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Examining Physiological, Physical, and Cognitive Changes Over a Thirteen Week Training Program

Vanessa L. Roof
University of Nebraska-Lincoln, vanessaroof@hotmail.com

EXAMINING PHYSIOLOGICAL, PHYSICAL, AND COGNITIVE CHANGES OVER A THIRTEEN WEEK TRAINING PROGRAM

by

Vanessa Roof

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EXAMINING PHYSIOLOGICAL, PHYSICAL, AND COGNITIVE CHANGES OVER A THIRTEEN WEEK TRAINING PROGRAM

Vanessa Roof, PhD

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Advisor: John Flowers

Ten members of Lincoln Fire and Rescue in Lincoln, Nebraska agreed to participate in a thirteen week tactical strength and conditioning fitness program conducted by Athology Inc. that included a Physiological, Physical, and Cognitive Component. Participants completed three workouts per week lasting approximately 90 minutes each, conducted by fitness trainers from Athology Inc. Participants completed lab draws at the beginning and end of the program as well as an EKG at the onset of the program, conducted off-site at a local hospital. Participants completed performance and agility testing at the onset and end of the program. Lastly, participants completed cognitive testing at a baseline, following a workout during the first week of the program, six weeks into the program, and during the final week of the program. Medical, fitness, and agility testing assessed changes in physical performance over the thirteen weeks, and cognitive testing assessed performance on cognitive tasks related to firefighter performance following a physically strenuous task. Finally, significant variables were combined to form an aggregate fitness and experience variable to test their impact on working memory and domain-specific decision making. In conclusion, fitness and experience did not predict performance on a working memory or decision making task for professional firefighters.

Authors' Acknowledgement

The authors thank the staff of Athology Inc. and Fire Chief Niles Ford for his cooperation. We are especially grateful to the firefighters who contributed their time, effort, and cooperation. Additional thanks to Randy Engle and his lab for permission to use the Automated O-Span Working Memory Task.

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1.0 Introduction to Study

It is well documented that firefighting is a physically demanding job and carries a high demand of mental focus. (Michaelides, M.A.; Parpa, K.M.; Thompson, J.; Brown, B. 2008; Von Heimburg, Rasmussen, & Medbo, 2006; Lusa, Louhevaara, Smolander, Kivimaki & Korhonen, 1993; Elgin & Tripton, 2005; Smith, Petruzzello, Kramer, & Misner, 1996). Basic expectations of a firefighter include pulling hoses, climbing stairs, carrying victims, breeching holes, working in harsh conditions, all while wearing over 48 pounds of personal protective equipment including a self contained breathing apparatus. While the physical demands of firefighting have been explored, the effects on basic cognition as they relate to performance under these extreme conditions have had minimal attention and warrant further exploration. Insights into the physical effects on cognition for this population could support training, policy, and improved safety features to decrease injury.

Current research provided the opportunity to integrate cognitive testing into a pre-existing program targeted at emergency responders that was comprised of a fitness program and corresponding medical and physical testing. Specifically, the current research investigated the integrated relationships between medical, physical, and cognitive factors, examining how factors of fitness and experience impacted working memory and decision making. Athology Inc. (See Appendix 1) developed a 13 week tactical strength and conditioning fitness program that focused on meeting the physical

needs of emergency responders. In addition to the fitness program, participants completed medical and physical testing at the beginning and end of the 13 week program. Current research added a cognitive component to the pre-existing fitness program, examining how memory and decision making were affected by the physical demands and changes of the program as well as evaluating and integrating the medical and physical components of the pre-existing program. In addition, fitness and experience variables were aggregated to test the relationships between fitness and experience on working memory and domain-specific decision making.

Participants included members of Lincoln Fire and Rescue in Lincoln, Nebraska who participated in the 13 week fitness program over the summer of 2010, coordinated by Athology Inc. Workouts were designed for tactical strength and conditioning, engaging muscle groups in exercises found in the line of duty for emergency responders. Participants volunteered from the pool of professional firefighters and then were randomly selected from the pool of volunteer participants and committed to exercising at the facility three times per week for 13 weeks and participating in medical, physical, and cognitive testing. The medical parameters were coordinated through a local hospital and included an EKG and basic blood work. The physical parameters were collected at Athology Inc. and the Training Division through Lincoln Fire and Rescue and included basic performance testing (e.g. shuttle run, push-ups in one minute, sit-ups in one minute, etc.) and testing on the Firefighter Physical Ability Test. Cognitive testing included collection of a baseline as well as testing immediately following workouts at the beginning, middle, and end of the training program. Cognitive testing was designed to

address how working memory and decision making are affected immediately following the physical demands of participation in individual workouts.

In addition to these aspects, current research focused on the integration of the medical, physical, and cognitive parameters as they relate to emergency personnel. As was previously noted, research among emergency personnel has addressed many physical aspects, but investigations into these parameters have had minimal investigation. Current research allows the opportunity to integrate findings from the medical, physical, and cognitive domains to access if performance is affected by measures of health and physical fitness. Specifically, current research investigates factors associated with fitness (including medical and physical variables) and experience as they relate to Working Memory and Decision Making.

1.1 Investigation in Cognitive Decision Making Research for Firefighters

On December 8, 1978, Herbert Simon attended The Nobel Prize Award Ceremonies in Stockholm, Sweden where he was awarded The Sveriges Riksbank Prize in Economic Sciences. During his Nobel Memorial Lecture, he discussed the intersection of psychology and economics, suggesting that the study of economics is, "on the one side a study of wealth; and on the other, and more important side, a part of the study of man." (Simon 1978). He went on to describe that in addition to psychology, economists have explored disciplines of political science and sociology, specifically as they relate to Decision Theory and one's ability to reason in the time of need. Simon discussed differences in decision making, specifically the differences between 'satisficing' and

'optimizing.' A decision making process of 'satisficing' would select the first option that works, as opposed to optimizing, which would evaluate all possible strategies to develop the best answer. He discussed this concept as an application of an Occam's razor, or accepting the simplest theory that works. These suggestions were later supported by Gordon Logan and associates who found that with experience, automatization occurs as a transition from algorithmic processing to quick memory retrieval. (Compton & Logan, 1991) Simon felt that great assumptions of the human cognitive system occur with quick decisions, and it was necessary to investigate those cognitions, albeit difficult to test these almost immediate decisions directly. Simon felt necessary implications of such research, not only for simply explaining the issues, but for external purposes of advising business and government.

In the years following Simon's lecture, a surge in research regarding judgment and decision making occurred. As Simon noted, a great overlap between disciplines has initiated a dissection of the complicated processes involved in making decisions as well as applications to a multitude of situations and professions. For example, decision making strategies among business people most likely hold vast differences from those professions that demand immediate decisions, such as an emergency room doctor or emergency responders. While both professions make costly decisions, the time allotted to deliver a confident decision holds great variability. The business person is most likely allotted a specific period of time where they are able to evaluate all aspects pertinent to the situation and eventually are able to deliver a decision, similar to the strategy of 'optimizing' discussed by Simon. Opposingly, one in an emergency profession is required to make a decision carrying great magnitude within seconds.

Gary Klein and his associates have investigated decision making strategies among emergency professionals, specifically fire ground commanders, in naturalistic settings for many years. He reported ten key features that define a naturalistic setting (Klein, et all. 1993). He described these features as time pressure, high stakes, experienced decision makers, inadequate information (information that is missing, ambiguous, or erroneous), ill-defined goals, poorly defined procedures, cue learning, context (higher-level goals, stress), dynamic conditions, and team coordination. These key features of naturalistic settings impact decision making in a variety of ways.

Klein (Klein, et all. 1993) reported the key feature of time pressure as a significant issue among fire ground commanders, as that he estimates they make 80% of their decisions in less than one minute. He described 'high stakes' as situations involving a high cost such as a life being lost in the event of a poor decision. Experienced decision makers are of interest because they generally make these critical decisions. Factoring inadequate information in a naturalistic setting is an issue since decision makers often are required to make these high-stakes decisions with missing or ambiguous information. Klein reported that fire ground commanders often are required to make quick decisions with an ill-defined goal upon arrival to a scene. For example, it is often not clear if the goal is to prevent a fire from spreading or to initiate search and rescue, as that each decision requires a different plan and related resources. The feature of poorly defined procedures refers to the difficulties associated with designing laboratory studies that mimic the situations faced in naturalistic settings. Naturalistic Designs do not allow for procedural design and control generally associated with a laboratory setting. Cue learning refers to the aspect of evaluating information in the environment and

incorporating it into your decision. Decisions made in Naturalistic settings often have an uncontrolled dimension from distractions of outside noise, interruptions, and other stressors. Context is closely related to the feature of dynamic conditions where Naturalistic Settings include ongoing changes of the environment. For example, in the instance of fire ground commanders, Klein estimated the situation changed an average of five times per incident. The final feature of Naturalistic Designs includes the aspect of teams, as that the decision makers, or experts, rarely work independently.

