immediately after a back strain were 53% believed it was beneficial. Whereas 60% of those with more experience believed that lying on their side while sleeping is ideal.

Spinal health questionnaire score (Pre vs Post)

The average spinal health score based on 86 participants at follow-up was 23.91 (*SD* = 2.65). A paired-samples t-test revealed a significant differences in the spinal health scores for those 86 participants before and after the study, t (85) = -8.32, $p < .01$. This indicates that the mean spinal health score after the study (*M* = 23.91) was significantly higher than the mean before the study (*M* = 22.21).

Pilot fitness program

This section highlights the results of the second phase of the study where 40 participants volunteered to take part in a pilot fitness program.

The training program consisted of two volunteer physical training sessions per week for eight weeks. Each individual session consists of a warm up, an aerobic period, a calisthenics session with predetermined illustrated exercises (Push-ups, Chin-ups, Dips, etc.) and a cool down period. A list of the exercises included in each session was provided to participants with the consent form.

Participants were asked to conduct those sessions three times a week and keep track of their progress in an exercise log provided, we recommended that they try to increase the repetitions of exercises whenever possible.

After the completion of the eight weeks program, participants came back for a strength and fitness follow-up session. They brought back the exercise log sheet indicating how many sessions they did during those eight weeks and the repetitions of each exercise on each session.

Measures

The Physical Work Capacity (PWC) score was computed pre and post program based on various standard series of strength tests which were designed to isolate different muscle groups in the body. These tests measure the Grip, arm, shoulder and torso strength statically System input included the person's physical ability test results and demographic data.

Two groups of calisthenics were used as general measures of back strength and endurance. The Back strength group consisted of bridges, wall squats and sit-ups, the endurance group consisted of pushups and curl ups. We counted the repetitions they can do in one minute. Data collected was used to develop 3 back strength scores (Bridge score, partial sit-ups score and wall squat score) and 2 endurance scores (pushups score and curl ups score).

Level of participation in the program defined as the number of sessions completed by participants was included in our analysis.

Actual V02 max was measured pre and post program using the *Oxycon Mobile systems* along with Ellestad treadmill protocol

Participants

Forty professional emergency workers personnel from Deerfield Beach firefighting department volunteered to participate in the pilot fitness program. The average age of participants was 35.8 years (SD=9) and their average years of experience was 11.12 (SD=8.4). Table 3 represents the demographic information of participants. We recoded age (18 to 35, 36 to 60) and years of experience (> 10 years, ≤ 10 years) for analysis purposes (table 5)

		N (%)
Gender	Male	40 (100)
Ethnicity	White	36 (90)
	Hispanic	2 (5)
	Other	2 (5)
Education	High school	9 (22.5)
	Associate or higher	31 (77.5)

Variable	range	N (%)
Age	18 to 35	22 (55)
	36 to 60	18 (45)
Years of experience	10 yrs or less	18 (45)
	more than 10 yrs	22 (55)

Table 5. Participants' demographics, Age and Years of Experience recoding

Thirty participants made it to the follow-up session. Seven participants withdrew, five of those withdrew because of injuries not related to the program. We had tremendous difficulties scheduling the last three for follow up assessment.

PWC, endurance, back strength scores and VO_{2max} Pre and Post program

Comparing pre and post physical work capacity score, endurance scores, back strength scores and VO_{2max} using paired T-Tests, PWC score showed significant increase in the post session $t(29) = 3.41$, $p < .05$. All endurance scores showed significant increase in the post session (Push-ups $t(29) = 2.38$, $p < .05$, Curl-ups $t(29) = 3.13$, $p < .05$). All back strength scores showed significant increase in the post session (Bridges $t(29) = 5.95$, $p < .05$, Wall squats $t(29) = 2.75$, $p < .05$, Partial sit ups $t(29) = 3.06$, $p < .05$). VO_{2max} showed no significant change between pre and post program.

Age and years of experience correlation to scores

The relationship between age and years of experience and the change in physical fitness using the differences between pre and post scores for physical work capacity, endurance scores and back strength scores using correlation was examined.

Age did not show correlation to the any of the calculated scores (PWC $r(28) = 0.152$, $p > .05$, Push-ups $r(28) = 0.136$, $p > .05$, Curl-ups $r(28) = 0.099$, $p > .05$, Bridges score $r(28) = 0.237$, $p > .05$, Partial sit-ups $r(28) = 0.036$, $p > .05$, Wall squats $r(28) = 0.107$, $p > .05$.

Years of experience did not show correlation to the any of the calculated scores (PWC $r(28) = 0.154$, $p > .05$, Push-ups $r(28) = 0.039$, $p > .05$, Curl-ups $r(28) = 0.113$, $p > .05$, Bridges score $r(28) = 0.172$, $p > .05$, Partial sit-ups $r(28) = 0.516$, $p > .05$, Wall squats $r(28) = 0.033$, $p > .05$.

Level of participation and scores

The relationship between level of participation in the program defined as the number of sessions completed by participants during the eight weeks span and the change in physical fitness using the differences between pre and post scores for physical work capacity, endurance scores and back strength scores using correlation was examined. For example, the PWC score was calculated as follows PWC score = PWC at follow-up – PWC at baseline.

Number of completed sessions was positively correlated to PWC score $r(28) = .487$, $p < .01$. Two of the three back strength scores showed positive correlation with number of sessions (Bridges score $r(28) = .476$, $p < .05$ and Partial sit-ups score, $r(28) =$

.391, $p < .05$). While endurance scores did not show significant correlation with number of completed sessions (Push-ups $r(28) = .097$, $p > .05$, Curl-ups $r(28) = .106$, $p > .05$.

Number of completed sessions did not show any correlation to age of participants $r(28) = .099$, $p > .05$ or their years of experience $r(28) = .164$, $p > .05$.

Developing non exercise VO_{2max} prediction linear regression model

Thirty nine of the participants (age 22 to 56 years), that did the fitness program, did the VO_{2max} test at baseline (All males), twenty eight of the participants that came for the follow up did the follow up VO_{2max} test. Participants Body Mass Index (BMI) was calculated based on their height and weight with their physical activity rating at baseline was also recorded (PA-R).

	Min	Max	Mean	Std. Dev.
Age	22	56	36.08	9.13
Measured VO2max at BL	20.20	52.60	40.97	6.66
(PA-R) at BL	.00	7.00	4.79	2.10
BMI BL	21.34	33.75	28.51	2.96

Table 6. Participants demographics

Investigating the variation of measured VO_{2max}, a paired t-test showed that there was no significant difference pre and post program ($t(27) = -1.75$, $p = .092$).

Testing the correlation between variability in measured VO_{2max} (Measured VO_{2max} at FU - Measured VO_{2max} at BL) and number of sessions showed no significant correlation to the variability in measured VO_{2max} $r(37) = .157$, $p > .05$..

Comparing the actual measured values to the values calculated based on the model developed by Jackson et al. in 1990. The Jackson model used was the male BMI model, $VO_{2max} = 67.350 + 1.921\ (PA\text{-}R) - 0.381\ (age) - 0.754\ (BMI)$

Table 7 shows descriptive statistics of measured versus calculated VO_{2max} values.

	N	Min	Max	Mean	Std. Dev.
Measured VO2max at BL	39	20.20	52.60	40.97	6.66
Measured VO2max at FU	28	21.50	51.20	41.76	6.60
Calculated VO2max at BL	39	20.65	56.33	41.31	6.63
Calculated VO2max at FU	30	22.53	56.64	42.40	6.69

Table 7. Measured versus Calculated VO2max

Testing correlation between Calculated and Measured VO_{2max} values pre and post, all four values were correlated (table 8). The correlation between measured and calculated scores means that the Jackson model can be used as a no exercise VO_{2max} prediction model for firefighters.

		Measured VO2maxat BL	Measured VO2maxat FU	Calculated VO2maxat BL	Calculated VO2maxat FU
Measured VO2max at BL	Pearson Correlation	1	.993**	.918**	.922**
	Sig. (2-tailed)		.000	.000	.000
	N	39	28	39	30
Measured VO2max at FU	Pearson Correlation	.993**	1	.925**	.927**
	Sig. (2-tailed)	.000		.000	.000
	N	28	28	28	28
Calculated VO2max at BL	Pearson Correlation	.918**	.925**	1	.991**
	Sig. (2-tailed)	.000	.000		.000
	N	39	28	39	30
Calculated VO2max at FU	Pearson Correlation	.922**	.927**	.991**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	30	28	30	30

Table 8.Correlation between measured and calculated VO2max

Developing N-Ex prediction model using our measured data

To develop our N-EX prediction equation for predicting VO_{2max}, we used the thirty nine measured VO_{2max} values at baseline to fit a multiple linear regression model.

Plotting the matrix plot including measured VO_{2max} at baseline, age, BMI, and Physical Activity Rating(PA-R)

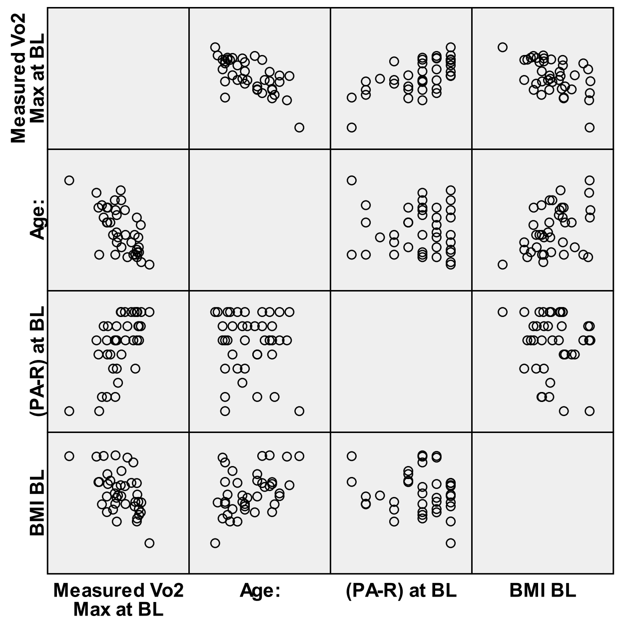

Figure 13. Predicted and predictors matrix plot

Measured VO_{2max} was correlated with Age $r(37) = -.663$, $p < .01$, BMI $r(37) = -.530$, $p < .01$ and PA-R $r(37) = .643$, $p < .01$. Age showed some correlation with BMI $r(37) = .418$, $p = .008$ but we decided to test keeping it as a predictor.

Using SPSS, we ran a step wise regression analysis.

The Model with most variability explained yielded the N-EX prediction equation

VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$) = 61.739 – (0.378 x age) – (0.557 x BMI) + (1.826 x PA-R).

