

Physical Fitness in Army National Guard Soldiers
and Its Relationship on Utilization of Medical Resources During Combat

by

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ABSTRACT

The effects of a long-term combat deployment on a soldier's physical fitness are not well understood. In active duty soldiers, combat deployment reduced physical fitness compared to pre-deployment status, but no similar research has been performed on Army National Guard soldiers. This study is the first to identify physical fitness changes in Arizona National Guard (AZNG) soldiers following deployment to a combat zone and to assess the relationships between physical fitness and non-combat injuries and illness (NCII). Sixty soldiers from the Arizona National Guard (AZNG) completed a battery of physical fitness tests prior to deployment and within 1-7 days of returning from a 12-month deployment to Iraq. Pre and post-deployment measures assessed body composition (Bod Pod), muscular strength (1RM bench press, back-squat), muscular endurance (push-up, sit-up), power (Wingate cycle test), cardiorespiratory fitness (treadmill run to VO_2 peak), and flexibility (sit-and-reach, trunk extension, shoulder elevation). Post deployment, medical records were reviewed by a blinded researcher and inventoried for NCII that occurred during deployment. Data were analyzed for changes between pre and post-deployment physical fitness. Relationships between fitness and utilization of medical resources for NCII were then determined. Significant declines were noted in mean cardiorespiratory fitness (-10.8%) and trunk flexibility (-6.7%). Significant improvements were seen in mean level of fat mass (-11.1%), relative strength (bench press, 10.2%, back-squat 14.2%) and muscular endurance (push-up 16.4%, sit-up 11.0%). Significant ($p < 0.05$) negative correlations were

detected between percentage change in fat mass and gastrointestinal visits ($r = -0.37$); sit-and-reach and lower extremity visits ($r = -0.33$); shoulder elevation and upper extremity visits ($r = -0.36$); and cardiorespiratory fitness and back visits ($r = -0.31$); as well as behavioral health visits ($r = -0.28$). Cardiorespiratory fitness changes were grouped into tertiles. Those who lost the greatest fitness had significantly greater number of NCII visits (8.0 v 3.1 v 2.6, $p = .03$). These data indicate a relationship between the decline in cardiorespiratory fitness and an overall increase in utilization of medical resources. The results may provide incentive to military leaders to ensure that soldiers maintain their cardiorespiratory fitness throughout the extent of their deployment.

DEDICATION

I dedicate this dissertation to my beautiful wife, Alicia, and three wonderful children, Riley, Jackson, and Liliana. Without their love, support, and sacrifices, completion of this dissertation would not have been possible. My ability to persevere was only made possible by knowing that I had them at home to return to on a daily basis. They helped me keep things in perspective throughout this learning experience.

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Chapter 1

OVERVIEW

INTRODUCTION

Millions of soldiers have deployed to Iraq and Afghanistan since the events of September 11, 2001. These soldiers have lived in environments ranging from austere to relatively comfortable for periods of time extending from 6-15 months. Going to war or serving in combat is an extreme form of physical activity. The impact of a long term deployment to a combat zone on a soldier's physical fitness level is not well understood. There are very few studies to date that assess physical fitness levels of military service members prior to deployment (Lester et al., 2010; Sharp et al., 2008; Panichkul et al., 2007). While Panichkul et. al. (2007) utilized an Army physical fitness test for the evaluation of precombat preparedness; they did not explore the changes in fitness or the effects of extended combat on physical fitness. There has been only two research studies published examining deployments and physical fitness levels (Lester et al., 2010; Sharp et al., 2008). Clearly additional research is needed. The purpose of this work was to evaluate the effects of a long-term combat experience on physical fitness levels (body composition, muscular strength, muscular endurance, power, flexibility, and cardiorespiratory fitness) in male and female Arizona National Guard (AZNG) soldiers. Additionally, this study sought to evaluate the strength of relationships between physical fitness levels and utilization of medical resources for non-combat injuries and illness while deployed.

In contrast to the previously published reports that included only male subjects from the active duty component of the Army who were serving in a combat arms occupations (Lester et al., 2010; Sharp et al., 2008), this research included AZNG soldiers from a multitude of occupations, as well as women in proportionate amount to that which is currently serving in the Army. Women currently account for 13.5% of all active duty soldiers, 21.9% of reserve soldiers, and 15.2% of the National Guard (Women's Memorial, 2010).

Neither of the previous studies included members of the reserve components of the military (National Guard and Reserves) and they only evaluated men from combat arms occupations. Examples of combat arms occupations include infantry, field artillery, air defense artillery, aviation, special forces, corps of engineers, and armor. Combat arms units are considered the front-line warfighting occupations. Combat support and sustainment units are designed to support the combat arms units and occupations in their mission. There are a number of occupations within the combat support and sustainment branches that are serving in the same combat environments in a different capacity that have not been represented in previous research (Lester et al., 2010; Sharp et al., 2008). Examples of these combat support and sustainment branches include military police, military intelligence, transportation and ordinance to name a few.