After years of data collection in naturalistic settings and analysis, Klein and his associates developed the Recognition-Primed Decision Model (RPD) (Klein 1999). Klein's model allowed for factors associated with naturalistic settings, such as dynamic conditions, as well as new concepts such as expectancies and mental simulation. RPD hypothesizes that experienced decision makers first gauge whether the situation is novel or familiar. If the situation is familiar, they utilize resources from memory previously used in the familiar setting. Next, whether familiar or unfamiliar, experienced decision makers use mental imagery, imagining a course of action as opposed to a formal analysis and comparison. Experienced decision makers will not evaluate the best option but will formulate the first workable option. Once a workable option is formulated, experienced decision makers will not generate a large, complete set of options or evaluate the advantages and/or disadvantages of individual options. Strengths and weaknesses of the single option is evaluated through mental imagery, and the overall goal is to initiate action as opposed to taking time evaluating all possible decisions. While Klein's model incorporates features of naturalistic settings as they affect decision making strategies, his model does not incorporate individual differences in response to emotionally laden

situations. Klein addresses the issue of 'high stakes;' however issues pertaining to individual responses to those high stakes warrant further investigation.

Klein also examined the effects of stress on decision making processes (1996). Klein discussed how stress could not consistently be a negative influence, as that many experts are able to make highly critical decisions, with accuracy, under immense stress. He discussed how stressors such as time, noise, and ambiguity use working memory, interrupting our ability to rehearse information and ability to make decisions. He suggests that self-regulation is the primary factor that allows individuals to override distracting information, such as pain, noise or fear. He discussed how under circumstances of these distracters, self-regulation allows us to manage our reactions to the stressor. He also discusses the critical element that when we are self regulating, we are now managing two operations, one to manage and cope with the stressor, and the other to complete the decision.

Stress and performance has been studied for numerous years suggesting an inverted U-shaped relationship where the absence of stress or presence of excess stress creates lowest performance (Yerkes & Dodson, 1908). Studies on stress and performance have examined some select populations who execute decisions under immense time pressure and 'high stakes,' such as baggage search and radiology (Ethell & Manning 2001). Both professions require a search for a specific target which often has low prevalence and poor performance results in extremely negative consequences. Again, previous theories of serial, exhaustive search (Treisman & Gelade, 1980) generally are not applicable for these select groups due to the nature of the naturalistic decision.

Over the past 20 years, Randy Engle and colleagues have studied working memory and the implications of self regulation on working memory. He defines working memory as a multi-component system that is responsible for maintaining information while processing ongoing information and distractions. Domain-specific storage and rehearsal processes and domain-general executive attention maintain information in working memory, and these processes are influenced by domain-specific skills (such as chunking and rehearsal), individual ability, task context and related interactions (Conway et al., 2005). Engle suggests that in order to complete goal directed behaviors, we need to self regulate distracting information and keep relevant information in working memory. Success is determined by planning, maintaining the goal in active memory, updating information, and changing the goal when needed, all being influenced by individual differences in both self regulation and working memory. Such an approach treats working memory capacity as both a trait and state variable, adding that "differences in the ability to control information being attended to, and therefore the contents of working memory, and believe there might be important similarities and links between successful self regulation, self regulatory failure, and working memory capacity." (Ilkowska & Engle, p. 265, 2010)

Engle further describes influences for individual differences in working memory capacity, attributing differences to individual abilities to maintain information active in primary memory while remaining able to successfully and efficiently search and retrieve information from a secondary memory. (Ilkowska & Engle, 2010) In addition, there are individual differences in ability to process top-down attentional control, leading to differences in the ability to be flexible in allocation of attentional resources to relevant

stimuli and suppress inappropriate responses. In addition, working memory capacity is seen as a state variable that is directly affected by many factors such as stereotype threat (Schmader & Johns, 2003), depression (Arnett et al., 1999), stress (Klein & Boals, 2001), and alcohol consumption (Finn, 2002). Gohar and colleagues studied internal medicine residents in residency rotations and found that working memory recall decreased and math errors increased on the Operation-Span test of working memory when the interns were on-call and under stress and experiencing fatigue.

Engle's research shed light on the benefits of working memory tasks, specifically the reading span, operation span, and counting span tasks. These tasks not only are consistently methodologically sound but also provide implications to constructs of cognition. Working Memory Tasks reveal working memory capacity which plays an important role in a variety of complex human behaviors such as comprehension, reasoning, and problem solving. In the reading span task, participants read sentences and remember words for each sentence that is presented. The sentences are presented in groups that range in size from two to six, and word recall is prompted at the completion of a sentence. This tasks has been adapted over the past 20 years to include fewer groups of sentences, correct syntax, and variations of the target recall word. The current version of Engle's reading span task includes presentation of a sentence and recall of an isolated letter that follows each sentence, with variation in number of presented sentences. (Conway et al., 2005).

Turner and Engle (1989) developed the first operation span task that included 84 mathematical operation strings. Each string consisted of a mathematical equation with two arithmetic operations on one side of the equation and a stated solution on the other

side of the equation. The stated solution was correct on half of the trials and all calculations were completed without aid, e.g. pencil or paper. Presentation order for number of items in a sequence was randomized to eliminate any strategies of memorizing the order set. One limitation of this presentation is early presence of difficult items which may discourage some participants (Conway et al. 2005). Please note Appendix 2 for additional descriptions of the operation span task.

The counting span task often is used to measure working memory in school age children as well as other populations, e.g. the elderly and nonnative English speakers, due to the simplicity of the processing component. The underlying structure of the reading span, operation span, and counting span are similar; however the task for the counting span involves is much simpler and involves counting shapes and remembering the count totals for later recall (Case et al., 1982). A similar version of the task for adults included more complex visual displays that included target shapes among a field of distracters that shared the same shape or color. (Engle, Tuholski, et al. 1999).

1.2 Intentions of Current Research

When considering the dynamic factors of naturalistic decision making, self regulation becomes a necessity for firefighters to successfully retain relevant information in working memory and formulate decisions. Domain specific factors that could potentially affect self regulation, working memory, and decision making include fatigue, exposure to trauma, previous experience, adequate training, and physical and mental preparedness. As noted, the physical aspects of firefighting have received attention while

cognitive factors have been relatively unexplored. The purpose of the current research is to examine decision making and working memory among firefighters.

The current research utilized the pre-existing components of programming offered by Athology, Inc. As discussed, professional firefighter participants enrolled in a tactical strength and conditioning program including workouts three times per week that focused on engaging muscle groups in exercises found in the line of duty for emergency responders. Under this premise, the current research intends to examine working memory capacity and domain specific problem solving following individual workouts as well as evaluating the utility of the workout program by examining medical and physical factors. As noted, previous research has focused on the physical aspects of firefighting but has minimally investigated the interactions of physical demands and cognitive aspects. In addition to examining working memory, problem solving, and evaluating the utility of the workout program, the current research focuses on interactions between the medical, physical, and cognitive components of the training program, seeking to provide exploratory information to these domains. Specifically, the current research provides information to investigate how variables of fitness and experience impact working memory and cognition.

2.0 Method

2.1 Overall Review of Study: Participants

Participants for the study were randomly selected from an initial pool of 290 employees from Lincoln Fire and Rescue in Lincoln, Nebraska. All participants were paid employees of a city fire and rescue department. Athology Inc. presented the elements of the Training Program to Lincoln Fire and Rescue, and following the initial presentation, members of Lincoln Fire and Rescue were provided the opportunity to volunteer and commit to the Program. Of the initial 290 employees, 76 volunteered to participate in the study, and recruitment did not exclude gender or race. Of those 76, only ten were selected to participate in the Program due to limited resources. The 76 volunteers were divided into those over age 35 and under age 35 to construct a semi-stratified sample that would represent variability associated with experience. Five participants were randomly selected from each age group to participate in the Program. The Program was available to other members of Lincoln Fire and Rescue; however they were required to pay the required fees to become a member of Athology Inc. Three additional firefighters agreed to render services by their own accord and did participate in the initial cognitive testing as well as initial demographic assessment.

The current research had three major assessments to include a Medical Study (which included EKG, blood work, and a back assessment), Physical Study (which included physical agility testing and completion of the Physical Ability Test), and Cognitive Study (which included conducting the O-SPAN Working Memory Task and domain-specific positive and negative recall items). The final assessment integrated demographic, medical, and physical factors to assess the combined effects on working memory and decision making. The additional three firefighters who rendered services on their own accord did not participate in the Medical Study, with the exception of the back

assessment, or the Physical Study. Table 1 displays the demographics as well as employment history of the participants. All participation was completely voluntary and participants were reminded they were allowed to remove themselves from the Program at any time. In addition, all participants agreed to testing that would include blood samples (collected at Bryan Heart Institute), and physical performance testing, physical agility testing, and cognitive testing (all conducted at Athology Inc.). Appendix 3 contains a permission letter from Chief Niles Ford, Lincoln Fire and Rescue, Appendix 4 contains permission from Athology Inc., and Appendix 5 contains a Request of Information from Bryan Heart Institute.

The Program began on 5/10/2010, and participants were offered workout times three times per day, Monday through Saturday, all occurring at Athology Inc. Participants could attend any of the workouts; however they were expected to attend three workouts per week. The Program was for 13 weeks, ending on 8/14/2010. Testing occurred intermittently throughout the Program with the first testing cycle occurring between 5/15/2010 – 5/22/2010, the second testing cycle occurring between 6/24/2010 – 6/26/2010, and the final testing occurring between 8/10/2010 – 8/14/2010. Workout procedures were pre-determined by Athology Inc., as were aspects of the Medical and Physical Studies. Lastly, participants completed a demographic questionnaire at the onset and completion of the program (See Appendix 6 and 7).