(R^2 =.845, Adj. R^2 =.832, SEE = 2.72 $mL \cdot kg^{-1} \cdot min^{-1}$)

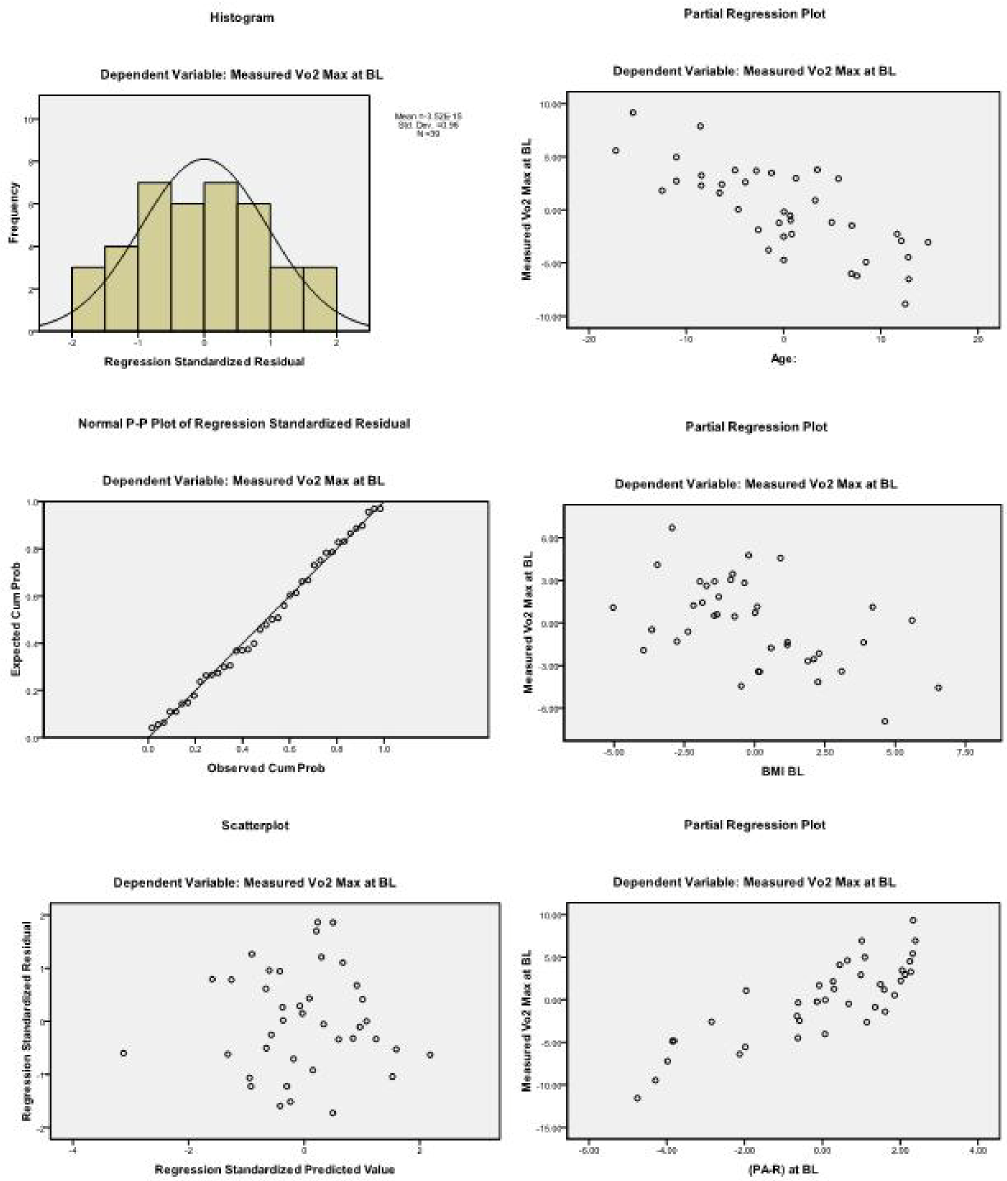

Figure 14. Model 1 Histogram, residual plot and partial regression plots

Although the model fit well, there was an apparent outlier on the standardized residual plot, looking back at the data, participant “3123” had a significantly low VO_{2max} (20.2 $mL \cdot kg^{-1} \cdot min^{-1}$) compared to the rest of the participants who had a mean VO_{2max} = 41.52 $mL \cdot kg^{-1} \cdot min^{-1}$with STD of 5.79

We decided to remove the outlier and re-run the regression analysis

The Model with most variability explained yielded the N-EX prediction equation

VO_{2max} (mL·kg^{-1}·min^{-1}) = 61.223 – (0.367x age) – (0.541 x BMI) + (1.767 x PA-R).

(R^2 =.793, Adj. R^2 =.775, SEE = 2.75 mL·kg^{-1}·min^{-1})

Despite the slight reduction in Adj. R^2, the model showed better residual plots with n outliers figure 15.

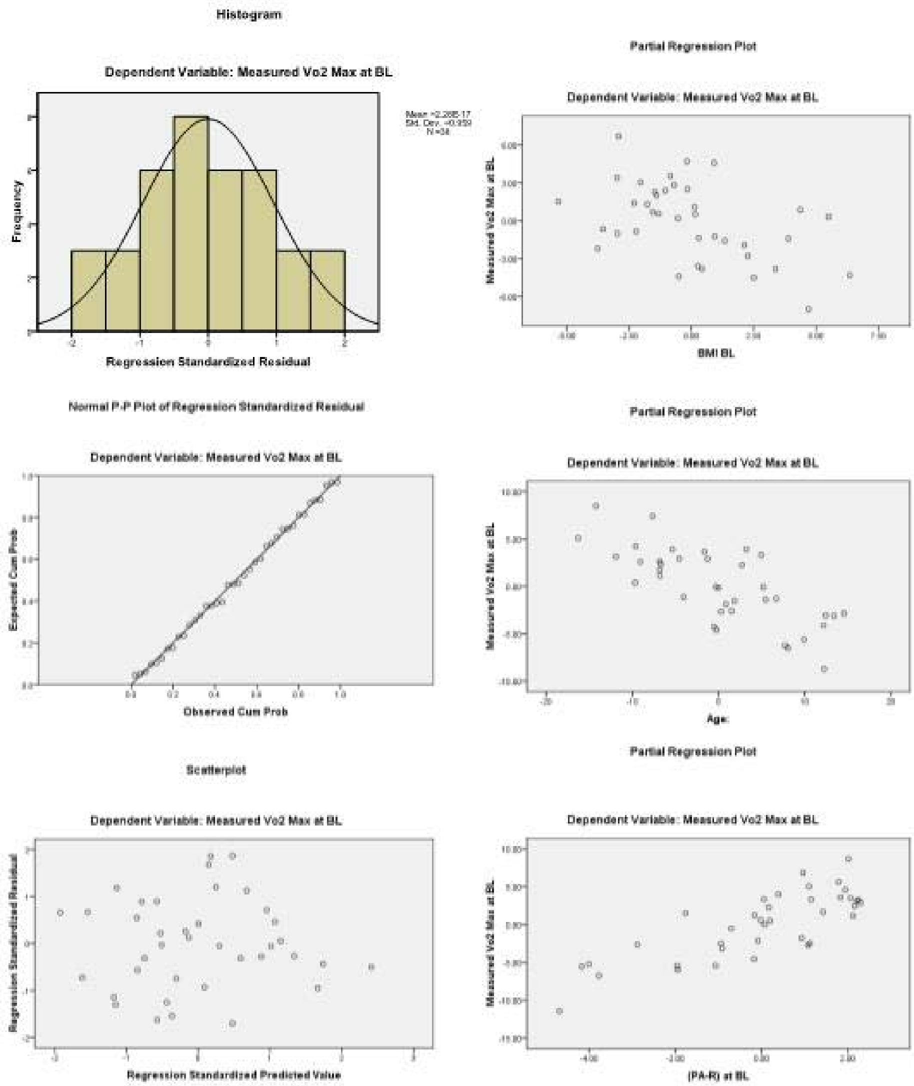

Figure 15. Model 2 Histogram, residual plot and partial regression plot

Chapter 5: Discussion

Back injuries accounted for 32% of the 1.2 million reported lost-time injuries and illnesses in 2007, (BLS, 2008). Back injuries were the highest reported injuries among our participants with older participants having more injuries than the young.

NFPA reported that the leading type of injury received during fire ground operations was strain, sprain or muscular pain (52.8%), followed by wound, cut, bleeding and bruise (14.2%). This pattern of injuries conclusively shows that fire fighters are more likely to receive sprains, strains, and other muscular pain injuries than other types of injuries. The high incidence of strains and sprains should be an indication that the application of ergonomics is strongly needed in the fire and emergency medical services to avoid more of these injuries (NFPA, 2011)

Workplace injuries consume an immense amount of resources. The average amount of days lost from back injuries was seven days. Back injuries cost $30-$50 billion dollars each year in the United States affecting 15%-20% (31 million) of the entire population (Bray, 2001). Employers also spend an additional $50 billion on indirect costs--such as finding and training substitute workers, and running work-hardening (physical conditioning) and reduced-work programs that help ease employees back into their jobs (Grossman,2001). Total cost of low-back pain in the United States is $100 to $200 billion per year. Two-thirds of these costs are indirect costs, principally due to lost wages. This is paralleled by a patient burden of pain, disability, and psychological and social consequences (Katz, 2006).

The estimated costs to the fire service of firefighter injuries and their prevention is 2.8 to 7.8 billion dollars per year (TriData, 2004). The direct costs in workers' compensation, medical treatment and vocational rehabilitation are very high. Additionally, indirect costs such as lost production, retraining and sick or administrative time can be at least four times the direct costs. An indirect cost of particular concern is the disruption of the professional integrity of services provided. That is why there have been numerous approaches to set guidelines on how to identifying risks for back injuries in the work place and developing back injury prevention programs, this includes redesigning tasks and changing work setups, using assistive devices and personal protective equipment, training and education on safe practices to prevent injuries or implementing physical programs that focus on strengthening back and abdominal muscles to help reduce the stresses on the spine. It is important for emergency workers do understand that injuries are indeed preventable with training and the implementation of safe practices (Wassell, 2000).

We examined perceptions and knowledge about musculoskeletal injuries among emergency workers, with an emphasis on back injuries. Overall, our participants (across all age groups, education and experience levels) perceived that musculoskeletal injuries are costly, prevalent and hard to prevent. Specifically back injuries are perceived as the most costly, prevalent and the hardest to prevent. Our participants perceived that back injuries prevention is a major industrial safety challenge.

Overall, participants perceived that workplace factors are the leading cause of back injuries when compared to external factors and personal factors. More experienced participants considered external factors to be a significant cause of back injuries. However, it is interesting that personal factors such as fitness, nutrition and team commitment were not perceived to be major contributors to injuries. There were some differences in perceptions according to level of work experience and education. Those with less experience indicated that the lack of fitness programs, lack of back injury prevention education and inadequate safety training can lead to injuries. Participants with higher education also supported the need for injury prevention training. Overall, these findings suggest there is a need for more safety education programs for emergency personnel.

Back injuries were the highest reported injuries among our participants with older participants having more injuries than the young. That coincides with BLS statistics indicating that back injuries accounted for 32% of the 1.2 million reported lost-time injuries and illnesses in 2007, (BLS, 2008).

Eighty percent of our participants reported having had previous musculoskeletal injuries. Back injuries were the most frequent reported injury. Fifty nine percent of the participants reported having a back injury, 28% reported having ankle injuries and 20% reported having knee injuries.

There was an age difference in back injury prevalence. As expected, 67.8% of the older participants reported having back injuries, whereas only 29% of younger participants reported having a back injury. Of those participants who reported having an injury, 26% indicated they underestimated the severity of the injuries and thus did not report it. However, 50% documented the injury in case it became serious and required coverage, 13% did not report it to avoid being assigned light duty and 7% did not report it to avoid jeopardizing promotions. Respondents in the older age group were more likely to underestimate the severity of an injury.

The fact that nearly 25% underestimated a severe injury thinking it is minor and thus did not report it and another 20% did not report it so it will not affect their assignments only shows how important safety education is especially among older personnel where injuries are usually more probable and more severe.

The Spinal Health questionnaire was designed to assess the emergency workers personnel general knowledge of spinal health and safety and trying to identify the common misconceptions related to back injuries and safety then quantify that knowledge in to a knowledge score. Participants were then offered an educational session as part of the program to correct those misconceptions and educate them about injury prevention best practices. The questionnaire was re-administered at the end of the program (after 8 weeks) to test whether there is a significant change in their knowledge.

Spinal health score at baseline varied according to age, level of experience education or prior history of having back injury such that those who were older, had more experience and education had more knowledge. Spinal health score was correlated to history of reported back injury such that those that reported history of back injuries had more knowledge.