The current study included males and females as well as a number of different occupations ranging from personnel clerk to explosive ordinance technicians. All recruited subjects were Arizona National Guardsmen who deployed into a combat zone. Participants completed service ranging from 6 to 11

months in a combat zone. Three separate units were represented in this study. Each of the three units had a different mission and composition of occupations within the unit. Clearly, this population of soldiers is different from the homogenous groups of Active Duty soldiers that have been previously researched.

The results of this study have the potential to demonstrate differences in physical fitness readiness and injury illness susceptibility between Active Duty and the AZNG group studied. Despite the fact that the Army needs to have their soldiers similarly prepared and ready for combat, differences between these groups exist. For example, a 2009 report comparing medical visits during deployment of Active Duty versus National Guard soldiers, found that NG soldiers utilized health care facilities for non-combat injuries or illness twice as frequently as active duty soldiers (Hartstein, Boor, & Nystuen, 2009). These differences could be the result of a multitude of reasons. Unit leadership and mission operations tempo likely influence individual fitness levels before and during deployments. Possible cultural differences amongst occupational fields within the National Guard can have bearing on physical fitness outcome measures. Whereas, the typical combat arms soldier may view fitness as a means of survival, a combat support soldier may approach physical fitness as simply a requirement.

Measuring pre and post-deployment fitness levels and evaluating change which occurred during combat deployments will help establish how the military is assisting soldiers to prepare for combat and maintain the physical standards required to perform soldier tasks during these long-term deployments. Different

from training competitive athletes, there is no peak event for which to focus physical fitness training while deployed. Soldiers must remain prepared to do any of a variety of physically demanding tasks at any point during these deployments. Ideally, soldiers reach their peak physical performance just before the deployment begins and they need to maintain this level throughout the extent of the deployment. Recognizing this physical demand of soldiers, necessitates understanding and perhaps altering physical fitness training procedures pre-deployment and during deployment. If physical fitness levels are decreasing, improvements can be made during the course of the deployment to prevent these declines or potentially increase the level of pre-combat training in an effort to counter these declines.

Due to the different standards that exist for day to day training between the AZNG and an active duty unit, it is certainly conceivable that reserve component soldiers have a different set of needs in the pre-deployment and deployment periods when speaking of physical fitness training. Soldiers in the AZNG are expected to maintain the standards of physical fitness on an individual basis, possibly performing unit physical fitness training when they meet on the assigned one weekend per month. Their active duty counterparts typically spend 1-1.5 hours on 4 days per week performing physical fitness training as a unit. Due to this increased variability in pre-deployment physical fitness training amongst the AZNG when compared to active duty soldiers, it is certainly conceivable that the AZNG soldiers could experience a different set of changes to their fitness than those which have been previously reported in the active duty soldiers. Potentially,

a deployment could offer the AZNG soldiers an opportunity to improve components of their physical fitness. The change in lifestyle and absence of distractions such as family, civilian jobs, and community involvement may ultimately allow these AZNG soldiers to spend more time focusing on their physical fitness.

There have been no research studies that evaluate the relationship of soldier fitness and medical resource utilization. This is surprising considering that typically soldiers report that their general health has decreased when they return from combat. According to the Medical Surveillance Monthly Report (May 2010), of the 133,000 soldiers returning from deployment who were surveyed, approximately 25% reported that their health was worse than before deployment. This perceived decline in health may be related to the occurrence of illness or injuries that have occurred during the deployment. Between 54-77% of soldiers report experiencing diarrhea, 69% report the occurrence of upper respiratory infections, and 35% report some type of non-battle injury (Sanders et al., 2005). Is it possible that these exceptionally high rates of occurrence of non-combat related injury and illness may be influenced by one's physical fitness? It is certainly conceivable that a relationship may exist between different components of physical fitness and non-combat related injuries or illnesses. This research was designed to explore this potential relationship. Non-combat injuries and illness should not be minimized when the one considers that injury and illness can result in days of work lost or worst case, death. Over 800 cases of non-hostile deaths had been reported through the first 6.5 years of the current conflicts (Goldberg,

2010). This is nearly 125 deaths per year that are not the result of combat. There are a number of influences that could be leading the doubling of medical visits by deployed National Guard soldiers when compared to active duty counterparts (Hartstein, Boor, & Nystuen, 2009). This research intended to evaluate the influence of physical fitness.

It has already been demonstrated that increased physical fitness affects job performance within occupations that are considered physically demanding (Rhea, Alvar, & Gray, 2004; Knapik et al., 1990; Pleban, Thomas, & Thompson, 1985). It is certainly safe to assume that a relationship between fitness and combat related injuries would not be expected, as combat injuries are not necessarily controllable, at least through modification of one's fitness. On the other hand, the relationship between physical fitness and non-combat injuries and illness in soldiers serving in combat zones is plausible, but has not yet been explored.