3.0 1st Analysis: Medical Investigation

The first analysis involved examining the direct physical effects of participating in a 13 week fitness program, examining blood work, EKG, and back pain. Significant variables will later be integrated into an aggregate fitness measure to test working memory and performance on a domain-specific decision making task. As an additional measure of change throughout the program, participants completed a back pain assessment at the beginning and end of the study to assess overall back pain and/or discomfort. Back pain was assessed using the Standardized Nordic Questionnaire (Kuorinka 1987), and was included in the demographic questionnaires presented at the beginning and end of the study.

3.1 Materials/Procedure for 1st Analysis

During the first week of the Program (5/10/2010 – 5/14/2010), participants reported to Bryan Heart Institute where they received an EKG as well as routine lab draws. Bryan Heart Institute collected 7.5 cc of blood and tested Sodium, Potassium, Chloride, Glucose, Bun, Creatine, Triglyceride, Cholesterol, HDL, and LDL. Bryan Heart Institute was responsible for the collection and analyzing of all blood work, and all records were kept as the property of Bryan Heart Institute. Willing participants signed a release of information to the primary researcher to release protected health information for the purposes of this study, and records for lab work as well as the EKG were released. Weight was self-reported and collected at Athology Inc. and recorded on the initial questionnaire.

During the final week of the program (8/10/2010 – 8/14/2010), participants reported to Bryan Heart Institute for a second lab draw. Again, 7.5 cc of blood was collected and tested for Sodium, Potassium, Chloride, Glucose, Bun, Creatine, Triglyceride, Cholesterol, HDL, and LDL. Identical procedures were followed for the second lab collection. EKG's were only conducted at the initial assessment. Weight was self-reported and collected at Athology Inc. and recorded on the final questionnaire.

3.2 Results of 1st Analysis

Overall, the majority of lab results remained stable with significant changes in Sodium, Creatine, and Cholesterol. On average, Sodium levels were found to slightly increase, Creatine levels were found to slightly increase, and Cholesterol had a significant decrease, indicating a positive physiological change following participation in the program. Of the 10 participants, five had normal EKG readings, 3 were abnormal, and 2 warranted further investigation. Overall, participants had a significant weight loss at the conclusion of the program. In addition, participants who reported initial back discomfort did not report back discomfort at the conclusion of the study.

Table 2 displays the Univariate statistics as well as Analysis of Variance (ANOVA) results for the 1st Analysis. There was a significant mean difference in Sodium levels between time 1 (mean = 136.0, S= 1.41) and time 2 (mean = 139.0, S = 1.33), F (1,9) = 23.824, p=.001, Mse = 1.889, r = .84. There was a significant mean difference in Creatine levels between time 1 (mean = 0.996, S = 0.18) and time 2 (mean = 1.10, S = 0.15), F (1,9) = 15.889, p=0.003, Mse = 0.003, r = 0.97. There was a

significant mean difference between Cholesterol levels between time 1 (mean = 159.1, S = 24.50) and time 2 (mean = 149.30, S = 21.41), F (1,9) = 6.67, p = 0.03, Mse = 71.98, r = 0.63. There were non-significant changes in blood levels between time 1 and time 2 for Potassium, Chloride, Glucose, Bun, Triglycerides, HDL, or LDL. Table 2 displays the Univariate statistics as well as ANOVA results for these labs.

EKG results reveal that mean resting heart rate = 58.90 (S = 5.55). There were 3 abnormal EKG's, 5 normal EKG's, and 2 EKG's that were unable to be interpreted due to lack of information from the collecting agency.

There was a significant weight loss in pounds for all participants as well as a substantial variability in weight loss among all participants. Initial mean weights (M= 202.31, SD = 44.89) were on average 5.91 pounds heavier than final mean weights (M= 196.40, SD= 37.79), r (10) = 0.978, p <.001.

Interpretation of the Nordic Questionnaire found overall significant changes in back discomfort over the course of the Program for those who initially reported some form of back discomfort. One participant reported a substantial back injury that will eventually require surgical attention, and this participant did not experience any relief in back pain over the course of the program. Table 3 displays the Univariate Statistics for the Nordic Questionnaire.

4.0 2nd Analysis: Physical Investigation

4.1 Materials/Procedure for 2nd Analysis

The second analysis involved examining the physical effects of participating in a 13 week fitness program. Basic physical performance measures assessed physical changes at the beginning and end of the program. Performance on Physical Agility was recorded on a Vertical Jump, Broad Jump, Push-Throw, Maximum number of push-ups in one minute, maximum number of sit-ups in one minute, a sit and reach, and a 300 yard shuttle run three weeks into the Program and during the last week of the Program. All testing occurred at Athology Inc.

In addition, all participants completed the Physical Ability Test, a test that consists of a series of tasks designed to assess the physical abilities necessary for fire fighting. All details are listed in the *Firefighter Physical Ability Test.* The Physical Ability Test is timed and during the course, participants will advance with a charged line, simulate forcible entry, simulate carrying equipment, breach and pull a ceiling, ladder heel, ladder raise, climb four flights of stairs with equipment, and rescue a victim. Applicants must wear a self-contained breathing apparatus (SCBA), excluding the face piece and low pressure hose. The SCBA tank is filled, weighing approximately 25 pounds. Applicants were able to wear tennis shoes, a safety helmet, and long pants during the exercise. Participants are not allowed to run during the test as that firefighters are not allowed to run at fires. The following is a brief definition of each of the tasks in the Firefighter Physical Ability Test:

- *Charged Line Advance:* For the Charged Line Advance, 150 feet of 1 ¾ line hose was connected to a hydrant and the participant was required to pull the charged line for 90 feet.

• *Forcible Entry Task:* For the Forcible Entry task, participants were asked to use a fifteen pound sledge hammer to strike a 'sled target' located three feet off of the ground. This task is intended to simulate forcible entries such as a locked door. The object of the task is to move the sled a distance of 9 inches. The participant must remain standing on a designated platform during the task.

• *Equipment Carry:* For the Equipment Carry portion, participants are required to carry a jaws hydraulic tool weighing 48 pounds for a distance of 100 feet without dropping the tool.

• *Ceiling Breach and Pull:* The Ceiling Breach and Pull occurs in a simulator where participants are required to breach and pull a ceiling with a pike pole which was positioned in a target on the breach portion of the simulator. Participants were required to perform three breach repetitions. At that point in time, they hook the pike pole onto the pull portion of the simulator and perform five pull repetitions. This sequence was repeated for four total cycles. The breach side offers 60 pounds of resistance and the pull side requires a pull force of 80 pounds.

• *Ladder Heel:* The Ladder Heel requires that participants raise a 24 foot extension ladder by 'walking it up' using a hand over hand technique. The ladder is then lowered in the reverse manner. Participants are not allowed to grasp the rails at any time, and this task is designed to assess basic coordination and upper body strength.

• *Ladder Raise:* During the Ladder Raise, participants raise the fly section of a 24 foot extension ladder using the halyard while the ladder is secured to the wall of a tower..

- *Stair Climb:* During the Stair Climb, participants will climb a stair tower, climbing three flights of stairs in total. Participants carried two sections of bundled 1 ¾ hose line weighing approximately 30 pounds. This task is designed to assess muscular and cardiovascular endurance.
- *Victim Rescue:* During the Victim Rescue (Dummy Drag) portion, participants drug a human form dummy weighing 170 pounds for 50 feet. Participants were required to drag the dummy by the protective harness only, and both the participant and the dummy must cross a finish line.

As noted, the course was timed, and per requirements of Lincoln Fire and Rescue, all participants must complete the course in less than six minutes and 22 seconds. Prior to hire with Lincoln Fire and Rescue, all potential employees must complete the course and pass under the allotted time. Testing for the current research for the Physical Ability Test occurred at the Lincoln Fire and Rescue Training Division, and testing was conducted by Lincoln Fire and Rescue Staff as well as researchers.

4.2 Results: 2nd Analysis

Table 4 displays the Univariate Statistics as well as ANOVA results for the Physical Agility Testing, and Figure 1 is a graphical depiction of the Physical Agility Testing for time 1 and time 2. Overall, participants showed significant improvements on all aspects of Physical Agility Testing with the exception of the Vertical Jump and Push-Throw. On average, participants increased their broad jump by close to eight inches (Time 1 mean = 79.85, $\underline{S}$ = 9.70, Time 2 mean = 87.35, $\underline{S}$ = 10.41). On average,

participants were able to increase their total number of push-ups in one minute by 13 push-ups (Time 1 mean = 34.6, S = 13.60, Time 2 mean = 47.40, S = 15.69) and increase their total number of sit-ups in one minute by 9 sit-ups (Time 1 mean = 38.20, S = 8.95, Time 2 mean = 47.40, S = 7.44). Their sit-reach measurements were marginally significant with average increases of two inches. Lastly, participants were able to decrease their shuttle run times by an average of 6 seconds. Participants completed two trials of the shuttle run both at time 1 and time 2, and both trials were averaged for a shuttle run time for time 1 and time 2 (Time 1 mean = 71.28, S = 7.12, and Time 2 mean = 65.22, S = 6.05).

Most significant, however, were the significant decreases in time to complete the Physical Ability Test with average times decreasing by close to one minute by the completion of the Program. On average, times to complete the course decreased by 42.6 seconds. Overall, there were non-significant changes in heart rate at baseline, post-course completion, 2 minutes post-completion, and 5 minutes post-completion. In addition, there were non-significant changes in blood pressure at resting, post-course completion, 2 minutes post-completion, or 5 minutes post-completion. These results suggest that training was successful in targeting firefighter needs as that the Physical Ability Test is seen as a measure of the necessary physical skill set for firefighters to perform their job, and following the end of the Program, they were able to complete the Physical Ability Test significantly faster than prior to entering the Program. Table 5 displays the Univariate Statistics as well as ANOVA results for the Physical Ability Testing.