The most common misconceptions about spinal health were related to lifting belts being beneficial, lying on their side while sleeping is ideal and the use of heat immediately after strains is beneficial. A large percentage of participants believed that lifting belts are beneficial, this was especially true among the less experienced workers. There is no clear evidence that back belts actually prevented back injuries, In 2001 Petra et al. conducted a systematic review of lumbar supports for prevention and treatment of low back pain, they concluded that there is no evidence that lumbar supports are or are not useful in the primary prevention of low back pain in industry. The results showed that there is conflicting evidence on the effectiveness of lumbar supports in the treatment of low back pain and thus that lumbar supports are not recommended for primary prevention and treatment of low back pain. In 2005 Ammendolia et al. conducted a review of the literature examining the incidence and/or duration of lost time of reported low back pain among workers using back belts. They concluded that because of conflicting evidence and the absence of high-quality trials, there is no conclusive evidence to support back belt use to prevent or reduce lost time from occupational low back pain.

Other common misconceptions were that lying on your stomach is the healthiest way to lie in bed, turning your palms upward when lifting is not recommended, using heat immediately after a back strain is beneficial and that anti-fatigue matting or sole inserts cannot help reduce back strain. These misconceptions also demonstrate the importance of providing workers with knowledge about spinal health. In addition, the data provided some suggestions about topics that need to be addressed in training program. The significant improvement in the Spinal health questionnaire score after the education an training program highlights the importance of spinal health education as part of any fitness and injury prevention program.

Investigating participants' perceptions of causes of severe and frequent back injuries. Participants indicated that being forced to lift objects/subjects in an unsafe way and pre-existing conditions were the highest causes of severe and frequent back injuries. Other factors perceived to be frequent contributors to injury included: fatigue, lack of experience, lack of fitness programs, lack of back injury prevention knowledge, and lack of back strengthening programs. We examined if perceptions regarding specific causes of back injuries varied according to participants' level of experience, the results indicated that participants with less work experience perceived lack of fitness programs, lack of back injury prevention education programs and inadequate safety training contributed to back injuries.

Participants with higher levels of education indicated that frequent back injuries are caused by lack of back injury prevention knowledge and lack of experience.

Participants recommended that a physical fitness programs be included within working hours and that departments should have better fitness facilities. They also suggested periodic back strength testing and meaningful incentives for participation in fitness programs Participants also recommended including online education follow-up sessions. Finally, participants recommended that the programs should include nutrition supervision, safe exercising guidelines, safe work practices and focus on improving cardiovascular fitness, improving back strength, flexibility and ways to reduce risks of strain and sprain.

Emergency workers personnel nature of work dictates very complicated schedules, making it very hard for them to commit to a standard fixed exercise schedule. When we designed the pilot fitness program, we made sure to use calisthenics as the primary mean of exercise to make it easier for participants to exercise in a simple setup that does not require any special equipment and at any time that is convenient to them.

The eight weeks pilot program showed significant improvement in participants' physical work capacity, endurance and back strength. Our results also showed that participants that were more consistent and did more exercise sessions through the eight weeks, experienced more improvements in their Physical Work Capacity and back strength. The fact that we saw successful results from a volunteer, no cost and no equipment program shows that fire fighters are truly motivated and that all they need is the proper coaching and more importantly the true motivation through support and education. Such a program can easily be implemented in any emergency department with little coaching and education and with no cost associated.

Limitations

Limitations of this study included the relatively small sample and the fact that the participants were drawn from one region in the United States. Clearly we need data on these issues from larger and more diverse samples. In addition, the questionnaires used in this project were newly developed and on the basis of this project will be further refined. Lastly, an inclusion of other related professional (medicine, nursing, private ambulances, etc.) would provide even more insight into worker safety and injury prevention. However, despite these limitations, the findings indicate the need for worker education and more injury prevention programs.

Other limitations included difficulty in program supervision to make sure participants did sessions three times a week as planned, we used a 2 week and 6 week reminder phone call to most participants.

The only solution to this problem is to make the program mandatory and have it done within working hours, which were both highly recommended by participants in the first phase of the study.

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Appendix A: Informed Consent

Informed Consent

The Design and Implementation of a Comprehensive Back Injury Prevention Program for Emergency Services Personnel

PURPOSE:

You are being asked to participate in a research study at the Deerfield Beach Fire Rescue training facility. This study involves the design and implementation of a comprehensive back injury prevention program for Emergency Services Personnel. Back injury prevention programs are intended to educate and strengthen uniformed personnel so that their mental, physical, and emotional capabilities are resilient enough to withstand the stresses and strains of life and the workplace. This form will outline the procedures used for this study, the risks of your participation, and other information that you will need to know. If you have any questions about this document, or find words or concepts are not clear to you, please let the investigators know and they will be pleased to answer all of your questions.

PROCEDURES:

The first session will be an orientation at the Deerfield Beach Fire Rescue training facility, where you will be introduced to the study team. At that time, you will be given a Physical Activity Readiness Questionnaire (PAR-Q). The questions in this questionnaire are 7 general health questions designed to assess your physical readiness to participate in physical activities. Upon completion of the PAR-Q, you will be given a spinal health questionnaire that is designed to assess your general knowledge of safe practices related to avoiding musculoskeletal injuries. Once you complete the spinal health questionnaire, you will be given an Emergency Services Personnel Back Injuries Questionnaire to provide your opinion on:

d) Where back injuries stand among other musculoskeletal injuries in terms of occurrence, expense of treatment, and controllability,
e) The causes of back injuries,
f) What your action(s) were if you experienced back injuries while either on or off duty, and

g) Whether you currently participate or would wish to participate in any strength, physical fitness and/or back injury prevention activities/programs.

The orientation will conclude with a one hour back injury prevention educational session. This session will introduce you to the best practices for back injury prevention and will discuss the misconceptions and practices that lead to musculoskeletal injuries in general with particular emphasis on back injuries.

Your next session will be a strength, endurance, flexibility and physical fitness testing session. In this session you will be performing various wellness and fitness tasks based on the Fire Service Joint Labor Management Wellness-Fitness Initiative guidelines. Medical personnel will be standing by on site at all times with Adult Cardiac Life Support (ACLS) equipment in case of emergency. For each test, you will perform three trials, one warm-up trial at fifty percent (50%) effort and two trials at voluntary maximum. This session will also be repeated at the end of the project. A list of the tests and their descriptions will be provided to you with this consent form. An experimenter will be on hand to answer any questions you may have about the tests.

After completion of both the orientation and testing sessions, you will start the training program. The training program will consist of two physical training sessions per week for eight weeks for a total of 30 hours (including orientation). Each individual session will focus on back strength and consist of a warm up, an aerobic period, a calisthenics session (Push-ups, Chin-ups, Dips, etc.) and a cool down period. A list of the exercises included in each session will be provided to you with this consent form. An experimenter will be on hand to answer any questions you may have about the exercises. There will also be a fifteen to thirty minutes educational session covering topics such as anatomy, body mechanics, posture, and other factors relevant to preventing back injuries.

RISKS:

You should be advised that there are risks associated with the procedures to be performed. You may strain some of your back, leg, or arm muscles during exercise. Some injuries may require extensive treatment, possible surgery. Every possible effort will be made to minimize the risks by the availability of qualified trainers and physical therapists instructing you on safe ways to exercise.

COMPENSATION FOR INJURY:

You may be exposed to risk of injury from participation in this study. If injury occurs, treatment in most cases will be available. If you should sustain an injury while participating in this study, it will be treated as though it occurred while on the job. This means that only the benefits arising from your employer's insurance and/or workers compensation will be provided. Be advised that the fire department has released the University of Miami of all liability from personal injury of any kind, nature, or description that may arise, from this study. You should be informed that in the event of injuries, no additional compensation is available.

BENEFITS:

Other than the standard benefits of exercising and knowledge gained during lectures, no direct benefits can be promised to you from your participation in this study.

COSTS:

You will not incur any costs as a result of participating in this study.

ALTERNATIVES:

You have the alternative not to participate in this study.

CONFIDENTIALITY

The investigator and his assistants will consider your records confidential to the extent permitted by law. Your records and results will not be identified as pertaining to you in any publication without your expressed permission. All data will be coded by subject number rather than by name and all results will be published as group averages or peaks only. In rare circumstances the U.S. Food and Drug Administration (FDA) or the U.S. Department of Health and Human Services (DHHS) may request copies of records. If this happens, the FDA or DHHS request will be granted. Your record may also be reviewed for audit purposes by authorized University of Miami employees or other agents who will be bound by the same provisions of confidentiality.

RIGHT TO WITHDRAW:

Your participation in this study is voluntary, and you will receive a signed copy of this consent form to review at any time. You will have the right to withdraw from the study, and your withdrawal or lack of participation will not prejudice your future care. If you are an employee of Deerfield Beach Fire Department, your willingness to participate, decline to participate, or withdrawal from the study will not affect your job standing in any way. The Investigators can remove you from the study without your consent if they feel it is in your best interest. You may ask any questions concerning the study and the investigators will answer your questions. If you have any questions concerning your rights as a research subject you may contact The Human Subjects Research Office at 305-243-3195.

____________________	________________________	_________________
Name of Subject	Signature of Subject	Date signed

___________________	________________________	_________________
Name of Person Obtaining Consent	Signature of Person Obtaining Consent	Date signed

Principal Investigator:

Name: Dr. Khaled Abdel Rahman, Ph.D.
Assistant Scientist
Industrial Engineering Department
University of Miami

Phone Number: (305) 284-3297

Co-Investigator:

Name: Chad Brocato, DHSc, REMT-P
Division Chief of Operations
Deerfield Beach Fire-Rescue

Phone Number :(954) 270-7837

Testing Procedure

I- Strength Testing:

You will be asked to perform a series of strength tests which are designed to isolate different muscle groups in the body. These tests will measure the grip, arm, shoulder, and torso strength statistically. You will perform these tests on the Jackson Strength Evaluation System (JSES). The system consists of a control unit, a load cell, a hand dynamometer fixture for the measurement of grip strength, and a heavy duty lifting platform, bar and chain. Each test type is performed three times one warm-up 50% effort and two additional times at voluntary maximum.

Grip strength testing: The grip strength test measures the grip of both hands. The hand dynamometer will be used to record the highest strength effort.

Arm Lift testing: The purpose of this test is to measure the lifting strength of the arms. We record the force that is exerted by muscles in the arms when lifting a weight with the elbows at 90° flexion.

Shoulder Lift testing: The purpose of this test is to measure the lifting strength of the shoulders. We record the force that is exerted by muscles in the shoulders when lifting a weight while the elbows point outward (without leaning back or using your legs).

Torso Pull Test: You will be asked to sit on the floor with feet firmly against a platform and straight. Then you will bend at the waist and grip the handle with the palms of your hands facing down. The test is completed when you pull the handle and lean back. At this time the force you exerted is recorded.

Leg Lift Test: You will be asked to stand on the platform with your feet spread a comfortable distance and a bar between your legs. You will be asked to grip the bar with your palms facing each other and hands as close to the center of the bar as possible. Starting with your knees bent and your chin up, you will be asked to lift up. At this time the force exerted will be recorded.

II- Back strength Tests:

This group of tests will examine your back strength both before and after participation in the study.

Bridge test: You will be asked to lie on your back with his knees bent, his feet flat on the floor and his arms at his sides. With your knees slightly parted, you will slowly raise your buttocks from the floor, keeping your stomach tight and abdomen in line with your thighs. You will be asked to hold this position for five seconds and return to the starting position.

Wall Squat test: You will be asked to lean against a smooth wall with your feet pointing straight ahead and heels 18 inches from the wall. You will slowly lower your upper body down the wall until your knees are bent to 90°. You will be asked to this position for five seconds, then return to the starting position.