Findings from previous occupational research which occurred in a non-combat setting support the theory that decreased fitness leads to increased injury and illness. Multiple investigators have published results that support lower levels of fitness lead to increased risk of low back injuries in occupational settings (Biering-Sorenson, 1984; Cady et al., 1979). Craig et al. (2006), reported that three investigated components of physical fitness were significantly associated with increased risk of occupational injury. These components included cardiorespiratory fitness, percent body fat, and low back and hamstring flexibility. It has even been shown that the cessation of exercise leads not only to decreased fitness, but has negative effects on mood states (Berlin et al., 2006). A similar

change in physical activity occurring throughout a deployment could lead to soldiers declining performance or depressed mood, which in turn could require treatment.

There is plenty of evidence to support that lower levels of physical fitness results in an increased risk for injury or illness in military populations. Knapik et al. (1993) demonstrated in a population of 298 male infantry soldiers that a slower run time as well as lower number of sit-up repetitions during the APFT was associated with a higher incidence of musculoskeletal injuries over a six month period. These findings were confirmed in a population of combat engineers (N=174), demonstrating that lower levels of cardiorespiratory fitness was associated with increased risk of musculoskeletal injuries (Reynolds et al., 1994). In a large study of Army basic trainees that included both men and women, it was shown that there was no gender difference in terms of risk for injury when adjusted for current level of physical fitness. In the same study, the level of illness between genders was approximately the same when gynecological complaints were excluded. There was increased risk for upper respiratory infections associated with lower levels of prior physical activity and fitness regardless of gender (Jones et al., 1988). These findings are not exclusive to the Army. Male Marine recruits with higher body mass index and lower levels of cardiorespiratory fitness, independently or in combination, were shown to be at higher risk for exertional heat illness by as much as eight-fold (Gardner et al., 1996).

Using the data presented in this manuscript, leaders preparing their

soldiers for deployment may be able to adjust training prior to and during deployment in an effort to minimize the detrimental changes. They may also find the presented data helpful in accentuating the possible positive changes. While both of the previous investigations have detected significant declines in aerobic capacity and body composition, improvements were noted by Lester et al. in upper body power as well as upper and lower body strength (Lester et al., 2010; Sharp et al., 2008). This demonstrates that improvement in physical fitness during deployments is attainable. Ideally, outcomes of non-combat injuries and illness could be modified through altered fitness prior to and during combat deployments. Before an appropriate program can be designed to modify outcomes, the relationship between physical fitness and medical resource utilization must first be explored. In an effort to establish this relationship, pre and post-deployment fitness were evaluated. This allowed for a comparison of pre-deployment fitness amongst the AZNG soldiers and the active soldiers. Then changes in fitness that occurred during deployment were evaluated by analyzing pre and post-deployment measures for significance. Finally, further analysis was completed to determine if the relationship was influenced by pre-deployment fitness level alone, the post-deployment fitness level, or influenced by changes to fitness that occurred during the course of deployment. This investigation essentially answers three questions.

- 1) What is the current pre-deployment fitness level of the Arizona National Guard and how does it compare to the active duty counterparts?

- 2) Did soldiers physical fitness levels change during deployment as determined by body composition, muscular strength, muscular endurance, power, flexibility, and aerobic capacity?

- 3) Is there a significant correlation between physical fitness levels (pre-deployment, post-deployment, or change in fitness) and utilization of medical resources for non-combat related injuries?

METHODS

Overview of Study Design

A simple pre versus post design was utilized for the first component of this project. Participating soldiers were evaluated prior to and following their long term deployments. After determining the effects of long term (6-15 months) combat deployments on physical fitness levels (body composition, muscular strength, muscular endurance, power, flexibility, and cardiorespiratory fitness), the relationship of physical fitness and disease and non-combat related injuries was evaluated. To determine these relationships, it was required to individually screen each participant's medical deployment medical records. The detailed inventory of the medical records allowed for an accurate assessment of non-combat related utilization of medical resources which occurred over the course of the investigation.

Study Participants

The current study qualifies as a preliminary investigation as there have been no published studies that have compared changes in physical fitness following a combat deployment in National Guardsmen or Army Reserve soldiers. Interest in this study was exceptionally high following the initial solicitation. However, the soldier's ability to complete all components of testing was limited at times due to other training requirements that had to be met prior to deployment.

The research team was able to successfully recruit, screen, and complete pre-deployment testing on 60 and post-deployment testing on 54 soldiers. The soldiers were recruited from three different units but included a variety of military occupations. Units that were represented in this project included the 363rd Explosive Ordnance Detachment (EOD) and the 1404th Transportation Company (TC).

Inclusion/Exclusion Criteria

To be considered for this study, soldiers had to be on orders to a combat zone. All races and gender were eligible for this study. Soldiers were cleared for deployment by the AZNG by completing the medical screening conducted during the Soldier Readiness Program.