5.0 3rd Analysis: Cognitive Investigation

5.1 Materials/Procedure for 3rd Analysis

Study 3 involved examining working memory capacity and domain specific problem solving following individual workouts. Athology Inc. structured the exercise regime to target muscle groups and exercises that are utilized by emergency personnel. As a result, the conclusion of a workout was intended to mimic the conclusion of actively working in the line of duty for a period of 90 minutes. The 90 minute time-frame was pre-determined by Athology Inc. Cognitive testing occurred on four separate occasions. Initially, a baseline was collected prior to participation in a workout during the first week of the Program. Participants were able to select the date they completed testing, as long as they completed Cognitive testing within the first week of the Program. Initially, a baseline was collected during the first week of the Program. Subsequent testing occurred immediately following a workout during the first week of the Program (Testing Time 1), midway through the program (Testing Time 2), and during the last week of the program (Testing Time 3).

Cognitive testing was comprised of two components, completion of the A-Ospan (Appendix 1) for Working Memory and domain specific recall of positive and negative items. Presentation order of the A-Opsan and domain-specific recall items were randomly assigned. A-Opsan included the presentation of letters followed by a distraction task (simple math problem). The problems and letters were blocked, varying between 3 and 7 problems. At the end of a block, the participant was asked to recall

letters, and the number of correctly recalled letters determined the letter score. Recalling letters in the correct sequence determined Ospan score. Accuracy errors were determined by incorrectly solved problems and problems not solved in time are speed errors. Math errors were the sum of accuracy and speed errors. A perfect score would include a Total Ospan score of 75, Correct Letters of 75, Math Errors of 0, Speed Errors of 0, and Accuracy Errors of 0.

Participants also completed domain-specific testing which included presentation of a series of pictures followed by a series of questions. This task was adapted from a training simulation program currently used by Lincoln Fire and Rescue, using software from Fire Studio. Photographs were taken of four apartment complexes as well as four homes in Lincoln, Nebraska. Using the software from Fire Studio, a simulated fire was added to each photo. (See Appendix 8 for a presentation of all photos). Each presentation was randomly presented and included a series of power point slides that were presented in a timed format. The first slide contained general information which included time of day, their assignment (e.g. captain on a specific engine), and instructions that they were 'par four,' meaning they were fully staffed. Slide two was informational, instructing them on type of fire, the related engine companies that were assigned (e.g. E4 = Engine 4), and that the participant was first on location. The next slide contained a map of the location that was retrieved from the maps used by Lincoln Fire and Rescue. The next slide contained the photograph of the structure (house or apartment) that contained a simulated fire. The slide presentation ended, and participants were asked to record their answers (on paper) to a series of questions. Participants were asked to record their approach report- a detailed list of assignments for each of the firefighters. Next,

participants were asked if they were familiar with the structure, and then they were asked to list as many items as possible that they could recall from the picture. Last, they were asked if they remembered seeing two true and two false items from the pictures, followed by their confidence ratings of their answers. Answers were recorded on a 5-point Likert Scale with high scores revealing high familiarity or confidence.

5.2 Results: 3rd Analysis

5.2.1 Results of Working Memory Assessment

Participants completed the Automated Operations-Span Test, a working memory assessment, collecting a baseline recording prior to any physical activity, and then immediately following a physical workout during the beginning, middle, and end of the 13 week program. As previously noted, research has addressed physical issues related to firefighting, but little to no data has been collected on the cognitive aspects of this select group. The intention of the Working Memory assessment was to assess if Working Memory efficiency was affected by the physical demands of the firefighting profession. Overall, Working Memory was not affected following the completion of a tailored workout; however, some interesting trends arose. It is assumed that some learning occurred, as that both baseline testing and testing for Time 1 occurred within the same week and there were non-significant differences between all values between Baseline and Testing Time 1. Highest scores for errors and lowest Total O-Span scores were seen at

Testing Time 2, following the peak of the Program. Table 6 displays the bivariate statistics for Automated Operations-Span Test.

It should also be noted that results from a Working Memory Assessment are often divided into High through Low Working Memory Groups (Conway et al. 2005) for Total O-Span. Suggested divisions include placing scores in quartiles, leaving scores in four categories based on performance. In the current study, there was not significant variability to account for division into quartiles, suggesting that all members of this study had similar ranges of Total O-Span with all members scoring in Medium-High Working Memory Capacity. It is assumed that this led to a fair amount of range restriction, limiting variability for Working Memory.

5.2.2 Results of Domain Specific Decision Making Task

Participants completed a Domain-Specific Assessment intended to replicate information received and decision-making processes at a fire call. Interpretation of the results included assessment of recorded familiarity of the structures, number of items recalled for each structure, number of correct items recalled for each structure, and the total number of correct items recalled. Overall conclusions revealed non-significant changes over time. In addition, participants were asked to rate their confidence in their recall of positive and negative items. Again, results were non-significant, but further examination of effect sizes of confidence ratings strongly suggests further examination, suggesting that confidence is highly impacted by the physical demands of the study.

Table 7 displays the bivariate statistics for familiarity and number of correct items. Table 8 displays the bivariate statistics for confidence ratings of positive and negative items.

6.0 Integration of Studies

Finally, data from each of the three studies was integrated to examine if performance on cognitive testing could be predicted by health and/or fitness measures as well as experience. Initially, variables that displayed non-significant change over time were combined into aggregate variables. Next, significant variables from the Medical and Physical Studies were scaled and then combined to form aggregate fitness variables. Regression analyses examined prediction of Working Memory measures as well as recall and confidence of domain specific content.

Number of correctly recalled positive and negative items was combined into total number of items recalled. Confidence ratings over positive and negative items were combined into a total confidence variable. Differences in scores from Time 1 and Time 2 for significant Medical and Physical variables were calculated for Sodium, Creatine, Cholesterol, Broad Jump, Push-Ups, Sit-Ups, Shuttle Run, Weight, and Physical Ability Times. Next, scores were converted to Z-Scores and aggregated to form a 'Fitness' Aggregate variable. Scores for "How long have you been at your current fire station in months," Age, Time for prior experience in months, and job time in months were converted to Z-Scores and aggregated to form an 'Experience' Aggregate variable.

Regression analyses examined relationships between the aggregated fitness and experience with outcomes of combined number of correct, confidence for positive items,

confidence for negative items and A-Opsan measures. Table 9 displays regression analyses for aggregated fitness and Table 10 displays regression results for aggregated experience. Overall, aggregated fitness was only a predictor for Math and Speed Errors and Experience was not a predictor for any of the outcomes.

7.0 Discussion

This project afforded the unique opportunity not only to investigate a select population, but also to engage in multiple discussions related to the dynamic and challenging situations involved with firefighting. Following testing on one occasion, participating firefighters discussed their evening from the night before. Members of Lincoln Fire and Rescue work 24 hour shifts, and many of the participants would attend workout sessions at the conclusion of their shift at 7:00 am. One firefighter in particular who had approximately 15 years of experience discussed how the previous day had been very quiet with a very busy night. He discussed complicated dynamics on a domestic call involving CPR and later resulted in a police investigation. Soon after the fire crew returned to the station, the crew responded to an immigrant who gave birth in her home and the related complications due to language and cultural barriers. This call was also unique as that the 'rookie' on the crew was able to help deliver the baby and cut the umbilical cord during the call. Again, the crew returned to the station only to be summoned to a fire call that lasted close to two hours. The firefighter discussed how the occupants of the home were not in the home during the time of the fire, which was determined after they had entered the building and performed a search, but the call was

complicated by the contents of the home. The firefighter discussed how the home was overly cluttered with belongings, and in many parts of the home was only a 'path' for the firefighters to walk through. The fire had spread to the attic, and the firefighter discussed the resulting assigned duties. He continued with perfect memory of who was assigned to enter the home, who was on the hose line, who was assigned to cut holes in the roof, and all of this was completed with their 'rookie' in tow. The crew returned to the fire station excited but exhausted around 4:00 am, proud of their successes of extinguishing the fire, saving as much of the home as possible, and escaping the entire event without any personal injury.

The complicated decision-making in the above example was influenced by multiple physical and mental factors. Basic physical expectations included pulling hoses, climbing stairs, breeching holes, maintaining personal safety, and extinguishing a fire, all while wearing over 48 pounds of personal protective equipment including a self contained breathing apparatus, with extremely low visibility. Previous research has investigated many of these physical demands; however the effects on basic cognition as they relate to performance under these conditions have received minimal attention. While this dimension of research warrants further examination, it poses a strong difficulty in replicating the dynamic situations involved in a firefighter's work shift. It would be nearly impossible to replicate and then test participants on a situation described in the previous paragraph. Therefore, research is presented with a unique challenge of creating a situation that replicates many of the physical responses in order to investigate any cognitive changes. The current research posed a unique opportunity to investigate

some of these questions with a group of professional firefighters participating in a tactical strength and conditioning program.