Partial sit-up test: You will be asked to lie on your back with your knees bent, your feet flat on the floor and arms at your sides. First tuck your chin into your chest. While holding this position, raise your head and shoulders up until your shoulder blades are off the floor. Your will be asked to hold this position briefly before returning to the starting position.

III- Flexibility - Sit and Reach Test

Flexibility is the range of movement about a joint. The objective of the sit and reach test is to evaluate the flexibility of the lower back and posterior thighs. With your shoes removed, you will sit with your feet flat against the test apparatus and knees fully extended. You will then extend your arms forward with your hands placed on top of each other stretching as far as possible and holding the position for one second. The farthest point reached is measured and recorded to the nearest 0.25 inch.

IV- Muscular Endurance Test

Muscular endurance is the ability of a muscle group to perform repeated contractions.

The push-up test: This test measures muscular endurance of the anterior chest girdle and the triceps. You will be asked to perform a series of push-ups in a two-minute time period.

The curl-up test: This test measures muscular endurance of the abdominal muscles. You will be asked to perform a series of curl-ups in a 3-minute time period. Evaluation is initiated from the supine position with knees bent at a 90 degree angle, hands cupped over the ears or at the temples and with hand and arm position maintained for the entire duration of the evaluation. The feet will be secured by a bar or a second administrator.

Aerobic Fitness Test

As a measure of the Aerobic fitness, we will monitor the development of the maximum oxygen uptake, also referred to as *V*O2max. *VO2max* is the maximum volume of oxygen consumed by the body each minute during exercise. Since the amount of oxygen consumed is directly related to the amount of energy used, a measurement of oxygen consumption is actually a measure of aerobic fitness. The *VO2max* is a measurement of the amount of oxygen a person is consuming while exercising at maximum capacity.

You will be asked to perform a maximal graded treadmill test while your *VO2max* is measured. A wireless portable ergospirometry system, called Oxycon Mobile, will be used during the test. This device measures the participant's metabolic response while exercising or working. The individualized running speed will be constant throughout the test at a level that would generally be considered moderate while the grade (treadmill tilt) will be increased by 2% every 2 min. A warm-up period of 3 minutes will begin once resting heart rate measurements are collected. The test will be considered maximal if *VO2max* increases by <150 ml/min or <2.1 ml/kg/min with an increase in work rate or if you decide to stop. We will also ask you to rate yourself on a scale of 0-7 in regards to your level of regular physical activity.

<u>I have read and understand the test I am asked to perform:</u>

____________________	________________________	_________________
Name of Subject	Signature of Subject	Date signed

____________________	________________________	_________________
Name of Person Obtaining Consent	Signature of Person Obtaining Consent	Date signed

Principal Investigator:

Name: Dr. Khaled Abdel Rahman, Ph.D.
Assistant Scientist
Industrial Engineering Department
University of Miami
Phone Number: (305) 284-3297

Co-Investigator:

Name: Chad Brocato, DHSc, REMT-P
Division Chief of Operations
Deerfield Beach Fire-Rescue
Phone Number :(954) 270-7837

Session Exercises

I- Calisthenics

Calisthenics are exercises that can be performed without equipment, although hand or ankle weights may be used. These types of exercises can be used to develop strength, muscular endurance, and flexibility. Calisthenics usually involve the repetitive lifting and lowering of a body segment as in push-ups, curl-ups, and arm circles. The participant will be asked to record the number of repetitions performed for each exercise performed during a session. It is recommended that the participant try to increase the repetitions by at least 5 per week throughout the program.

Push-ups: With hands outside the shoulders, push up while keeping back straight. Push-ups can be performed with legs straight and your weight resting on toes.

Chin-ups: With an underhand grasp on a bar, pull up until the chin is over the bar. To finish you will let down as slowly as possible.

Dips: Grasp the sides of a chair and let your feet slide forward while supporting your weight on your arms. Lower your body by bending the elbows to about 60 degrees and then push up to the starting position. Keep body close to the chair.

Chair Squats: Stand about 6 inches in front of a chair, facing away from the chair. With feet slightly wider than shoulder-width, move your hips back as you squat until the thighs are almost parallel to the ground, without sitting down on the chair. The kneecaps should be aligned towards the second toe and the knees should not travel beyond the mid-foot. Hold for 1-2 seconds. Return to the standing position.

Lunges and Forward Traveling Lunges: Stand with feet hip-width apart in a stride position and hands on hips. Lower the body directly between the feet by bending the knees to approximately 90-degree angles. Press back up to starting position. Perform the same number of lunges on the other side.

Standing Side Leg lifts: Stand with feet shoulder-width apart and hands on hips. Transfer body weight completely to the left leg. Lift a straight right leg directly to the side. Lower right leg just short of resting foot on the floor then lift again. Maintain erect posture. Perform the same number of lifts on the other side. Increase the number of lifts by at least 2 per week, up to a maximum of 25 per side.

II- Back Strength Exercises:

Abdominal muscle strength is important for core stability and back support. Performing these exercises on a regular basis helps reduce or prevent back injuries. The following are exercises specifically designed to strengthen the back and abdominal muscles. . It is recommended that the participant try to increase the repetitions by at least 5 per week throughout the program.

Bridge test: You will be asked to lie on your back with knees bent, feet flat on the floor and arms at the sides. With your knees slightly parted, you will slowly raise your buttocks from the floor, keeping your stomach tight and abdomen in line with your thighs. You will be asked to hold this position for five seconds and return to the starting position.

Wall Squat test: You will be asked to lean against a smooth wall with your feet pointing straight ahead and heels 18 inches from the wall. You will slowly lower your upper body down the wall until your knees are bent to 90°. You will be asked to this position for five seconds, then return to the starting position.

Partial sit-up test: You will be asked to lie on your back with your knees bent, your feet flat on the floor and arms at your sides. To begin this exercise, tuck your chin into your chest. While holding this position, raise your head and shoulders up until your shoulder blades are off the floor. You will be asked to hold this position briefly before returning to the starting position.

Rotational Sit-Up: You will be asked to lie on your back with the knees bent, feet flat on the floor and arms at your sides. Keeping your hips flat on the floor, rotate your upper body onto your left shoulder. Keeping your chin tucked in, curl your head and right shoulder upward by stretching out your arms and hands toward your left knee. Hold briefly before returning to the starting position. You will do the same for the right side.

Bench steps: You will be asked to step up onto a bench that is 8-12" high, bringing up both feet and then down again, one at a time, for 30 seconds (up-up-down-down). Switch the lead foot and repeat for 30 seconds. Increase the time for each lead foot by 10 seconds per week, up to a maximum of 60 seconds of stepping up and down with each lead foot.

Opposite Arm and Leg Lifts: You will be asked to lie face down on the floor with forehead resting on a towel. Arms are stretched overhead with hands shoulder-width apart. Raise the left arm and the right leg approximately 4-8 inches from the floor. Lower to starting position. Repeat on other side.

I have read and understand the exercises I am asked to perform:

____________________	________________________	__________________
Name of Subject	Signature of Subject	Date signed

____________________	________________________	__________________
Name of Person Obtaining Consent	Signature of Person Obtaining Consent	Date signed

Principal Investigator:

Name: Dr. Khaled Abdel Rahman, Ph.D.
Assistant Scientist
Industrial Engineering Department
University of Miami
Phone Number: (305) 284-3297

Co-Investigator:

Name: Chad Brocato, DHSc, REMT-P
Division Chief of Operations
Deerfield Beach Fire-Rescue
Phone Number :(954) 270-7837

Appendix B: Spinal Health Questionnaire

Spinal Health Questionnaire

1. Did you ever receive training on back injury prevention? ☐ Yes ☐ No

a. If yes, how many years ago did you receive training? ________ Years ago

For the remaining questions, please check the box to indicate your response.

2. Have you had a back injury, if so how severe?

☐ Never ☐ Mild ☐ Moderate ☐ Severe

3. How would you rate your department's instruction on back injury prevention?

☐ Excellent ☐ Good ☐ Satisfactory ☐ Poor ☐Very Poor

4. How would you rate your department's work environment (ergonomics) for back injury prevention?

☐ Excellent ☐ Good ☐ Satisfactory ☐ Poor ☐Very Poor

Use the scale below to indicate the degree to which you agree or disagree with the following 29 statements. **Please do not omit any questions—make your best guess.**

1 = strongly agree	**2 = agree**	**3 = disagree**	**4= strongly disagree**

_______	1. Twisting at the waist while lifting and moving a light object is harmful to spinal health.
_______	2. Spacing the feet shoulder–width apart when lifting an object is unsafe for spinal health.
_______	3. Lying on your stomach while sleeping is beneficial to spinal health.
_______	4. Keeping the palms turned upward when lifting an object has no impact on spinal injury.
_______	5. Bending at the waist, below mid–thigh height, to pick up a light object is harmful to spinal health.
_______	6. Bed rest for a week or more after a back strain is beneficial for spinal injury.
_______	7. Smoking cigarettes has no impact on spinal injury.
_______	8. Maintaining a waist smaller than your hip circumference has no impact on spinal injury.
_______	9. It is better for spinal health to raise the height of steps in order to reduce the number of steps you need to climb.
_______	10. It is safer to pull a stretcher rather than pushing it.

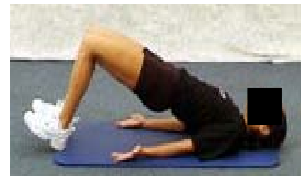
Continued

1 = strongly agree	2 = agree	3 = disagree	4= strongly disagree

________	11. Reaching above shoulder height to move an object is harmful to spinal health.
________	12. The best position for sleeping is lying on your side.
________	13. Carrying one bag of groceries in your arm rather than two bags, one in each arm, is beneficial to spinal health.
________	14. A diet rich in calcium is unnecessary for spinal health after you stop growing.
________	15. Using heat immediately after a back strain is beneficial for quick recovery.
________	16. Using a lifting belt is proven to be beneficial for spinal health.
________	17. For large objects it is beneficial to straddle the object when lifting it.
________	18. Moving an object from left to right can be safely done by twisting the upper body.
________	19. Using anti–fatigue matting or sole inserts will not reduce back strain.
________	20. Assessing the weight of an object before lifting it is beneficial to spinal health.
________	21. Tightening abdominal muscles during lifting, lowering and/or moving activities is harmful to spinal health.
________	22. Lifting or lowering more than once every five minutes is harmful to spinal health.
________	23. Adjusting handles to keep wrists in a neutral position has no impact on spinal health.
________	24. Keeping your back straight while putting an object on a shelf is beneficial to spinal health.
Continued	

1 = strongly agree 2 = agree 3 = disagree 4= strongly disagree

For the five pictures below indicate the extent to which you agree that the sitting, standing, or exercising postures are **BENEFICIAL** to spinal health.

________	25. Doing bridge exercises as shown here 
________	26. Doing abdominal crunches as shown here 
________	27. Doing straight-leg sit-ups as shown here 
________	28. Resting in this sitting posture 
________	29. Standing at rest in this posture 

Appendix C: Firefighters and Musculoskeletal Injuries Questionnaire

Emergency Services Personnel
(Firefighters, EMT and Emergency Management)
Back Injuries Questionnaire

Please do not omit any questions—make your best guess if you have to.

I. Demographics:

Please fill in the blanks/check appropriate choices for the following questions.

Gender: □ Male □ Female **Age** _____ **Date of Birth:**___/___/____

Ethnicity:
- □ African- American
- □ Asian
- □ Hispanic/Latin
- □ White
- □ Other (please specify) _______________

Marital status:
- □ Single
- □ Married or living together
- □ Divorced

Highest Education:
- □ High School
- □ Associate
- □ Bachelors
- □ Masters

Years in this profession: ________ Years

II. Injuries and emergency services personnel:

1) How **common** do you think the following injuries are for emergency services personnel?