Male soldiers greater than 45 years old, female soldiers greater than 55 years old, those having severe physical limitations that would prevent successful completion of testing, or uncontrolled chronic disease (i.e. HTN, diabetes, sleep apnea, asthma) were not considered eligible for this investigation. The research

team could not appropriately assess the effects of combat on physical fitness in those who had significant physical limitations. Soldiers on orders for less than 6 months or greater than 15 months were not included.

All volunteers read and signed an informed consent and were screened using the American College of Sports Medicine/American Heart Health/Fitness Facility Preparticipation Screening Questionnaire prior to the initial testing. Subjects also signed a Health Insurance Portability and Accountability Act (HIPAA) release forms, allowing for the review of deployment medical records.

Actions During the Study

Soldiers deployed to a combat zone for greater than 6 months but less than 15 months. They conducted physical fitness training in accordance with their respective unit requirements. This likely included minimal to no structure due to the operations tempo and duty requirements. Soldiers were encouraged to conduct themselves in similar fashion to that as if they were not enrolled in the study. The goal of the study was to evaluate the effects of the deployment itself without an additional intervention.

Data Collection

Variables. Primary outcomes for this study were determined by the measurements of individual body composition, muscular strength, muscular endurance, power, and flexibility, and aerobic fitness. A measure of the number of patient visits for non-combat injury or illness during the time of the deployment was determined by review of the medical records.

When conducting the needs analysis for this project soldier tasks had to be considered when selecting testing methods that would appropriately assess at what level of ability these soldiers might perform at while deployed. For example, one of the common soldier tasks that are trained is a 3-5 second rush. This maneuver is utilized to evade fire and move to a secure position. These 3-5 second rushes likely occur in combat under the load of body armor, helmet, ammunition, and a weapon. A soldier's ability to perform this task is clearly a function of their anaerobic power. With anaerobic power as a consideration, the Wingate Cycle test was selected to assess individual peak power. Over the course of the deployment soldiers need to be prepared to do a variety of physically demanding tasks. This may include but is not limited to repetitive lifting of items such as ammunition cans, hiking or patrolling with a back pack and weapon up the mountains of Afghanistan, and moving or carrying heavy objects such as a wounded comrade. The ability to perform any of these tasks requires soldiers to demonstrate muscular strength, endurance, power, and cardiorespiratory fitness.

Some tests were selected based on soldier familiarity and the fact that they are currently utilized by the Army to assess soldier fitness (FM 21-20). The push-up and sit-up events are both part of the APFT and designed to assess muscular endurance. Similar versions of these tests are also recommended by the ACSM for the assessment of muscular endurance (ACSM, 2010). While the Army currently uses a timed 2 mile run to assess cardiorespiratory fitness, a VO_2 peak test was selected for this investigation. It was intended to obtain a more accurate assessment of the soldiers' cardiorespiratory fitness through gas analysis.

Flexibility measures have not previously been performed on deploying soldiers. In fact flexibility has often been overlooked as a component of fitness in much of the research evaluating the effects of combat or combat like environments on physical fitness (Sharp et al, 2008; Lester et al., 2010; Nindl et al., 2007). This investigation team felt it important to explore for potential changes occurring to soldiers' flexibility. With repetitive wear of heavy body armor, daily foot marches under loads, or recurrent lifting activities it is conceivable that flexibility of the upper and lower extremity, or back could be affected. The flexibility measures selected (shoulder elevation, trunk extension, and sit and reach) were intended to provide a snapshot assessment of flexibility in soldiers. These three tests offer a quick assessment of flexibility in the upper extremity, lower extremity, and trunk. The assessment of flexibility will provide a significant contribution to the current literature.

The independent variable assessed during this investigation is a long term (6-15 months) combat experience. Combat itself can affect soldiers in many different ways ranging from physical to emotional side effects. The intention of this study was to assess the side effects, good or bad, that the combat experience has on a soldier's physical fitness and the relationship to utilization of medical resources.

Pre-deployment and post-deployment data collection was conducted in a standardized fashion as described below in an effort to minimize the introduction of potential bias. The investigation team selected assessment methods that were deemed to be the most appropriate for use in a population of soldiers based on

what the perception of their physical function might have been during deployment. Per NSCA recommendations, criterion for test selection included experience, training status, and age of the soldiers. The testing environment also had to be considered during the selection process. Reliability and validity were also a consideration when selecting tests (NSCA, 2008). Finally, transportability of the necessary equipment had to be incorporated. Realizing that components of the testing would be done outside of the laboratory, the investigation team had to select tests that not only assessed the appropriate components of physical fitness but were also feasible to conduct in a variety of locations.

Testing was conducted in order that was not only in accordance with NSCA recommendations, but also did not interfere with the soldiers' training schedules. Each unit that provided participants had a different schedule and set of training requirements that had to be accommodated. For planning purposes, testing was typically conducted over two to three periods for each soldier depending on their availability. Adjustments to testing sequence were made in order to maintain the highest level of validity for each test while minimizing bias from previous tests. The typical order of testing was as follows:

Session 1: anthropometrics, flexibility, muscular endurance, anaerobic power.