The tactical strength and conditioning program was coordinated by Athology Inc. and targeted muscle groups and exercises used by firefighters in the line of duty. Participation in the program focused on improving physical strength and agility, both skills necessary for job performance for a firefighter. The program included elements of medical and physical testing, elements which were intended to evaluate the efficacy of the program. Medical testing included basic blood work collected through a local hospital at the beginning and the end of the program. In addition, an EKG was performed at the onset of the program, and participants responded to a back pain questionnaire at the beginning and end of the program. Physical testing included basic agility testing (vertical jump, broad jump, push-throw, push-ups, sit-ups, sit-reach, and shuttle run) as well as a timed performance on the Firefighter Physical Ability Test. The Firefighter Physical Ability Test (PAT) is a test that consists of a series of tasks designed to assess the physical abilities necessary for fire fighting. Firefighters are required to pass the test in less than 6 minutes and 22 seconds in order to gain employment with Lincoln Fire and Rescue. The PAT is composed of a series of tasks that include advancing with a charged 1 ¾" hose line, simulating forcible entry, simulating carrying equipment, breaching and pulling a ceiling, ladder heel, ladder raise, climbing four flights of stairs with equipment, and rescuing a victim. Participants completed the PAT at the beginning and end of the program to assess any physical improvements from participation in the program. It was initially considered to include cognitive testing at the completion of the PAT; however

due to the short duration of the PAT, this would not replicate the time involved in a working fire.

The current research added a dimension of cognitive testing and included the unique opportunity of integrating findings from the medical and physical dimensions of the study. Cognitive testing included completion of the Automated O-Span Working Memory Task offered by Randy Engle and his lab. This task is considered valid and reliable in capturing components of working memory. In addition, participants completed a domain-specific decision making task that was replicated from current training procedures used by Lincoln Fire and Rescue. Participants were presented with novel stimuli that contained the necessary information that firefighters receive at the onset of a fire call, related assignments, a map of the area, and a picture of a house or apartment that included a simulated fire. The stimuli were presented in a timed manner and then participants were asked to answer questions regarding the stimuli. Participants recorded as many items as possible from the scene, followed by familiarity with the structure. Next, participants were asked if they could recall two positive and two negative items, followed by their confidence in their responses. In addition to the cognitive dimensions, the current research allowed the opportunity of integrating parameters from the medical and physical studies into assessment of cognitive performance. Specifically, factors which showed significant improvement in the medical and physical studies were tested via regression analyses to assess any predictive ability for working memory or performance on the decision making task.

The current research included an initial pool of nearly 300 professional firefighters, 70 of whom volunteered for the program, followed by 10 who were selected

to participate. An additional three participants agreed to participate in cognitive testing but did not participate in other aspects of the study. The 10 participants agreed to exercising three times per week for a 90 minute workout over a 13 week period in the summer of 2010. The mean age was 35.5, the mean job time was 121.69 months (10.14 years), and the average time at the current fire station was 34.6 months. In total, 12 males and 1 female participated in all aspects of the study. Participants included 1 captain, 6 paramedics, and 6 firefighters. All but one participant reported regular exercise, and 11 of the 13 participants reported serving in the military.

The medical results yielded significant changes in blood levels for Sodium, Creatine, and Cholesterol. Non-significant changes were found for Potassium, Chloride, Glucose, Bun, Triglycerides, HDL, and LDL. There were five normal EKG's, 3 abnormal EKG's and 2 EKG's reported a need for further investigation. Overall weight loss was significant with an average loss of over six pounds; however there was significant variability in weight and this would not be as reflective as another measure such as Body Mass Index. The Nordic Questionnaire reported significant improvements in back discomfort over the course of the program for those who initially reported some form of back discomfort. One participant reported a significant back injury which he believed would eventually require surgery, and this participant did not find overall improvement with his back pain.

The physical results yielded significant improvements in the broad jump, number of push-ups in one minute, number of sit-ups in one minute, and time to complete the shuttle run. Non-significant improvements were seen for the vertical jump, push-throw, or sit-reach. Most notably were the changes in time to complete the PAT course. As

noted, the maximum time to complete the course is 6 minutes and 22 seconds. At the onset of the program, average times were 295.6 seconds (4 minutes and 55 seconds, SD 40.42 seconds), and at the completion of the program, average times were 253.0 seconds (4 minutes and 13 seconds), showing an overall improvement of 42 seconds. There were non-significant changes in heart rate or blood pressure at resting, post-course completion, 2 minutes post-completion, or 5 minutes post-completion).

The cognitive results were somewhat disappointing and marked by limited variability in working memory. Generally, when a working memory task is presented, results are divided into quartiles for working memory capacity (Conway et al., 2005); however with this particular sample, all participants consistently scored in the medium-high working memory range. Reasons for this are speculated as a self-selecting population, initial recruitment and testing procedures select only participants who are of higher working memory capacity, and training and repetition procedures for this population are successful in managing only those with higher working memory capacities. Regardless, all participants did score in the medium-high working memory range, resulting in range-restriction.

Results on the Automated O-Span (A-Ospan) yielded non-significant changes from baseline over testing times 1-3 for Math Errors, O-Span Letters, O-Span Total, Speed Errors and Accuracy Errors. Non-significant results were supported by LSD analyses across all four testing times. It should be noted that baseline testing and Testing Time 1 occurred within the same week, and it appeared that some learning did occur. The strongest changes in scores, although non-significant, occurred between Testing Time 1 (first week of the study) and Testing Time 2 (midway through the program). In

addition, effect sizes ranged between 0.25 – 0.38 for all A-Ospan tests. Consideration of the minimal range of working memory scores and effect sizes suggests further investigation.

Results from the Domain-Specific Decision Making Task yielded non-significant changes from baseline over testing times 1-3, and these results were supported by non-significant LSD analyses across all four testing times. Number of items recalled seemed to slightly increase over the four testing times, suggesting some familiarity with the task (effect size 0.34). Mean number of recalled items for the house stimuli ranged from 5 – 6.8 and mean number of items recalled for the apartment ranged from 6.5 – 7.7. Number of correct items recalled for the house stimuli ranged from 2.7 – 3 (effect size 0.21), and number of correct items recalled for the apartment stimuli ranged from 2.0 – 3.0 (effect size 0.54). Number of correct positive items recalled was combined to form an aggregate which also yielded non-significant changes over the four testing times and had mean number of items ranging from 5 – 5.7 (effect size 0.29).

Participants were also asked if they could recall two positive and two negative items from the house or apartment stimuli and rank their related confidence in their answers. Again, results were non-significant over the four testing times, and this was supported by LSD analyses over time. Number of correct positive items ranged from 2.2 – 2.8 with highest scores occurring at Testing Time 1 (effect size 0.32). Number of correct negative items ranged from 2.7 – 3.2 with highest scores occurring at baseline and Testing Time 3 (effect size 0.30). Confidence ratings for positive items (on a five point scale) ranged from 3.1 – 3.5 (effect size 0.62), and confidence ratings for negative items

(on a five point scale) ranged from 3.0 – 3.63 (effect size 0.55). Despite the non-significant changes over time, the effect sizes suggest further investigation.

As noted, the current research provided the opportunity of examining the integrated relationships between the medical, physical, and cognitive factors collected in this study, specifically examining factors of fitness and experience impacted working memory and decision making. Responses from the A-Ospan were combined into aggregate variables for Math Errors, Letter O-Span, O-Span Total, Speed Error, and Accuracy Error. Number of Correct Positive and Number of Correct Negative items were combined to form an aggregate variable. Confidence Ratings for Positive and Negative items were also aggregated to form a confidence variable. The current research was interested in examining the effects of physical changes and experience on both working memory and decision making. Aggregated scores for fitness and experience were also created by combining significant variables from the medical and physical studies. Differences in scores from Time 1 and Time 2 were calculated for Sodium, Creatine, Cholesterol, Broad Jump, Push-Ups, Sit-Ups, Shuttle Run, Weight Loss, and Physical Ability Times. Next, scores were standardized and aggregated to form a 'Fitness' variable. Scores for 'How long have you been at your current fire station in months,' age, time for prior experience in months, and job time in months were standardized and aggregated to form an 'Experience' aggregate variable.

Aggregated fitness was only a predictor for Math Errors and Speed Errors. Math Errors were positively correlated with the aggregated fitness variable, and the fitness variable had a positive contribution to the regression predicting Math Errors, explaining 64% of the variance associated with Math Errors. Reasons for the positive correlation are

suspected to be related to increases in Speed Errors which also had a significant positive correlation with Fitness. Aggregated Fitness and Speed Errors were positively correlated, and aggregated fitness had a significant contribution to the regression predicting Speed Errors, explaining 72% of the variance associated with Speed Errors. Aggregated fitness was not correlated or a valid predictor for Letter O-Span, O-Span Total, Accuracy Error, Combined Positive/Negative Items or Combined Confidence for Positive/Negative Items.

Aggregated Experience was not correlated or a valid predictor for any of the variables in this study. Aggregated Experience was tested against Math Errors, Letter O-Span, O-Span Total, Speed Error, Accuracy Error, Combined Positive/Negative Items or Combined Confidence for Positive/Negative Items and was not found to be correlated or contribute to a regression predicting any of these variables.