	Very common	Common	Not Common
Shoulder injuries			
Back injuries			
Neck injuries			
Knee injuries			
Ankle injuries			
Elbow injuries			

2) How **expensive** in terms of treatment and loss of working time do you think the following injuries are for emergency services personnel?

	Very Expensive	Expensive	Not Expensive
Shoulder injuries			
Back injuries			
Neck injuries			
Knee injuries			
Ankle injuries			
Elbow injuries			

3) **How hard is it to prevent** the following types of injuries for emergency services personnel?

	Hard to Prevent	Preventable	Easy to Prevent
Shoulder injuries			
Back injuries			
Neck injuries			
Knee injuries			
Ankle injuries			
Elbow injuries			

4) Emergency services personnel severe back injuries are caused by either
   - **Uncontrollable external environment factors** (e.g. weather, rescue in confined spaces),
   - **Workplace factors** (e.g. night shifts, equipment used) and/or
   - **Personal factors** (e.g. commitment, experience, age)

a) Which factors do you think leads to **more frequent** back injuries
(Please select one)

☐ **External environment factors**

☐ **Workplace factors**

☐ **Personal factors**

b) Which factors do you think leads to **more severe** back injuries
(Please select one)

☐ **External environment factors**

☐ **Workplace factors**

☐ **Personal factors**

c) When considering the following **External Factors**. Which factors do you think will lead to severe and/or frequent back injuries?

	Lead to severe injuries		**Lead to frequent injuries**	
	Yes	**No**	**Yes**	**No**
Forced to lift objects/subjects in an unsafe way				
Extreme weather				
Large scale emergencies				
Collapsing structures				

d) When considering the following **Workplace Factors.** Which factors do you think will lead to severe and/or frequent back injuries?

	Lead to severe injuries		**Lead to frequent injuries**	
	Yes	**No**	**Yes**	**No**
Lack of fitness programs				
Lack of protective equipment				
Lack of back injury prevention Education				
Lack of back strengthening programs				
Shifts (24hrs. on / 48 hrs. off) or night shifts				
Emergency nature of work				
Poor staffing level				
Inadequate safety training				
Lack of support from local authorities				
Lack of nutrition counseling				
Lack of training on how to use protective equipment to prevent back injury				
Systems for personnel selection and promotion				

e) When considering the following **Personal Factors.** Which factors do you think will lead to severe and/or frequent back injuries?

	Lead to severe injuries		**Lead to frequent injuries**	
	Yes	**No**	**Yes**	**No**
Lack of commitment to the team				
Lack of back injury prevention knowledge				
Age				
Lack of experience				
Pre-existing conditions				
Fatigue due to repetition				
Bad eating habits				
Physical, mental or emotional stress				
Lack of self fitness/health awareness				

5) Have you ever had a musculoskeletal injury before?

( ) Yes ( ) No

a) If **Yes**, please specify, where in your body? What type of injury was it? What was the cause? How severe was it?

Where on your body?	**Type of Injury**	**Cause**	**Severity**
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe
	( ) Fracture ( ) Dislocation ( ) Sprain ( ) Strain	( ) Overexertion ( ) Overuse ( )Other______________________ ______________________________	( ) Mild ( ) Moderate ( ) Severe

6) The last time you experienced a severe injury whether off duty or on duty did you

	Yes	No
a) Consider it minor, so you did not report it, but later on realized it was severe.	( )	( )
b) Document injury in case it became serious and required coverage	( )	( )
c) Not report it fearing being assigned to "light duty"	( )	( )
d) Not report it to avoid jeopardizing promotions	( )	( )

7) Do you do any stretching exercises? ( ) Yes ( ) No

a) How many times do you stretch per week? __________ times
b) How much time do you devote to stretching each time? ________ Minutes

8) Do you workout? ( ) Yes ( ) No

a) How many times do you workout per week? __________ times
b) How much time do you devote to working out each time? ________ Minutes

9) Do you do exercises to increase the strength and/or flexibility of your back or abdominal muscles? ( ) Yes ( ) No

a) If Yes, Please name those exercises and/or explain briefly how they are done.

Exercise name (if applicable)	**How it is done**

10) What types of exercise interest you, and which ones do you actually practice?

Exercise	Interested in	Actually practice it
Walking		
Jogging		
Cycling		
Stationary Biking		
Elliptical Striding		
Swimming		
Stair Climbing		
Traditional Aerobics		
Strength Training		
Racquet Sports		
Yoga/Pilates		
Team sports (football, etc)		
Other, please specify_____ ________________________		

11) The table below shows some of the goals of any back injury prevention program. How important do you think each goal is?

Goals of any back injury prevention program	Not Import.	Neutral	Import.
Improve cardiovascular fitness			
Enjoyment			
Reduce risks of sprains and strains			
Emphasize on best practices to avoid back injury			
Reshape or tone body			
Improve performance for a specific sport or activity			
Improve moods and ability to cope with stress			
Improve back flexibility			
Increase back strength			
Increase energy level			
Correct misconceptions that lead to back injuries			
Feel better			
Body-fat weight loss			
Teach how to use personal protective equipment properly to help reduce injuries			
Other, please specify________________________			

12) To make sure a back injury prevention program more effective in achieving the goals mentioned in the previous question?

	Yes	No
a) Would you recommend it to be mandatory		
b) Would you recommend it to be included in your working hours		
c) Would you want your department to have/acquire more adequate facilities		
d) Would you want periodic testing to determine back strength objectives		
e) Would you recommend meaningful incentives to encourage participation		
f) Would you want it to include nutrition supervision and guidance		
g) Would you want it to include educational sessions on safe exercise		
h) Would you want it to include education sessions on safe work practices		
i) Would you want it to include online education follow-up sessions		

What else would you recommend to help make it more effective?

____
____
____
____
____
____
____

Appendix D: Physical Activity Readiness Questionnaire (PAR-Q)

Physical Activity Readiness Questionnaire (PAR-Q)[1]

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.
Common sense is your best guide in answering these few questions. Please read them carefully and check the yes or no opposite the question if it applies to you.

Yes	No	
		1. Has a doctor ever said you have a heart condition and recommended only medically supervised physical activity?
		2. Do you have chest pain brought on by physical activity?
		3. Have you developed chest pain within the last month?
		4. Do you tend to lose consciousness/fall over as a result of dizziness?
		5. Do you have a bone or joint problem that could be aggravated by the proposed physical activity?
		6. Has a doctor ever recommended medication for your blood pressure or a heart condition?
		7. Are you aware, through your own experience or a doctor's advice, of any other physical reason why you should avoid exercising without medical supervision?

If you answered YES to any of these 7 questions
Vigorous exercise and exercise testing should be postponed until medical clearance is obtained.

If you answered NO to all questions above
It gives a general indication that you may participate in physical and aerobic fitness activities and/or fitness evaluation testing.
<u>Delay becoming much more active:</u>

- If you are not feeling well because of a temporary illness such as a cold or a fever wait until you feel better, or
- If you are or may be pregnant -- talk to your doctor before you start becoming more active.

Reference:
1- Thomas, S., J. Reading, and R.J. Shephard. Revision of the Physical Activity Readiness Questionnaire (PARQ). Canadian Journal of Sport Science 17:338-345, 1992

Appendix E: Exercise Guide and Repetitions Log Sheet

TOGETHER
We will build a
Stronger and
Healthier Back

Warm-up and Stretching Guidelines

The following stretches are effective for improving in each muscle group. Begin warm-up periodically by performing light aerobic activity, such as marching or jogging in place and arm circles.

1. Side-to-Side Look stretches the neck muscles.

Slowly turn head and look to right then slowly turn head back to center and look to left.

2. Forward and Down Look stretches the neck muscles.

Slowly look downward. Do not put chin on chest. Repeat on other side.

3. Standing Cat Stretch stretches the upper and lower back.

Stand with feet slightly wider than shoulder-width apart. Keep knees bent. Hinge forward at hips and place hands just above knees. Do not bend at the waist. Begin with back straight and flat, arch back up pulling in with abdominals and curl chin towards chest. Return to flat back position. Do not arch back down past the flat back position.

4. Shoulder Turn stretches the lower back.

Stand with feet slightly wider than shoulder-width apart. Keep knees bent. Hinge forward at hips and place hands just above knees. Do not bend at the waist. With back straight and flat, gently press left shoulder downward and bring right shoulder upward with a smooth twisting motion. Repeat on other side

5. Chest Stretch stretches chest muscles.

Stand next to wall approximately 8 – 12 inches away. Extend arm back placing palm of hand on wall below shoulder level. Thumb faces the ceiling. Slowly rotate body away from wall.

6. Shoulder Stretch stretches the shoulders and upper back muscles.

Stand up straight with feet shoulder-width apart and knees slightly bent. Reach left hand across body to right shoulder. Use right hand to hold arm. Place right hand on back of left arm just above the elbow. Gently press the left arm with the right hand. Do not rotate torso. Repeat on the other side.

7. Arm Circles stretches the chest and shoulder muscles.

Standing with feet shoulder-width apart and knees slightly bent, perform slow, full-arm circles backward 5 to 10 times, then forward the same number of times. The thumb-side of the hand should always lead and the arms should brush past the ears and the sides of the trunk.

8. Side Stretch or Reach stretches the muscles on the sides of the trunk.

Standing with feet shoulder-width apart and knees slightly bent, place the left hand on the right outer thigh and extend the right arm overhead with the thumb pointing backward. Reach straight up with the right hand as you slide the left hand down thigh towards knee until you feel a stretch up side. Do not allow the right foot to raise the floor. Reposition the arms and do the same on the other side.

9. Wall Lean stretches the muscles in the back of lower legs.

Stand about an arm's distance away from a wall with feet slightly apart. Put both hands on the wall. Keeping the heel on the floor, toe slightly turned in and the leg straight, slide one-foot back until a stretch is felt in the calf. Repeat on the other side.

10. Stride Stretch stretches the muscles in the front of the thigh.

Stand facing sturdy bench approximately 2 – 3 feet high. Keeping hips and shoulders straight forward place one foot flat on the top of bench. Maintain erect posture while pushing hips forward until you feel the stretch in the front of the hip. Do not allow the front knee to go beyond the mid-foot. Repeat on the other side.

11. **Hamstring Stretch** stretches the muscles in the back of the thigh.

    Stand facing sturdy bench approximately 2 -3 feet high. Keeping hips and shoulders straight forward, place one heel on top of bench. Maintain a flat back while hinging slightly forward at the hips until you feel the stretch. Do not bend at the waist. Sit with back flat against the wall. Bring the soles of feet together and allow knees to drop to the floor. Gently press the knees toward floor with hands.

12. **Groin Stretch** stretches the muscles of the inner thighs and hips.

    Sit with back flat against the call. Bring the soles of feet together and allow knees to drop to the floor. Gently press the knees toward the floor with hands.

13. **Knee to Chest** stretches the muscles in the lower back and the back of the thighs.

    Lie on the floor on back. Pull one knee toward chest with hands clasped behind bent knee. Repeat with other leg. Finally, pull both knees toward chest.

14. **Supine Leg Stretch** stretches the muscles of the back of the thigh.

    Lie on the floor on back with one leg bent and foot flat on the floor and the other leg extended in the air. Wrap a towel behind the extended knee. Slowly pull the leg back toward head. Repeat on the other side.

Strength Exercises

Push-ups: With hands outside the shoulders, push up while keeping back straight. Push-ups can be performed with legs straight and weight resting on toes.

Chin-ups: With an underhand grasp on a bar, pull up until the chin is over the bar. To finish you will let down as slowly as possible.

Dips: Grasp the sides of a chair and let feet slide forward while supporting weight on arms. Lower the body by bending the elbows to about 60 degrees and then push up to the starting position. Keep body close to the chair.