Session 2: body composition, muscular strength, aerobic capacity.

This sequence was also in accordance with NSCA test administration recommendations (NSCA, 2008).

Body composition. Body composition (percent body fat and fat free mass) was measured using air displacement plethysmography (Bod Pod, Life Measurement, Inc.) It has been reported that the test-retest reliability of the Bod Pod is between .92 and .99 (McCrory et al., 1995; Collins et al.; Maddalozzo, Cardinal, & Snow, 2002). The Bod Pod can be considered highly correlated to hydrostatic weighing (.96) and dual energy x-ray absorptiometry (.89-.94) in terms of predicting percent body fat (Dixon et al., 2005; Ball & Altona, 2004; Maddalozzo, Cardinal, & Snow, 2002). Research suggesting that the Bod Pod systemically predicts body fat percentage lower than hydrostatic weighing but higher than dual energy x-ray absorptiometry is controversial (Ball & Altona, 2004; Collins et al., 1999). The difference in measuring technique could result in a difference of approximately 2%.

Calibrations of the Bod Pod and electronic scale were performed prior to each testing session. Between each soldier a standard two-point calibration was performed. This included the measurement of an empty chamber, followed by the measurement of the calibration cylinder.

Soldiers were asked to abstain from eating for the two hours prior to their arrival at the testing facility. Soldiers wore form-fitting, non-cotton, compression shorts with a non-cotton, lycra cap to compress the hair to the head as snugly as possible thereby minimizing excess surface area. Soldiers were also asked to remove all jewelry prior to testing. The soldier was instructed to sit in the Bod Pod, maintain normal respirations, keep their hands in their laps, and refrain from moving. Body composition assessments were performed prior to other physical

fitness tests in order to prevent an elevation in body temperature. Soldiers' body volumes were measured at least two times to ensure that measurements were within 150 ml. In the event that the volumes were inconsistent a third measurement was performed and the two closest volumes were averaged.

Muscular strength. Strength was determined using the 1 repetition maximal (RM) bench press and back squat. Protocol for the 1RM testing followed the guidelines set forth by the National Strength and Conditioning Association (NSCA) and the American College of Sports Medicine (ACSM) (American College of Sports Medicine 2010, National Strength and Conditioning Association, 2008). The 1RM bench press was used to assess upper body strength, while the 1RM back squat was used to assess lower extremity strength. The 1RM testing was selected for use based on the ability to perform testing in a variety of locations, ease of administration to trained or untrained individuals, and the previous use to identify maximal strength in soldiers (Nindl et al., 2002)

1RM bench press. The test-retest reliability of the 1RM bench press test has proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .93-.99 (Doan et al, 2002; Levinger et al., 2009; Hoeger et al., 1990). Soldiers performed this test after a block of instruction provided by one of the investigation team. They were asked to grasp the bar at approximately shoulder width and lift it off of the rack. Spotters were in place throughout the testing. Soldiers then performed each repetition by lowering the bar to within one inch of the chest and then raising the bar until the elbows reached full extension. Soldiers first performed 10 repetitions of approximately

40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

1RM back squat. The test-retest reliability of the 1RM back squat test has also proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .92-.97 (Blazevich, Gill, & Newton, 2002; Harris et al., 2000). Soldiers performed this test after a block of instruction provided by one of the investigation team. Spotters were in place behind the soldiers throughout the testing period. Soldiers positioned the bar across the shoulders before lifting it off of the rack. They were then asked to lower their bodies by bending at the knees and hips while maintaining a straight back. A repetition was counted when the soldier was within approximately 10 degrees of getting the upper leg parallel to the floor. Soldiers first performed 10 repetitions of approximately 40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

Muscular Endurance. Muscular endurance was assessed by completion of a push-up and sit-up test in accordance with the United States Army Physical

Fitness Test protocol. This testing method was selected because it is similar to that described by the ACSM but is more familiar to the soldiers because of its inclusion in the Army Physical Fitness Test (American College of Sports Medicine, 2010, Department of the Army, 1992). Push-ups and sit-ups have been used to assess muscular endurance in previous research which evaluated occupational fitness to include firefighters and military service members (Knapik et al., 1990; Misner, Boileau, & Plowman, 1989). Test-retest reliability for a timed push-up test has been reported to be .93, while the sit-up has been reported to be .88-.94 (Knudson, 1995; Invergo, Ball, & Looney, 1991).

Push-up. Soldiers were instructed to take the ready position which required them to be positioned with their hands on the floor approximately shoulder width apart. Male and female soldiers were required to perform the event with their toes in contact with the floor, head and eyes directed forward, hips in extension, spine parallel to the floor, and elbows in extension. Neither males nor females were allowed to perform the push-up with their knees in contact with the floor. Soldiers were instructed to do as many push-ups as possible in the two minute period without putting their knees in contact with the floor or removing their hands from the floor. A push-up was counted if the elbows were brought to flexion of 90 degrees or greater and then returned to full extension, while keeping the body elevated on the toes. The test was discontinued if the soldier dropped to the knees or reached volitional fatigue (Department of the Army, 1992).