As noted, previous research has examined many of the physical effects associated with firefighting. The current research provided the opportunity to evaluate a pre-existing program targeted towards improving fitness among emergency responders, as well as integrating working memory and domain specific decision making tasks into the pre-existing program. Additionally, the current research was able to integrate subject variables associated with fitness and experience to test their effects on Working Memory and Domain-Specific Decision Making. In summary, participants showed significant medical and physical improvements, primarily noted by their changes in lab scores, weight loss, decrease in back pain, gains in distance broad jump, number of pushups and sit-ups in one minute, and shuttle run times. Most notable was the nearly one minute decrease in times to complete the Physical Ability Test.

Significant changes were not found in Working Memory or Domain Specific Decision Making scores. One issue related to non-significant results would be related to the small variability in Working Memory Scores. Additionally, due to limited resources for the nature of this project, the small sample size could have impacted non-significant results. As that data of this nature (to the knowledge of this researcher) has not been collected of firefighters, results still yield important exploratory information into the relationships between the medical, physical, and cognitive factors associated with firefighting.

Future research could include a measurement of Body Mass Index in addition to weight loss to account for the variability for individuals participating in a similar program. Other replications of medical variables would not be necessary as that the program overall created successful changes.

Future investigations into Working Memory and Decision Making could target more variability, including a non-firefighter comparison group. As noted, the current research provided exploratory information for this expert group related to Working Memory and Decision Making, and the current sample suffered range restriction as that all participants scored in the medium-high working memory capacity. Future investigations could include a larger sample that would lend greater variability for Working Memory, in turn lending insights to relationships between working memory and physical demands associated with firefighting. Lastly, it is assumed that an element of learning occurred during collection of baseline and testing for Time 1. Future research should include a greater period of time than one week between collection of baseline and initial testing.

Lastly, other perceptual differences from this expert group warrant further investigation. As noted, this population poses difficulties for research to replicate a naturalistic situation. Future research could include testing Working Memory and Decision Making during periods of time when firefighters are experiencing situations similar to a working fire to include poor visibility, elevated heart rate, and including wearing of protective gear and self-contained breathing apparatus.

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Table 1: Demographic Information

		Mean	Standard Deviation
Age		35.15	6.40
Height (inches)		70.23	5.93
Weight in pounds (onset)		202.31	44.88
Weight in pounds (end of study)		196.4	37.78
Job time in months		121.69	78.55
Time at current fire station in months		34.6	33.37
Gender	Males	n=12 (92.3%)	
	Females	n=1 (7.7%)	
Current Job Title	Captain	n=1 (7.7%)	
	Paramedic	n=6 (46.2%)	
	Firefighter	n=6 (46.2%)	
Ethnicity	Caucasian	n=11 (84.6%)	
	African American	n=1 (7.7%)	
	Other	n=1 (7.7%)	
Do you exercise regularly?	Yes	n=12 (92.3%)	
	No	n=1 (7.7%)	
How long has this been your routine?	1	n=0	
	2	n=2 (15.4%0	
	3	n=9 (69.2%)	
	4	n=2 (15.4%)	
Please rate you fit you currently see yourself?	Slightly	n=3 (23.1%)	
	Fit	n=3 (23.1%)	
	Somewhat fit	n=7 (53.8%)	
	Very fit	n=0	
When thinking about entering the Program, which best describe your goals?	Lose weight	n=1 (7.7%)	
	Improve fitness	n=7 (53.8%)	
	Be able to better perform job	n=5 (38.5%)	
How important is your fitness?	Important	n=2 (15.4%)	
	Somewhat important	n=1 (7.7%)	
	Extremely important	n=9 (69.2%)	
Have you served in the military	No	n=2 (15.4%)	
	Yes	n=11 (84.6%)	

Table 2: Univariate Statistics and ANOVA results for 1st Analysis - Medical Study

Variable	***Mean time 1/SD***	***Mean time 2/SD***	***F-value***	***p-value***
Sodium	136.00/1.41	139.00/1.33	23.824	*0.001
Potassium	4.27/0.22	4.33/0.27	0.574	0.468
Chloride	98.60/1.71	99.70/1.25	3.524	0.093
Glucose	84.60/8.86	85.50/6.13	0.169	0.69
Bun	17.9/2.51	22.00/5.62	6.03	0.36
Creatine	0.996/0.18	1.10/0.15	15.889	*0.003
Triglyceride	129.6/120.71	78.8/53.47	3.25	0.105
Cholesterol	159.10/24.50	149.30/21.41	6.672	*0.03
HDL	42.20/9.58	42.90/10.48	0.15	0.705
LDL	95.56/20.52	95.78/15.02	0.952	0.358
Heart Rate	58.90/5.55			
EKG	Normal: n=5			
	Abnormal: n=3			
	Needs further investigation: n=2			
Self-reported Weight			***r-value***	***p-value***
	202.31/44.89	196.40/37.78	.978	*<.001

Table 3: Univariate Statistics for the Standardized Nordic Questionnaire

Question		Pre-Program			Post-Program			Chi-Square	p-value	Effect Size
		n	%		n	%				
Question #1: Have you ever had back trouble, e.g. ache, pain, or discomfort?	*Yes*	4	30.8%		2	15.4%		1.003	0.606	0.27
	No	9	69.2%		9	69.2%				
Question #2: Have you ever been hospitalized because of low back trouble?	*Yes*	0	0.0%		1	7.7%		NA	>.05	NA
	No	13	100.0%		10	76.9%				
Question #3: Have you ever had to change jobs or duties because of low back trouble?	*Yes*	1	8.3%		0	0.0%		0.218	>.05	0.13
	No	11	91.7%		11	84.6%				
Question #4: What is the total length of time tha tyou have had low back trouble?	*0 Days*	5	41.7%		5	45.5%		11.944	0.216	0.74
	1-7 days	3	25.0%		3	27.3%				
	More than 30 but not daily	3	25.0%		2	18.2%				
	Every day	1	8.3%		1	9.1%				
Question #5: Has low back trouble caused you to reduce your work activity?	*Yes*	4	66.7%		1	7.7%		3	0.223	0.5
	No	8	33.3%		10	76.9%				
Question #6: Has low back trouble caused you to reduce your leisure activity?	*Yes*	4	66.7%		1	7.7%		2.75	0.253	0.48
	No	8	33.3%		10	76.9%				
Question #7: What is the total length of time that low back trouble has prevented you from doing your normal work?	*0 Days*	7	58.3%		10	90.9%		4.444	0.108	0.66
	1-7 Days	3	25.0%		0	0.0%				
	8-30 Days	2	16.7%		1	9.1%				
Question #8: Have you ever been seen by a doctor, physical therapist, or chiropractor or other such person because of low back pain?	*Yes*	2	16.7%		3	23.1%		7.2	0.27	0.77
	No	10	83.3%		8	61.5%				
Question #9: Have you ever had low back pain at any time?	*Yes*	7	58.3%		4	30.8%		0.686	0.71	0.22
	No	5	41.7%		7	53.8%				

Table 4: Univariate Statistics and ANOVA results for 2nd Analysis - Physical Agility Testing

Variable	***Mean time 1/SD***	***Mean time 2/SD***	***F-value***	***p-value***
Vertical Jump (inches)	22.23/3.85	23.68/4.46	5.61	0.42
Broad Jump (inches)	79.85/9.70	87.35/10.41	59.21	* <.001
Push-Throw (inches)	193.5/39.95	194.4/34.24	0.064	.806
Push-Ups (total in one minute)	34.6/13.60	47.40/15.69	41.94	* <.001
Sit-Ups (total in one minute)	38.2/8.95	47.4/7.44	28.68	* <.001
Sit-Reach (inches)	43.45/3.77	45.6/3.98	3.96	0.078
Shuttle run (seconds)	71.28/7.16	65.22/6.05	19.67	* 0.002

Table 5: Univariate Statistics and ANOVA results for 2nd Analysis - Physical Ability Testing

Variable	***Mean time 1/SD***	***Mean time 2/SD***	***F-value***	***p-value***
Course completion time (seconds)	295.6/40.42	253.0/29.45	72.836	* <.001
Heart Rate:				
Resting Heart Rate	78.22/4.94	73.33/10.63	2.29	0.169
Post-course completion	125.11/43.92	152.0/10.49	4.064	0.079
2 minutes post-completion	114.0/10.0	108.89/8.13	2.06	0.189
5 minutes post-completion	101.11/10.82	95.11/8.78	1.78	0.219
Blood Pressure:				
Resting Blood Pressure (Systolic)	132.22/13.76	126.22/10.84	0.923	0.365
Resting Blood Pressure (Diastolic)	78.22/13.51	74.22/8.45	0.393	0.55
Post-course completion (Systolic)	169.33/14.7	170.0/15.84	0.011	0.92
Post-course completion (Diastolic)	68.22/13.65	70.22/10.51	0.117	0.742
2 minutes post-completion (Systolic)	140.22/10.60	140.22/17.10	0.0	1.0
2 minutes post-completion (Diastolic)	70.44/12.32	64.89/9.01	1.86	0.21
5 minutes post-completion (Systolic)	126.22/6.44	124.22/8.10	0.462	0.52
5 minutes post-completion (Diastolic)	68.67/12.57	67.56/6.22	0.097	.763