Chair Squats: Stand about 6 inches in front of a chair, facing away from the chair. With feet slightly wider than shoulder-width, move hips back as you squat until the thighs are almost parallel to the ground, without sitting down on the chair. The kneecaps should be aligned towards the second toe and the knees should not travel beyond the mid-foot. Hold for 1-2 seconds. Return to the standing position.

Lunges and Forward Traveling Lunges: Stand with feet hip-width apart in a stride position and hands on hips. Lower the body directly between the feet by bending the knees to approximately 90-degree angles. Press back up to starting position. Perform the same number of lunges on the other side.

Standing Side Leg lifts: Stand with feet shoulder-width apart and hands on hips. Transfer body weight completely to the left leg. Lift a straight right leg directly to the side. Lower right leg just short of resting foot on the floor then lift again. Maintain erect posture. Perform the same number of lifts on the other side. Increase the number of lifts by at least 2 per week, up to a maximum of 25 per side.

Abdominal muscle strength is important for core stability and back support. Performing these exercises on a regular basis helps reduce or prevent back injuries. The following are exercises specifically designed to strengthen the back and abdominal muscles.

Bridges: Lie on back with knees bent, feet flat on the floor and arms at the sides. With knees slightly parted, slowly raise buttocks from the floor, keeping stomach tight and abdomen in line with thighs. Hold this position for five seconds and return to the starting position.

Wall Squat: Lean against a smooth wall with feet pointing straight ahead and heels 18 inches from the wall. Slowly lower the upper body down the wall until knees are bent to 90°. Hold this position for five seconds, then return to the starting position.

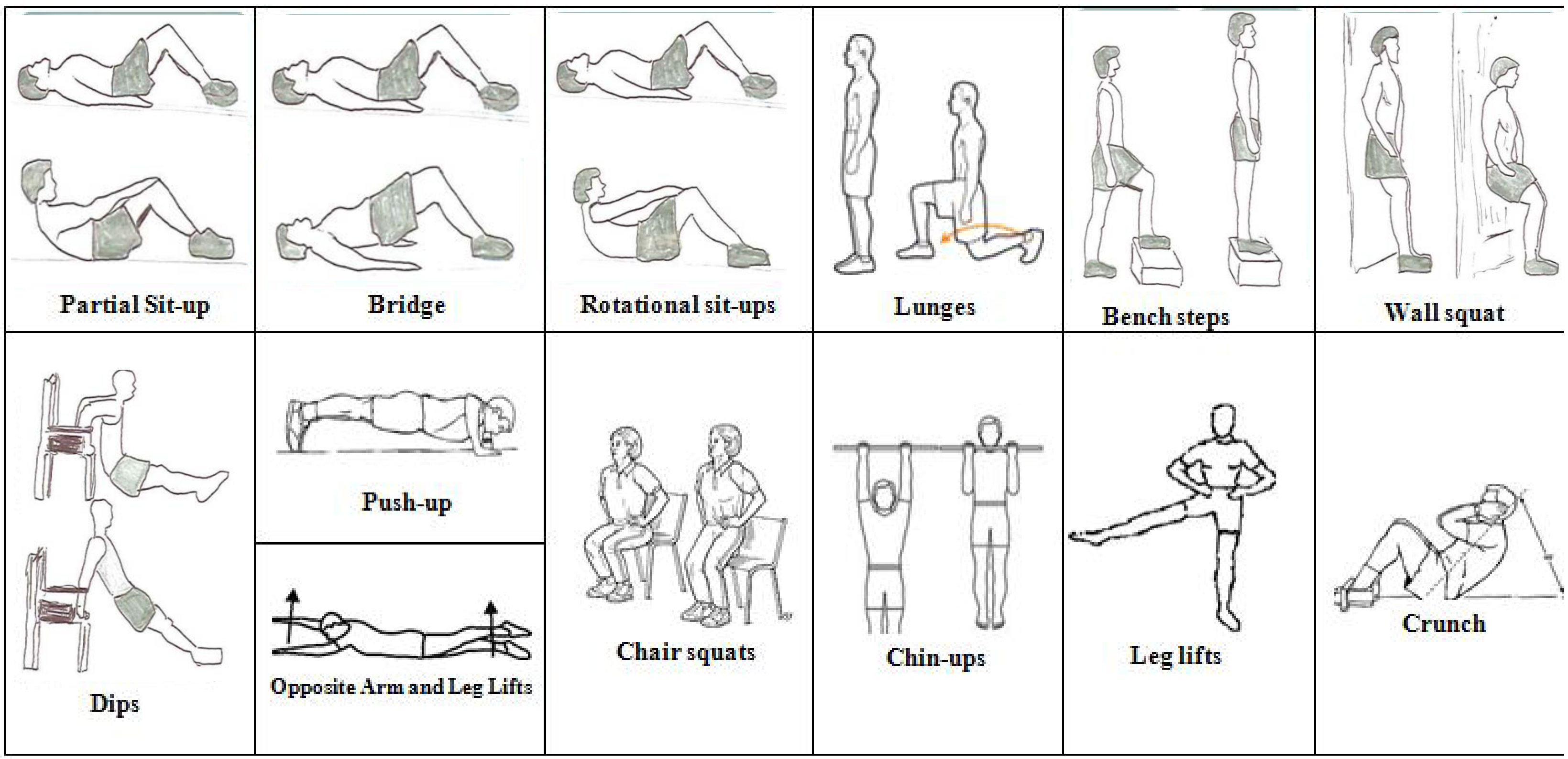
Partial sit-up: Lie on back with knees bent, feet flat on the floor and arms at sides. To begin this exercise, tuck chin into chest. While holding this position, raise head and shoulders up until shoulder blades are off the floor. Hold this position briefly before returning to the starting position.

Rotational Sit-Up: Lie on back with the knees bent, feet flat on the floor and arms at sides. Keeping hips flat on the floor, rotate upper body onto left shoulder. Keeping chin tucked in, curl head and right shoulder upward by stretching out arms and hands toward left knee. Hold briefly before returning to the starting position. Do the same for the right side.

Bench steps: Step up onto a bench that is 8-12" high, bringing up both feet and then down again, one at a time, for 30 seconds (up-up-down-down). Switch the lead foot and repeat for 30 seconds. Increase the time for each lead foot by 10 seconds per week, up to a maximum of 60 seconds of stepping up and down with each lead foot.

Opposite Arm and Leg Lifts: Lie face down on the floor with forehead resting on a towel. Arms are stretched overhead with hands shoulder-width apart. Raise the left arm and the right leg approximately 4-8 inches from the floor. Lower to starting position. Repeat on other side.

Exercise Guide



Exercise Log Sheet

Subject ID : ______-__

Pre-Exercise Do's Warm-up and stretch for 15-20 minutes before exercise, Do drink water before, during, and after exercise.

Pre-Exercise Don'ts Do not eat, smoke, and drink alcohol or caffeinated beverages for at least one hour before an exercise session.

Repetitions	Week 1			Week 2			Week 3			Week 4			Week 5			Week 6			Week 7			Week 8		
Date	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/
Partial sit-ups																								
Bridges																								
Rotational sit-ups																								
Lunges																								
Bench steps																								
Wall squats																								
Dips																								
Push-ups																								
Opposite arm/leg lifts																								
Chin-ups																								
Chair Squats																								
Leg lifts																								
Crunches																								

Appendix F: SPSS Syntax for Statistical Analysis

```
*Demographics
--------------------------

FREQUENCIES
  VARIABLES=BIQGENDER  BIQEduc  BIQYrsExp  BIQmarital BIQEthnsty
  /ORDER=  ANALYSIS .
DESCRIPTIVES
  VARIABLES= BIQYrsExp BIQAGE
  /STATISTICS=MEAN STDDEV RANGE MIN MAX .

*Age
---------

RECODE
  BIQAGE
  (18 thru 35=1)  (35 thru 60=2)  INTO  BIQAGE_rec
EXECUTE .
value labels BIQAGE_rec
1 '18 to 35'
2 '35 to 60'.
EXECUTE .
FREQUENCIES
  VARIABLES=BIQAGE_rec
  /BARCHART  PERCENT
  /ORDER=  ANALYSIS .

Education
---------

RECODE
  BIQEduc
  (1 thru 1=1)  (2 thru 4=2)  INTO BIQEduc_rec.
EXECUTE .

value labels BIQEduc_rec
1 'High school'
2 'Associate or higher'.
EXECUTE .
FREQUENCIES
  VARIABLES=BIQEduc_rec
  /ORDER=  ANALYSIS .

*Years of Experiance
-------------------------------

RECODE
  BIQYrsExp
  (1 thru 5=1)  (6 thru 15=2) (16 thru 30=3)  INTO BIQYrsExp_rec .
EXECUTE .
value labels BIQYrsExp_rec
1 'Little exp'
2 'Moderate exp'
3 'Lots of exp'.
EXECUTE .

FREQUENCIES
  VARIABLES=BIQYrsExp_rec
  /ORDER=  ANALYSIS .

RECODE
  BIQYrsExp
  (1 thru 10=1)  (11 thru 30=2)  INTO BIQYrsExp_rec2 .
```

```
EXECUTE .

value labels BIQYrsExp_rec2
1 '10 yrs or less'
2 'More than 10 yrs'
EXECUTE .

FREQUENCIES
  VARIABLES=BIQYrsExp_rec2
  /ORDER=  ANALYSIS .

*Musculoskeletal injury
---------------------------------
*Musculoskeletal injury (common, expense, prevent)
---------------------------------------------

FREQUENCIES
  VARIABLES= BIQ21a BIQ21b BIQ21c BIQ21d BIQ21e BIQ21f BIQ22a BIQ22b BIQ22c BIQ22d BIQ22e BIQ22f
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  /ORDER=  ANALYSIS .
FREQUENCIES
  VARIABLES= BIQ21a_rec BIQ21b_rec BIQ21c_rec BIQ21d_rec BIQ21e_rec BIQ21f_rec BIQ22a_rec BIQ22b_rec
BIQ22c_rec BIQ22d_rec BIQ22e_rec BIQ22f_rec BIQ23a_rec BIQ23b_rec BIQ23c_rec BIQ23d_rec BIQ23e_rec
BIQ23f_rec
  /ORDER=  ANALYSIS .

RECODE
 BIQ21a BIQ21b BIQ21c BIQ21d BIQ21e BIQ21f
  (1 thru 1=3) (2 thru 2=2)  (3 thru 3=1)  INTO BIQ21a_ BIQ21b_ BIQ21c_ BIQ21d_ BIQ21e_ BIQ21f_  .
EXECUTE .

COMPUTE MCommon  = sum(BIQ21a_,BIQ21b_,BIQ21c_,BIQ21d_,BIQ21e_,BIQ21f_) .
EXECUTE .

RECODE
 BIQ22a BIQ22b BIQ22c BIQ22d BIQ22e BIQ22f
  (1 thru 1=3) (2 thru 2=2)  (3 thru 3=1)  INTO BIQ22a_ BIQ22b_ BIQ22c_ BIQ22d_ BIQ22e_ BIQ22f_  .
EXECUTE .

COMPUTE MCostly  = sum(BIQ22a_,BIQ22b_,BIQ22c_,BIQ22d_,BIQ22e_,BIQ22f_) .
EXECUTE .

COMPUTE Mprvntabl  = sum(BIQ23a,BIQ23b,BIQ23c,BIQ23d,BIQ23e,BIQ23f) .
EXECUTE .

DESCRIPTIVES
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  /STATISTICS=MEAN STDDEV RANGE MIN MAX .

CROSSTABS
  /TABLES=BIQYrsExp_rec BY  BIQ22a BIQ23b  BIQ23d
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY   BIQ23b  BIQ23d
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

```
*CORRELATIONS
  /VARIABLES=BIQAge  BIQ21a_rec BIQ21b_rec BIQ21c_rec BIQ21d_rec BIQ21e_rec BIQ21f_rec BIQ22a_rec
BIQ22b_rec BIQ22c_rec BIQ22d_rec BIQ22e_rec BIQ22f_rec BIQ23a_rec BIQ23b_rec BIQ23c_rec BIQ23d_rec
BIQ23e_rec BIQ23f_rec
  /STATISTICS=ALL.