Sit-up. Soldiers were asked to assume the start position which required the feet and shoulder blades to be in contact with the floor, while the knees were flexed to approximately 90 degrees. The hands were to be behind the head, but not required to have the fingers interlocked. After the command was given to begin and the timer started, a sit-up repetition was counted if the soldier kept their hands behind their head, bringing the base of their spine to at least a vertical position and then returning the shoulder blades to the floor. The test was discontinued at the end of two minutes or if the soldier reached volitional fatigue prior to the end of the two minutes (Department of the Army, 1992).

Power. Lower extremity power was assessed using a Wingate anaerobic cycle test (Nieman, 2008). The Wingate is considered a reliable and reproducible assessment of power maintaining a correlation coefficient of .89-.98 (Bar-Or, 1987). The Wingate test has been used in multiple military studies to evaluate power due to its simplicity of use and ability for untrained individuals to successfully complete the test with brief familiarization (Knapik et al., 1995; Knapik et al., 1990; Murphy et al., 1987). The Wingate has been used for the assessment of power in men and women alike from numerous occupations other than military service, such as firefighting (Misner, Boileau, & Plowman, 1989).

The 30 second Wingate was completed on an Ergomedic Peak Bike 894E, Monark. Soldiers were given detailed instructions and familiarized with the cycle prior to completion. Prior to starting the test the seat height and handle bars were adjusted appropriately. After a warm-up period soldiers were instructed to pedal at their maximal speed without resistance. Once the maximal speed was achieved

the soldier pressed the button located on the handlebars, which then increased the resistance on the wheel to .075 kilograms per kilogram of body weight. The soldiers continued an all out bout of pedaling for 30 seconds followed by a resistance free cool down period prior to dismounting the bike (Nieman, 2008).

Flexibility. Flexibility was assessed using three different tests; sit and reach, shoulder elevation, and trunk extension. Lower extremity flexibility was determined using the sit and reach test (SNR). The SNR test is simple to administer and has demonstrated exceptional test-retest reliability ($r=.98-.99$) in multiple investigations (Gabbe et al., 2004; Simoneau, 1998). The SNR has also been found to be valid measure of hamstring flexibility (Baltaci et al., 2003; Simoneau, 1998; Liemohn, Sharpe, & Wasserman, 1994).

Shoulder flexibility was determined by the shoulder elevation test. Trunk flexibility was determined by the trunk extension test. These expedient field tests were selected based on their ease of administration and their potential ability to provide a snapshot of soldiers' upper extremity and trunk flexibility. Although not many published studies have utilized the trunk flexibility and shoulder elevation tests, normative values have been established (Acevedo & Starks, 2003; Johnson & Nelson, 1969).

Sit and Reach. Soldiers were asked to remove their shoes and sit on the floor. They were asked to place the soles of their feet against the SNR box with the back of the leg and knee flat against the floor. They were then asked to place one hand on top of the other and slowly reach forward with extended arms pushing the slide as far forward as possible. Subjects were given two attempts

and the highest score was recorded (American College of Sports Medicine, 2010; Acevedo & Starks, 2003).

Trunk Extension. Trunk flexibility was determined by using the trunk extension test. This test is intended to assess the flexibility of the core muscles of the abdominal region. First the trunk was measured by having the soldier sit with their back flat against the wall and legs extended. A yard stick was placed between the legs of the soldier. The trunk length was determined by the distance between the floor and the suprasternal notch. Following the trunk measurement, the soldier laid in the prone position with his or her hands behind the back. The soldier was asked to raise up their head and neck as high as possible while extending the spine, but keeping the feet in contact with the floor. At the peak of trunk elevation, the tester measured the distance from the floor to the suprasternal notch. The soldier was given two attempts and the highest value was recorded. The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1969):

$$\text{trunk extension score} = \text{back extension (in.)} \times 100 / \text{trunk length (in.)}$$

Shoulder Elevation. The shoulder elevation test was used to assess the flexibility of the chest and shoulder muscles. First the length of the arm was determined by having the soldier hold a yard stick in closed fists of both hands with arms fully extended. A measurement was taken from the acromion process to the proximal edge of the stick. The soldier was then asked to lie in the prone position with the stick still grasped in the hands and the elbows extended. The fists were initially in contact with the floor until the soldier was given the

command to elevate the hands as high as possible. At this point a measurement was taken from the floor to the level of the yard stick. This was followed by a measurement of the soldier's ability to elevate the arm, while the chin remained in contact with the ground. The elbows were to be kept in extension while the tester measured from the floor to the bottom of the stick. The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1969):

$$\text{shoulder elevation score} = \text{shoulder elevation (in.)} \times 100 / \text{arm length (in.)}$$