Table 6: Bivariate Statistics for Operations-Span Test

Variable	***Mean/SD***	***F-value***	***p-value***	***Effect Size***	***LSD***
Math Errors		0.748	.538	0.33	3.976
Baseline	5.71/3.20				
Time 1	7.71/6.13				
Time 2	8.43/2.57				
Time 3	7.0/5.39				
O-Span Score		0.384	0.766	0.25	9.71
Baseline	34.29/8.14				
Time 1	35.86/12.58				
Time 2	31.00/15.43				
Time 3	33.43/12.43				
O-Span Total		0.797	0.511	0.34	8.643
Baseline	55.71/5.77				
Time 1	57.71/7.78				
Time 2	52.00/13.18				
Time 3	53.00/11.17				
Speed Errors		0.317	0.813	0.22	2.34
Baseline	1.57/2.07				
Time 1	1.86/3.53				
Time 2	2.29/2.29				
Time 3	2.57/2.51				
Accuracy Error		1.006	0.413	0.38	2.401
Baseline	4.86/2.48				
Time 1	5.86/3.13				
Time 2	6.14/1.77				
Time 3	4.43/3.26				

Table 7: Bivariate Statistics for Fire Studio Testing for Number of Recalled Items

Variable	***Mean/SD***	***F-value***	***p-value***	***Effect Size***	***LSD***
Familiarity of House		1.974	0.161	0.53	1.07
Baseline	1.833/1.33				
Time 1	2.17/1.33				
Time 2	2.17/1.33				
Time 3	3.00/1.79				
Familiarity of Apartment		1.402	0.281	0.47	1.002
Baseline	2.00/1.26				
Time 1	2.50/1.38				
Time 2	2.83/1.17				
Time 3	2.83/1.17				
Number of Recall Items – House		0.635	0.604	0.34	3.02
Baseline	6.0/1.78				
Time 1	5.0/2.31				
Time 2	6.5/3.61				
Time 3	6.83/3.43				
Number or Recall Items – Apartment		0.673	0.582	0.34	2.57
Baseline	6.00/0.63				
Time 1	6.5/3.72				
Time 2	7.67/2.16				
Time 3	6.83/1.72				
Number of Correct Items – House		1.241	0.87	0.214	1.18
Baseline	3.00/1010				
Time 1	2.67/.52				
Time 2	3.00/.89				
Time 3	2.67/.82				
Number of Correct Items – Apartment		2.11	0.14	0.54	1.105
Baseline	2.17/0.75				
Time 1	3.00/0.63				
Time 2	2.00/.89				
Time 3	3.0/.89				
Total Number of Correct Items (House and Apartment Combined)		0.47	0.71	.29	1.51
Baseline	5.17/1.47				
Time 1	5.67/.82				
Time 2	5.00/.63				
Time 3	5.67/1.37				

Table 8: Bivariate Statistics for Fire Studio Testing for Confidence of Positive and Negative Items

Variable	***Mean/SD***	***F-value***	***p-value***	***Effect Size***	***LSD***
Correct, Positive Items					
Baseline	2.167/.75	0.57	0.643	0.32	1.135
Time 1	2.83/0.75				
Time 2	2.33/.52				
Time 3	2.5/1.22				
Correct, Negative Items					
Baseline	3.17/1.17	0.484	0.698	0.297	1.082
Time 1	2.83/.41				
Time 2	2.67/0.52				
Time 3	3.17/1.17				
Confidence, Positive Items					
Baseline	3.08/0.80	0.567	0.645	0.62	0.758
Time 1	3.25/0.91				
Time 2	3.54/.70				
Time 3	3.30/.68				
Confidence, Negative Items					
Baseline	3.0/.57	2.17	0.134	0.55	0.758
Time 1	3.63/.47				
Time 2	3.58/.87				
Time 3	3.58/.67				

Table 9: Regression Analyses for Aggregated Fitness

Correlations with Aggregated Fitness

	Mean	*SD*	*r*	*p-value*
Fitness Aggregate	.27	3.44		
Math Errors	28.5	14.79	.80	*0.029
Letter O-Span	141.67	38.19	.258	0.311
O-Span Total	224.17	27.42	-.009	0.493
Speed Error	7.33	8.29	0.85	*0.02
Accuracy Error	22.0	8.51	0.48	0.17
Combined Positive/Negative	21.80	1.64	0.10	0.44
Confidence Positive/Negative	26.85	4.51	0.49	0.201

Regression Results

	R^2	*F-value*	*p-value*	*b*	*p-value*	*Constant*
Math Errors	0.64	6.95	*0.058	3.42	0.058	27.56
Letter O-Span	0.07	0.285	0.622	2.87	0.622	140.89
O-Span Total	0.0	0.0	0.99	-0.08	0.99	224.19
Speed Error	0.72	10.32	*0.03	2.05	0.33	6.77
Accuracy Error	0.23	1.18	0.34	1.19	0.34	21.68
Combined Positive/Negative	0.009	0.028	0.88	0.041	0.88	21.80
Confidence Positive/Negative	0.240	0.95	0.403	0.579	0.403	26.80

Table 10: Regression Analyses for Aggregated Experience

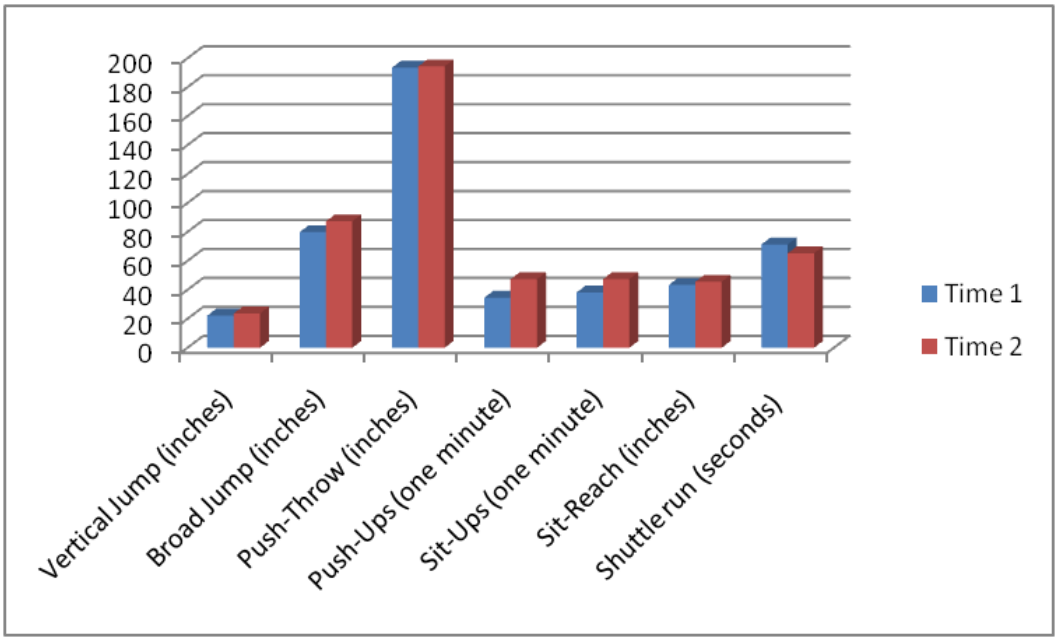
Correlations with Aggregated Experience

	Mean	*SD*	*r*	*p-value*
Experience Aggregate	0.18	1.86		
Math Errors	28.86	13.53	0.16	0.37
Letter O-Span	134.57	39.60	0.32	0.24
O-Span Total	218.43	29.27	0.37	0.21
Speed Error	8.29	7.97	-.10	0.42
Accuracy Error	21.29	7.99	0.51	0.12
Combined Positive/Negative	21.67	1.51	-.46	0.18
Confidence Positive/Negative	26.96	4.04	-.33	0.26

Regression Results

	R^2	*F-value*	*p-value*	*b*	*p-value*	*Constant*
Math Errors	0.24	0.13	0.74	1.01	0.74	29.14
Letter O-Span	0.10	0.58	0.48	6.09	0.48	136.30
O-Span Total	0.14	0.80	0.41	5.20	0.41	219.91
Speed Error	0.01	0.05	0.84	-.362	0.84	8.18
Accuracy Error	0.26	1.80	0.24	1.97	0.24	21.84
Combined Positive/Negative	0.21	1.06	0.36	-.37	0.36	21.73
Confidence Positive/Negative	0.11	0.48	0.53	-.71	0.53	27.08

Figure 1: Graphical depiction of Physical Agility Testing for time 1 and time 2.



Appendix 1: Definition of Athology Inc.

Athology Inc. is a training facility in Lincoln, Nebraska that offers training for a variety of purposes. Classes are available to the general public with introductory classes focusing on mobility, agility, and beginning conditioning. Upper level classes are targeted towards college and professional athletes who are preparing for activities such as the NFL combine or are in need of pre-season or off season training. In addition, tactical strength and conditioning classes are offered for civil service workers that focus on their physical needs. For additional information, please see:

Athology.org

Appendix 2: Automated Ospan Test (Gohar et al. 2009)

The automated Ospan (A-Ospan) is a computerized test that includes items (letters) to remember and a distracting activity in the form of problem solving. The A-Ospan consists of a basal part and the actual test. The basal part includes 12 problems to solve without letters to memorize, and a mean time used to solve the 12 equations is calculated to determine when equations will disappear during the actual test (for establishing speed error criteria). The actual test consists of 75 simple math problems with 75 letters to recall. The problems and letters are blocked, with each block containing a number of problems (between 3 and 7), with 1 letter to recall following each problem. At the end of each block, a screen appears, and the resident attempts to select the letters in the sequence in which they were revealed following the math problem. The number of correctly recalled letters determines the letter score, and recalling letters in the correct sequence determines the Ospan score. Incorrectly solved problems count as accuracy errors, and problems not solved in time are speed errors. Math errors are the sum of the accuracy and speed errors. The perfect Ospan score 75, total correct letter 75, math errors 0, speed errors 0 and accuracy errors 0.