*CROSSTABS all insign
  /TABLES=BIQYrsExp_rec2 BY   BIQ21a_rec BIQ21b_rec BIQ21c_rec BIQ21d_rec BIQ21e_rec BIQ21f_rec
BIQ22a_rec BIQ22b_rec BIQ22c_rec BIQ22d_rec BIQ22e_rec BIQ22f_rec BIQ23a_rec BIQ23b_rec BIQ23c_rec
BIQ23d_rec BIQ23e_rec BIQ23f_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS BIQYrsExp_rec  with recoded had no sign
  /TABLES=BIQYrsExp_rec BY  BIQ21a_rec BIQ21b_rec BIQ21c_rec BIQ21d_rec BIQ21e_rec BIQ21f_rec
BIQ22a_rec BIQ22b_rec BIQ22c_rec BIQ22d_rec BIQ22e_rec BIQ22f_rec BIQ23a_rec BIQ23b_rec BIQ23c_rec
BIQ23d_rec BIQ23e_rec BIQ23f_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS BIQAGE_rec with original no sign
  /TABLES=BIQAGE_rec BY  BIQ21a BIQ21b BIQ21c BIQ21d BIQ21e BIQ21f BIQ22a BIQ22b BIQ22c BIQ22d
BIQ22e BIQ22f BIQ23a BIQ23b BIQ23c BIQ23d BIQ23e BIQ23f
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQAGE_rec BY  BIQ21e_rec BIQ21f_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQEduc_rec BY   BIQ22f  BIQ23b BIQ23f
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQEduc_rec BY   BIQ22f_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CORRELATIONS
  /VARIABLES=SpinalHlthScoreBL  BIQ21b_rec BIQ21c_rec
  /STATISTICS=ALL.

CORRELATIONS
  /VARIABLES= MCommon MCostly Mprvntabl BIQEduc BIQAGE BIQYrsExp
  /STATISTICS=ALL.
```

```
*CORRELATIONS
  /VARIABLES=SpinalHlthScoreBL  BIQ21a BIQ21b BIQ21c BIQ21d BIQ21e BIQ21f BIQ22a BIQ22b BIQ22c
BIQ22d BIQ22e BIQ22f BIQ23a BIQ23b BIQ23c BIQ23d BIQ23e BIQ23f
  /STATISTICS=ALL.

*Back injury
------------------------
*Back injury Causes
----------------------------------------------

CROSSTABS
  /TABLES=BIQYrsExp_rec BY  BIQ23b_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY  BIQ23b_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQAGE_rec BY  BIQ23b_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQEduc_rec BY  BIQ23b_rec
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

* correlated however 21b is all common!
CORRELATIONS
  /VARIABLES=SpinalHlthScoreBL  BIQ21b_rec
  /STATISTICS=ALL.

FREQUENCIES
  VARIABLES= BIQ24a BIQ24b
 /ORDER=  ANALYSIS .

*CROSSTABS insign
  /TABLES=BIQYrsExp_rec BY  BIQ24a BIQ24b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY  BIQ24b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.
```

```
*CORRELATIONS no correlation
  /VARIABLES=SpinalHlthScoreBL  BIQ24a BIQ24b
  /STATISTICS=ALL.

*CROSSTABS insign
  /TABLES=BIQAGE_rec BY BIQ24a BIQ24b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS insig
  /TABLES=BIQEduc_rec BY BIQ24a BIQ24b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

FREQUENCIES
  VARIABLES= BIQ24c1a BIQ24c1b  BIQ24c2a BIQ24c2b  BIQ24c3a BIQ24c3b BIQ24c4a BIQ24c4b  BIQ24d1a
BIQ24d1b  BIQ24d2a BIQ24d2b  BIQ24d3a BIQ24d3b  BIQ24d4a BIQ24d4b
BIQ24d5a BIQ24d5b  BIQ24d6a BIQ24d6b  BIQ24d7a BIQ24d7b  BIQ24d8a BIQ24d8b  BIQ24d9a BIQ24d9b
BIQ24d10a BIQ24d10b  BIQ24d11a BIQ24d11b  BIQ24d12a BIQ24d12b  BIQ24e1a BIQ24e1b  BIQ24e2a
BIQ24e2b  BIQ24e3a BIQ24e3b  BIQ24e4a BIQ24e4b  BIQ24e5a BIQ24e5b  BIQ24e6a BIQ24e6b  BIQ24e7a
BIQ24e7b  BIQ24e8a BIQ24e8b  BIQ24e9a BIQ24e9b
 /ORDER=  ANALYSIS .

* (only if needed) FREQUENCIES
  VARIABLES= BIQ24c1 BIQ24c2 BIQ24c3 BIQ24c4 BIQ24d1 BIQ24d2 BIQ24d3 BIQ24d4 BIQ24d5 BIQ24d6
BIQ24d7 BIQ24d8 BIQ24d9 BIQ24d10 BIQ24d11 BIQ24d12 BIQ24e1 BIQ24e2
 BIQ24e3 BIQ24e4 BIQ24e5 BIQ24e6 BIQ24e7 BIQ24e8 BIQ24e9
 /ORDER=  ANALYSIS .

CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY    BIQ24d1a BIQ24d3a  BIQ24d8a
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS  all came insign
  /TABLES=BIQYrsExp_rec BY  BIQ24c1a BIQ24c1b  BIQ24c2a BIQ24c2b  BIQ24c3a BIQ24c3b BIQ24c4a
BIQ24c4b  BIQ24d1a BIQ24d1b  BIQ24d2a BIQ24d2b  BIQ24d3a BIQ24d3b  BIQ24d4a BIQ24d4b
BIQ24d5a BIQ24d5b  BIQ24d6a BIQ24d6b  BIQ24d7a BIQ24d7b  BIQ24d8a BIQ24d8b  BIQ24d9a BIQ24d9b
BIQ24d10a BIQ24d10b  BIQ24d11a BIQ24d11b  BIQ24d12a BIQ24d12b  BIQ24e1a BIQ24e1b  BIQ24e2a
BIQ24e2b  BIQ24e3a BIQ24e3b  BIQ24e4a BIQ24e4b  BIQ24e5a BIQ24e5b  BIQ24e6a BIQ24e6b  BIQ24e7a
BIQ24e7b  BIQ24e8a BIQ24e8b  BIQ24e9a BIQ24e9b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQAGE_rec BY  BIQ24c1b  BIQ24c4a
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQEduc_rec BY    BIQ24d1a BIQ24e2b BIQ24e4b
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
```

```
 /CELLS=COUNT
 /COUNT ROUND CELL.

CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL    BIQ24d1a  BIQ24e8b
 /STATISTICS=ALL.

*Back injury Personal reported history
-----------------------------------------------------------------

FREQUENCIES
 VARIABLES= BackInj SHQ2
 /BARCHART  PERCENT
 /ORDER=  ANALYSIS .
RECODE
 SHQ2
 (1 thru 1=1)  (2 thru 3=2) (4 thru 4=3)  INTO SHQ2_rec .
EXECUTE .
value labels SHQ2_rec
1 'Never'
2 'Mild'
3 'severe'.
EXECUTE .
FREQUENCIES
 VARIABLES= SHQ2_rec
 /BARCHART  PERCENT
 /ORDER=  ANALYSIS .

CROSSTABS
 /TABLES=BIQYrsExp_rec BY    BackInj SHQ2 SHQ2_rec
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQYrsExp_rec2 BY    BackInj SHQ2 SHQ2_rec
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQAGE_rec BY BackInj SHQ2_rec
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQEduc_rec BY BackInj SHQ2 SHQ2_rec
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT  ROUND CELL.

CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL SHQ2 SHQ2_rec
 /STATISTICS=ALL.
*Musculoskeletal injury Personal reported history
----------------------------------------------------------------------

FREQUENCIES
 VARIABLES= BIQ5 SHQ2 BackInj AnklInj KneInj  ShdrInj ArmInj HndInj NkInj WrstInj LgInj RibInj FtInj HipInj
```

```
 /ORDER=  ANALYSIS .


CROSSTABS
 /TABLES=BIQYrsExp_rec BY    BIQ5 SHQ2_rec  BackInj
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQYrsExp_rec2 BY   SHQ2_rec  BackInj
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQAGE_rec BY BIQ5 SHQ2_rec BackInj AnklInj KneInj ShdrInj
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQEduc_rec BY BIQ5  BackInj  ShdrInj
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

*CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL BIQ5 SHQ2 BackInj AnklInj KneInj  ShdrInj ArmInj HndInj NkInj WrstInj
LgInj RibInj FtInj HipInj
 /STATISTICS=ALL.


FREQUENCIES
 VARIABLES= BItyp_r KneItyp_r AnklITyp_r ShdrITyp_r ArmITyp_r
 /ORDER=  ANALYSIS .

FREQUENCIES
 VARIABLES= BICse_r KneICse_r  AnklICse_r  ShdrICse_r  ArmICse_r
 /ORDER=  ANALYSIS .

FREQUENCIES
 VARIABLES= BISvrty_r KneISvrty_r  AnklISvrty_r  ShdrISvrty_r   ArmISvrty_r
 /ORDER=  ANALYSIS .

CROSSTABS
 /TABLES=BIQAGE_rec BY  KneICse_r
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQEduc_rec BY AnklISvrty_r
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

*CROSSTABS
```

```
 /TABLES=BIQYrsExp_rec BY    BItyp_r KneItyp_r AnklITyp_r ShdrITyp_r ArmITyp_r BICse_r KneICse_r
AnklICse_r  ShdrICse_r  ArmICse_r BISvrty_r KneISvrty_r  AnklISvrty_r  ShdrISvrty_r   ArmISvrty_r
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQYrsExp_rec2 BY    KneICse_r
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL   ShdrITyp_r
 /STATISTICS=ALL.

* Actions when had injury
-------------------------------------

FREQUENCIES
 VARIABLES=  BIQ6a BIQ6b BIQ6c BIQ6d BIQ7 BIQ7a_rec BIQ7b_rec BIQ8 BIQ8a_rec BIQ8b_rec BIQ9
 /ORDER=  ANALYSIS .


CROSSTABS
 /TABLES=BIQYrsExp_rec BY   BIQ6b  BIQ8b_rec BIQ9
   /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQYrsExp_rec2 BY  BIQ8a_rec BIQ8b_rec BIQ9
  /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQAGE_rec BY BIQ6a  BIQ8a_rec BIQ8b_rec BIQ9
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.
CROSSTABS
 /TABLES=BIQEduc_rec BY BIQ8b_rec
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL  BIQ6a
 /STATISTICS=ALL.

FREQUENCIES
 VARIABLES=  BIQ12a BIQ12b BIQ12c BIQ12d BIQ12e BIQ12f BIQ12g BIQ12h BIQ12i
 /ORDER=  ANALYSIS .

*CROSSTABS all insign
 /TABLES=BIQAGE_rec BY BIQ12a BIQ12b BIQ12c BIQ12d BIQ12e BIQ12f BIQ12g BIQ12h BIQ12i
 /FORMAT=AVALUE TABLES
```

```
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQEduc_rec BY BIQ12g  BIQ12i
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS
  /TABLES=BIQYrsExp_rec BY   BIQ12a BIQ12b BIQ12c BIQ12d BIQ12e BIQ12f BIQ12g BIQ12h BIQ12i
    /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY  BIQ12a BIQ12b BIQ12c BIQ12d BIQ12e BIQ12f BIQ12g BIQ12h BIQ12i
   /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CORRELATIONS
  /VARIABLES=SpinalHlthScoreBL  BIQ12a BIQ12b BIQ12c BIQ12d BIQ12e BIQ12f BIQ12g BIQ12h BIQ12i
  /STATISTICS=ALL.