Cardiorespiratory fitness. Peak cardiorespiratory function can be defined as the "the maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscle and of the exercising muscle to extract oxygen from the blood" (Albouaini et al., 2007). An incremental treadmill test is preferred for the measurement of peak oxygen consumption, as it requires the use of large muscle mass (Weber et al., 1988). Incremental treadmill tests have been used successfully to assess cardiorespiratory fitness in multiple military studies (Sharpe et al., 2008; Nindl et al., 2002; Knapik et al., 1990)

Soldiers' cardiorespiratory fitness (VO_2 peak) was estimated with indirect calorimetry while completing a treadmill test. Indirect calorimetry was completed using a metabolic cart (AEI Technologies, Pittsburgh, PA). A modified version of the Bransford and Howley protocol was selected in order to allow the soldiers to run at a self-selected pace (Morgan et al., 1991; Bransford & Howley, 1977).

Soldiers were first fitted with a Polar heart rate monitor, Hans Rudolph head gear and two-way non-rebreather valve. They were then given individual instruction to select a running pace that they would normally complete the 2 mile

run for the Army Physical Fitness Test (Department of the Army, 1992). After a brief warm-up, the initial two-minute period was completed at 0% grade. The grade was incrementally increased by one percent every minute following this initial two minute period until the soldier reached volitional fatigue. Criteria for adequate testing included the following: RER > 1.00 or heart rate + or - 10 beats per minute of age predicted maximum heart rate (Sharp et al., 2008).

Medical records inventory. Screening of deployment medical records was conducted in order to inventory number of visits to the medical facility that were related to non-combat injury or illness. Screening exams, immunizations, and mandatory visits were not counted during the inventory. A total number of visits for each subject was determined by each category of the visit. This number of visits was then compared to the physical fitness outcome measures in order to determine the relationship between the fitness variables and medical resource utilization. Medical visits were categorized in a similar fashion to what has been reported in previous literature. Categories are listed in Table 1. and reflect those which have previously been used in research but also had a reasonable potential of influencing a relationship with physical fitness (Zouris, Wade, & Magno, 2009; Sanders et al., 2005).

Table 1.1

Medical Records Categorization

Respiratory
Digestive
Musculoskeletal Injury
Lower Back
Upper Back
Neck
Shoulders
Arm
Wrist/Hand
Hip
Knee
Ankle/Foot
Physical Therapy
Behavioral Health
Miscellaneous
Total Visits

Medical records review occurred at Medical Command, Papago Military Reservation. Electronic medical records were reviewed at a designated computer terminal. No records were allowed to leave the facility. Only an inventory of records reviewed was maintained for data analysis. Records were initially inventoried with a high level of specificity that included a greater number of categories. After completion of the inventory, categories were appropriately collapsed for analysis. For example, lower back, upper back, and neck were consolidated into one category titled spine.

Adherence and Dropouts

Participant adherence to this investigation was high because there was no rigid or structured training program associated with this investigation. Soldiers were expected to exercise in accordance with the guidelines that their chain of

command provided. The investigation team understood that the soldiers were expected to work-out in an autonomous environment. It was understood that this autonomy is a large component of how and why the combat experience affects the physical fitness status of the soldiers.

Dropouts during the investigation did occur. Of the 60 soldiers who completed pre-deployment testing, 54 (M=47, F=7) completed post-deployment testing. Three of the soldiers did not complete the required time of deployment and three soldiers withdrew from testing during the post-deployment period. Of the three soldiers who did not complete the required length of deployment, one was sent home early due to a non-combat injury while the other two were sent home at the discretion of their unit commander.

Incentives

No incentives for participation were offered. Per the recommendation of the Arizona National Guard legal advisor, there was to be no potential for financial or career benefit from participating in this study. It was emphasized to the unit leaders that no favoritism be demonstrated to soldiers participating in this study. This was done in effort to prevent the introduction of any potential bias.

RESULTS

The results of this research are presented in three distinct manuscripts. The first offers a comparison of the AZNG soldiers' pre-deployment physical fitness levels to that of their active duty counterparts. The second analyzes the changes in physical fitness levels which occurred between the pre and post-deployment testing. The third presents the relationships between the measured

physical fitness levels and the utilization of medical resources for non-combat related injury and illness.

This study was designed to evaluate the physical fitness levels before and after a long term combat deployment for soldiers in the AZNG. Not only does this study add to a small pool of knowledge, but it has expanded on it by evaluating the effects based on gender, and differences between the active duty and National Guard components. This innovative research can provide military leaders with a better understanding of the effects of combat and will allow them to improve the training of soldiers prior to and during these extended deployments. Data collected from this study has the potential to influence military policy and training protocols. Essentially it will assist military leaders to better prepare soldiers against non-combat injuries and illness. Prevention of injuries and illness through improvement or maintenance of fitness levels will not only improve the strength of our nation's fighting force, but also benefits the health of the individual soldiers.