Appendix 3: Permission Letter from Chief Niles Ford

University of Nebraska

Office of Research

301 Canfield, PO Box 880433

Lincoln, NE 68588-0433

RE: Permission for Vanessa Roof to conduct research with members of Lincoln Fire and Rescue

4/13/2010

To Whom It May Concern:

This letter authorizes Vanessa Roof, graduate student in Cognitive Psychology at the University of Nebraska, to conduct research with members of Lincoln Fire and Rescue. Mrs. Roof has communicated that her advisor, Dr. John Flowers, will supervise the project. During meetings, we have discussed the parameters of her research and the factors she is testing are not outside of the daily demands of a professional firefighter. She is using stimuli directly used in regular fire training, stimuli that were developed for training purposes with Lincoln Fire and Rescue. We have established a means of communication, and I am able to contact Mrs. Roof with any concerns throughout the project.

Appendix 4: Permission Letter from Athology Inc.

University of Nebraska
Office of Research
301 Canfield, PO Box 880433
Lincoln, NE 68588-0433

4/13/2010

To Whom It May Concern:

The Protectors Challenge is an event highlighting the men and women of civil service. The 90 day event will have a variety of testing components. This letter authorizes Vanessa Roof to review all data collected throughout the 90 day event, as well as any data collected before May 10, 2010, and after August 27, 2010. Vanessa is also allowed access to the Athology facility throughout all hours of operation. Vanessa and Athology coaches have established a means of communication at all times through conference, email, phone or meetings. If you have any questions or concerns feel free to contact me at pichi@athology.org or 402-6134648.

Pichi

Pichi Balet, President
Athology, Inc

ATHOLOGY, INC.
www.athology.org
email: info@athology.org

Appendix 5: Release of Information, BryanLGH Heart Institute

BryanLGH Heart Institute

1600 S. 48th Street, Suite 600 • Lincoln, NE 68506 • Phone 402/483-3333 • Fax 402/483-3304

AUTHORIZATION FOR RELEASE OF INDIVIDUALLY IDENTIFIABLE HEALTH INFORMATION TO DESIGNATED PARTY

This Authorization grants permission to the Designated Party(ies) named below to: request and/or receive copies of my medical records.

Purpose of Need of Disclosure: *(Check Applicable Categories)*

- ☐ Further Medical Care
- ☐ Patient's Request (personal use)- fee may be charged
- ☐ Obtain Payment for Insurance Claims
- ☐ Changing Doctors due to Dissatisfaction with care
- ☐ Social Security Disability
- ☐ Legal Investigation
- ☐ Application for Insurance
- ☐ Other_____

I authorize BryanLGH Heart Institute to: ☐ Send Records To DR ☐ Get Records From

_____ _____

(Name of Person or Place to send the records to OR to get the records from) Phone #

_____ _____ _____

Address City/State/Zip Code Fax#

Records to Request/Release: ☐ Complete Record ***Date(s) of Service needed:*** _____ to _____

Other (specify):_____

I understand that:

1. Medical information to be disclosed pursuant to this authorization may be subject to re-disclosure by the recipient and no longer protected by State or Federal law.
2. This authorization is effective for 6 months after the date it was signed. I understand that I may revoke th authorization at any time by giving written notice to the Health Information Director. My revocation will not b effective to the extent action has already been taken in reliance on my authorization.
3. I have read (or had read to me) this document. This document and disclosure are at my request.
4. A photocopy or exact reproduction of this signed authorization shall have the same force and effect as the original.

I understand I do not have to sign this authorization in order to get health care benefits (treatment, payment or enrollment). However, I do have to sign an authorization form:

1. To take part in a research study; or
2. To receive health care when the purpose is to create health information for a third party.

Patient Name:_____ DOB:_____SSN: _____

Address:_____ _____ Phone:_____

_____ _____ _____

Signature of Patient or Patient's Authorized Representative **Today's Date**

OFFICE USE ONLY: Date Completed: ____ / ____/____ *ROI for Medical Records*

Appendix 6: Initial Questionnaire

University of Nebraska Lincoln

DEPARTMENT OF PSYCHOLOGY
238 Burnett Hall
Lincoln, NE 68588-0308
(402) 472-7789

Initial Questionnaire

Participant number:_____

I. Demographic Information

a. Gender: ☐ Male ☐ Female

b. Age: _____

c. Height:_____

d. Weight:_____

e. How many years and months have you been doing your present type of work?

   a. Years? _____ Months? _____

f. What is your current job title?

   a. ☐ Captain
   b. ☐ Fire Apparatus Operator
   c. ☐ Firefighter/Paramedic
   d. ☐ Firefighter

g. Ethnicity

   ☐ Caucasian/European American
   ☐ African American
   ☐ Asian/Pacific Islander
   ☐ Hispanic
   ☐ Other Please Specify: _____

h. Do you exercise regularly? Y N

   a. If so, how many times per week? _____

   b. And how long has this been your routine? _____

i. Please rate how fit you currently see yourself.

   ☐ 0 – Not fit at all
   ☐ 1 – Slightly fit
   ☐ 2 – Fit
   ☐ 3 – Somewhat fit
   ☐ 4 – Extremely fit

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Lincoln, NE 68588-0308
(402) 472-7789

a. When thinking about the upcoming 12 week regime, which one item best describes your personal goals:

- ☐ 0 – Lose weight
- ☐ 1 – Improve fitness
- ☐ 2 – Be able to better perform my job
- ☐ 3 – Change my current workout
- ☐ 4 – Other:_____

b. When you think about how fitness affects your job performance, how important do you feel it is to be physically fit?

- ☐ 0 – Not at all important
- ☐ 1 – Slightly important
- ☐ 2 – Important
- ☐ 3 – Somewhat important
- ☐ 4 – Extremely important

II. Questions about low back trouble

c. Have you ever had low back trouble (ache, pain or discomfort)?

a. ☐ No ☐ Yes

If you answered No to Question 'm,' do not answer questions m-s.

d. Have you ever been hospitalized because of low back trouble?

a. ☐ No ☐ Yes

e. Have you ever had to change jobs or duties because of low back trouble

a. ☐ No ☐ Yes

f. What is the total length of time that you have had low back trouble during the last 12 months

a. ☐ 0 Days
b. ☐ 1-7 Days
c. ☐ 8-30 Days
d. ☐ More than 30 days, but not every day
e. ☐ Every day

g. Has low back trouble caused you to reduce your activity during the last 12 months?

a. Work activity (at home or away from home)?

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(402) 472-7789

i. ☐ No ☐ Yes

b. Leisure activity?

i. ☐ No ☐ Yes

b. What is the total length of time that low back trouble has prevented you from doing what your normal work (at home or away from home) during the past 12 months?
   i. ☐ 0 Days
   ii. ☐ 1-7 Days
   iii. ☐ 8-30 Days
   iv. ☐ More than 30 days

c. Have you been seen by a doctor, physical therapist, or chiropractor or other such person because of low back through during the past 12 months?
   i. ☐ No ☐ Yes

d. Have you ever had low back trouble at any time during the last 12 months?
   i. ☐ No ☐ Yes

II. Fire Questions

e. Please circle your current fire station:

1 2 3 4 5 6 7 8 9 10 11 12 13 14

f. How long have you been at your current fire station (in six month increments)?

_____

g. Have you worked in fire service prior to LFR? Y N If so, how long (in six month increments)?

_____

h. Have you served in the military? Y N If so, how long (in six month increments)?

_____

Thanks!

Appendix 7: Final Questionnaire

University of Nebraska Lincoln

DEPARTMENT OF PSYCHOLOGY
238 Burnett Hall
Lincoln, NE 68588-0308
(402) 472-7789

Final Questionnaire

Participant number:_____

I. Demographic Information

a. Weight:_____

II. Questions about low back trouble

b. Have you ever had low back trouble (ache, pain or discomfort)?

   a. ☐ No ☐ Yes

   If you answered No to Question 'm,' do not answer questions m-s.

c. Have you ever been hospitalized because of low back trouble?

   a. ☐ No ☐ Yes

d. Have you ever had to change jobs or duties because of low back trouble

   a. ☐ No ☐ Yes

e. What is the total length of time that you have had low back trouble during the last 12 months

   a. ☐ 0 Days
   b. ☐ 1-7 Days
   c. ☐ 8-30 Days
   d. ☐ More than 30 days, but not every day
   e. ☐ Every day

f. Has low back trouble caused you to reduce your activity during the last 12 months?

   a. Work activity (at home or away from home)?

      i. ☐ No ☐ Yes

   b. Leisure activity?

      i. ☐ No ☐ Yes

g. What is the total length of time that low back trouble has prevented you from doing what your normal work (at home or away from home) during the past 12 months?

   i. ☐ 0 Days
   ii. ☐ 1-7 Days

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(402) 472-7789

i. ☐ 8-30 Days
ii. ☐ More than 30 days

b. Have you been seen by a doctor, physical therapist, or chiropractor or other such person because of low back through during the past 12 months?
   i. ☐ No ☐ Yes

c. Have you ever had low back trouble at any time during the last 12 months?
   i. ☐ No ☐ Yes

Thanks!

Appendix 8: Stimuli Created from Fire Studio