FREQUENCIES
  VARIABLES=  BIQ11a_r BIQ11b_r  BIQ11c_r  BIQ11d_r  BIQ11e_r  BIQ11f_r  BIQ11g_r  BIQ11h_r  BIQ11i_r
BIQ11j_r  BIQ11k_r  BIQ11l_r  BIQ11m_r  BIQ11n_r
  /ORDER=  ANALYSIS .

*CROSSTABS
  /TABLES=BIQEduc_rec BY BIQ11a_r BIQ11b_r  BIQ11c_r  BIQ11d_r  BIQ11e_r  BIQ11f_r  BIQ11g_r  BIQ11h_r
BIQ11i_r  BIQ11j_r  BIQ11k_r  BIQ11l_r  BIQ11m_r  BIQ11n_r
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

*CROSSTABS
  /TABLES=BIQYrsExp_rec BY   BIQ11a_r BIQ11b_r  BIQ11c_r  BIQ11d_r  BIQ11e_r  BIQ11f_r  BIQ11g_r
BIQ11h_r  BIQ11i_r  BIQ11j_r  BIQ11k_r  BIQ11l_r  BIQ11m_r  BIQ11n_r
    /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQYrsExp_rec2 BY  BIQ11j_r
   /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=BIQAGE_rec BY   BIQ11c_r   BIQ11l_r
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ
  /CELLS=COUNT
```

```
 /COUNT ROUND CELL.

CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL   BIQ11c_r
 /STATISTICS=ALL.


*Spinal health score
____________________

*FREQUENCIES
 VARIABLES= SHQ51_rec SHQ55_rec  SHQ511_rec  SHQ512_rec  SHQ517_rec  SHQ520_rec  SHQ522_rec
SHQ524_rec  SHQ525_rec  SHQ526_rec  SHQ529_rec SHQ52_rec SHQ53_rec  SHQ54_rec  SHQ56_rec  SHQ57_rec
SHQ58_rec  SHQ59_rec
SHQ510_rec  SHQ513_rec  SHQ514_rec  SHQ515_rec  SHQ516_rec  SHQ518_rec  SHQ519_rec  SHQ521_rec
SHQ523_rec  SHQ527_rec  SHQ528_rec
 /ORDER=  ANALYSIS .

DESCRIPTIVES
 VARIABLES=SpinalHlthScoreBL
 /STATISTICS=MEAN STDDEV RANGE MIN MAX .


CORRELATIONS
 /VARIABLES=SpinalHlthScoreBL   BIQYrsExp  BIQAGE  SHQ2_rec BIQYrsExp_rec BIQYrsExp_rec2
BIQAGE_rec BIQEduc_rec
 /STATISTICS=ALL.

FREQUENCIES
 VARIABLES= SHQ516_rec  SHQ522_rec SHQ56_rec SHQ517_rec   SHQ512_rec SHQ527_rec SHQ54_rec
SHQ515_rec    SHQ526_rec   SHQ519_rec
 /ORDER=  ANALYSIS .



CROSSTABS
 /TABLES=BIQYrsExp_rec BY   SHQ516_rec  SHQ512_rec    SHQ515_rec
   /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQYrsExp_rec2 BY  SHQ516_rec  SHQ512_rec    SHQ515_rec
  /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.
CROSSTABS
 /TABLES=BIQAGE_rec BY     SHQ512_rec    SHQ515_rec
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.

CROSSTABS
 /TABLES=BIQEduc_rec BY  SHQ512_rec    SHQ515_rec
 /FORMAT=AVALUE TABLES
 /STATISTICS=CHISQ
 /CELLS=COUNT
 /COUNT ROUND CELL.
```

```
DESCRIPTIVES
  VARIABLES=SpinalHlthScoreBL SpinalHlthScoreFU SHQ1a
  /STATISTICS=MEAN STDDEV RANGE MIN MAX .

T-TEST
  PAIRS = SpinalHlthScoreBL  WITH SpinalHlthScoreFU(PAIRED)
  /CRITERIA = CI(.95)
  /MISSING = ANALYSIS.


DESCRIPTIVES
  VARIABLES=SpinalHlthScoreBL SpinalHlthScoreFU SHQ1a
  /STATISTICS=MEAN STDDEV RANGE MIN MAX .


FREQUENCIES
  VARIABLES=SHQFU51_r SHQFU55_r  SHQFU511_r  SHQFU512_r  SHQFU517_r  SHQFU520_r  SHQFU522_r
SHQFU524_r  SHQFU525_r  SHQFU526_r  SHQFU529_r SHQFU52_r SHQFU53_r  SHQFU54_r  SHQFU56_r
SHQFU57_r  SHQFU58_r  SHQFU59_r
SHQFU510_r  SHQFU513_r  SHQFU514_r  SHQFU515_r  SHQFU516_r  SHQFU518_r  SHQFU519_r
SHQFU521_r  SHQFU523_r  SHQFU527_r  SHQFU528_r
  /ORDER=  ANALYSIS .


T-TEST PAIRS=PWC_Bl WITH PWC_Fu (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.

T-TEST PAIRS=fa1bdg WITH fa2bdg (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.

T-TEST PAIRS=fa1waqt WITH fa2waqt(PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.


T-TEST PAIRS=fa1Su WITH fa2Su(PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.

CORRELATIONS
  /VARIABLES=reps  PWCs Bdgs Waqts sus
  /STATISTICS=ALL.

DESCRIPTIVES
  VARIABLES= reps PWCs Bdgs Waqts PaSus Pus Cus
  /STATISTICS=MEAN STDDEV RANGE MIN MAX .

CORRELATIONS
  /VARIABLES=PWCs Bdgs Waqts PaSus Pus Cus  BIQYrsExp  BIQAGE  SHQ2_rec  BIQYrsExp_rec2
BIQAGE_rec BIQEduc_rec
  /STATISTICS=ALL.

MEANS
  TABLES= PWC_Bl PWC_Fu BY reps
  /CELLS MEAN COUNT STDDEV
  /STATISTICS ANOVA.

GLM
PWC_Bl PWC_Fu BY reps
  /WSFACTOR = time 2 Polynomial
```

```
  /METHOD = SSTYPE(3)
  /PLOT = PROFILE( time*reps )
  /EMMEANS = TABLES(reps) COMPARE ADJ(LSD)
  /PRINT = DESCRIPTIVE
  /CRITERIA = ALPHA(.05)
  /WSDESIGN = time
  /DESIGN = reps .


CORRELATIONS
  /VARIABLES=V02_BL V02_FU vo2pre vo2pst
  /STATISTICS=ALL.

CORRELATIONS
  /VARIABLES=V02_BL V02_FU vo2pre vo2pst
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.


REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT vo2pre
  /METHOD=STEPWISE  BMI_pre BIQAGE Fa1Pars
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HIST(ZRESID) NORM(ZRESID).

*FACTOR
  /VARIABLES v1 v2 v5 v6 v7 v10 v11 v12 v13 v15 v16 v17 v18 v19 v20 v21 p1 p2
  p3 p4 p5 p6  /MISSING LISTWISE /ANALYSIS v1 v2 v5 v6 v7 v10 v11 v12 v13 v15
  v16 v17 v18 v19 v20 v21 p1 p2 p3 p4 p5 p6
  /PRINT INITIAL AIC ROTATION
  /PLOT EIGEN
  /CRITERIA MINEIGEN(1) ITERATE(25)
  /EXTRACTION ALPHA
  /CRITERIA ITERATE(25)
  /ROTATION VARIMAX .

 - - - - - - - - - - -   F A C T O R   A N A L Y S I S   - - - - - - - - - - -

*COMPUTE vo2diff = vo2pre - vo2pst .EXECUTE .


*EXAMINE
  VARIABLES=vo2diff
  /PLOT BOXPLOT STEMLEAF NPPLOT
  /COMPARE GROUP
  /STATISTICS DESCRIPTIVES
  /CINTERVAL 95
  /MISSING LISTWISE
  /NOTOTAL.


* CROSSTABS
  /TABLES=levels  BY score
  /FORMAT= AVALUE TABLES
  /STATISTIC=CHISQ
  /CELLS= COUNT
```

```
  /COUNT ROUND CELL .

*GLM
  bcesd fcesd BY cethnic
  /WSFACTOR = time 2 Polynomial
  /METHOD = SSTYPE(3)
  /PLOT = PROFILE( time*cethnic )
  /EMMEANS = TABLES(cethnic) COMPARE ADJ(LSD)
  /PRINT = DESCRIPTIVE
  /CRITERIA = ALPHA(.05)
  /WSDESIGN = time
  /DESIGN = cethnic .


*T-TEST
  PAIRS = Basline WITH Followup (PAIRED)
  /CRITERIA = CI(.95)
  /MISSING = ANALYSIS.

*CORRELATIONS
  /VARIABLES=banxiety bcesd bscbobj bscbsub bsstot btadl btiadl bmmse
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE .

*MEANS
  TABLES= ftiadl ftadl  BY cethnic
  /CELLS MEAN COUNT STDDEV
  /STATISTICS ANOVA .

* PARQ.
*COUNT
PARQ = PARQ1 PARQ2 PARQ3 PARQ4 PARQ5 PARQ6 PARQ7 (1).
*EXECUTE .

*FREQUENCIES
  VARIABLES=PARQ PARQ1 PARQ2 PARQ3 PARQ4 PARQ5 PARQ6 PARQ7
  /BARCHART  PERCENT
  /ORDER=  ANALYSIS .
DATASET ACTIVATE DataSet1.
T-TEST PAIRS=vo2pre WITH vo2pst (PAIRED)
  /CRITERIA=CI(.9500)
  /MISSING=ANALYSIS.

REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS BCOV R ANOVA COLLIN TOL CHANGE ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT vo2pre
  /METHOD=ENTER BIQAGE Fa1Pars BMI_pre
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE COOK.

REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL ZPP
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
```

```
  /DEPENDENT lnvo2
  /METHOD=STEPWISE  BMI_pre BIQAGE Fa1Pars
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /SAVE COOK.

EXAMINE VARIABLES=COO_4
  /COMPARE VARIABLE
  /PLOT=BOXPLOT
  /STATISTICS=NONE
  /NOTOTAL
  /ID=SID
  /MISSING=LISTWISE.


COMPUTE BMI_pst=Fa2wt*703/(Fa1ht*Fa1ht).
EXECUTE.

COMPUTE BMI_pre=Fa1wt*703/(Fa1ht*Fa1ht).
EXECUTE.

COMPUTE V02_BL=67.350+(1.921*Fa1Pars)-(0.381*BIQAGE)-(0.754*BMI_pre).
EXECUTE.

COMPUTE V02_FU=67.350+(1.921*Fa2Pars)-(0.381*BIQAGE)-(0.754*BMI_pst).
EXECUTE.

DATASET ACTIVATE DataSet1.
GRAPH
  /SCATTERPLOT(MATRIX)=BIQAGE vo2pre Fa1Pars BMI_pre
  /MISSING=LISTWISE.

REGRESSION
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT vo2pre
  /METHOD=ENTER BIQAGE Fa1Pars BMI_pre
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(3.5)
  /SAVE ZRESID.

DATASET ACTIVATE DataSet1.
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA COLLIN TOL CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT vo2pre
  /METHOD=STEPWISE BMI_pre BIQAGE Fa1Pars
  /PARTIALPLOT ALL
  /SCATTERPLOT=(*ZRESID ,*ZPRED)
  /RESIDUALS HIST(ZRESID) NORM(ZRESID)
  /CASEWISE PLOT(ZRESID) OUTLIERS(3.5)
  /SAVE ZPRED ZRESID cook.
```