Finally, this study has provided insight on the feasibility of future studies involving National Guard soldiers. Due to the intermittent training schedules and limited control of the command elements, data collection proved to be difficult at times. This investigation team worked through many obstacles and was always prepared to finish the job by remaining adaptive and responsive to the lifestyle of these National Guard soldiers. This experience provided a better understanding of the feasibility for future studies utilizing National Guard soldiers. The

investigation recommends that future researchers remain flexible, adaptive, and understanding to the demands that these soldiers are attempting to meet.

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Chapter 2

AN ASSESSMENT OF PRE-DEPLOYMENT FITNESS IN THE ARIZONA NATIONAL GUARD

INTRODUCTION

More than a million service members have deployed to Iraq and Afghanistan since the events of September 11, 2001. Going to war or serving in combat is an extreme form of physical activity that requires an appropriate fitness level prior to deployment. However, it is not currently well understood what level of fitness is necessary nor is it well known what level of fitness deploying soldiers maintain. Currently, there are only a few studies that assess physical fitness levels of military service members prior to deployment (Lester et al., 2010; Sharp et al., 2008; Panichkul et al., 2007). While Panichkul et al. discusses the utilization of a modified Army Physical Fitness Test for the evaluation of pre-combat preparedness; their population only includes soldiers serving in the Royal Thai Army. This information is not necessarily translatable to the United States Armed Forces.

In recent years, there have been two research studies published examining deployments and physical fitness levels in the United States Army (Lester et al., 2010; Sharp et al., 2008). Both of these recent studies only utilized males from the active duty component. The purpose of the present study was to evaluate physical fitness levels (body composition, flexibility, muscular strength, muscular endurance, power, and cardiorespiratory fitness) in 60 male and female Arizona National Guard (AZNG) soldiers, 18-45 years old, from multiple units and

occupations. This was a novel investigation as this investigation team knows of no published studies that have evaluated physical fitness prior to a combat deployment in any National Guard soldiers. It was the intention of this study to assess predeployment physical fitness levels in AZNG soldiers in an effort to provide descriptive pre-deployment fitness data which develops a better understanding of the current health of military service members. The collection of this data also allowed for a comparison of AZNG soldiers pre-deployment fitness levels to the previously studied active duty soldiers. This information will better assist fitness professionals in developing a clear understanding of what is required of their clients who may also be serving in the National Guard or reserves.

In contrast to previous investigations that only evaluated male soldiers from an active duty combat arms unit (Lester et al., 2010; Sharp et al., 2008), the current study included male and female National Guardsmen preparing for deployment to a combat zone. All recruited subjects were anticipated to spend between 6-15 months in a combat zone. Volunteer soldiers represented a number of different units with separate missions and occupations ranging from personnel clerk to military police (see Table 1.) Many aspects of the soldier's lives prior to deployment maintain the potential to influence individual fitness levels before and during deployments. The soldier's job requirements may directly influence their physical fitness levels. Additionally, unit leadership, mission operations tempo, and cultural differences amongst occupational fields within the National Guard may have an influence on physical fitness outcome measures. Certain

occupations, such as an infantry soldier, may view fitness as a means of survival, where as other occupations, such as a supply clerk, may see physical fitness as simply another required task. It could be hypothesized that the typical infantry soldier may desire a higher level of fitness prior to deployment when compared to their administrative counterpart. Based on current circumstances, the investigation team felt it important to include as many occupations as possible to provide results which were truly reflective of the AZNG as a whole.

Table 2.1. Occupations of Participating Soldiers

<i>Occupation</i>	<i>No. of Subjects</i>
Motor Transport Operator	31
Explosive Ordnance Specialist	9
Light Wheel Vehicle Mechanic	6
Supply and Logistics	6
Military Police	5
Human Resource Specialist	2
Health Care Provider	1

Measuring pre-deployment fitness levels in National Guard soldiers can help identify differences between the active and reserve components and assist military leaders in preparing soldiers for the combat experience. Pre-deployment physical fitness may contribute to soldier's effectiveness during long-term deployments. National Guard soldiers' pre-deployment fitness is currently unknown, and thus it is unknown whether deployment status improves or diminishes this population's fitness. Different standards for day to day training between the AZNG and an active duty unit do exist and may lead to discrepancies in pre-deployment fitness. A National Guard soldier may only train with his unit one time per month versus the active duty soldier who typically trains four to five

times per week. It is certainly conceivable that substantial differences between these two components may exist. This study allows for the comparison of physical fitness in the AZNG to that of reported active duty soldiers and offers the opportunity to make some generalizations pertaining to their current levels of fitness.

METHODS

Experimental Approach to the Problem

This investigation was designed to assess and describe physical fitness of AZNG soldiers preparing to deploy to a combat zone. The subjects were soldiers in the pre-mobilization phase of their training in preparation for a deployment to a combat setting (Middle East). This pre-mobilization training period typically occurred in the final six to twelve weeks before their departure from the United States.

In the past there has been very little research utilizing any National Guard or reserve soldiers as subjects in military research. Thus this study also served to determine the feasibility of conducting research on reserve component soldiers while they were completing their pre-deployment training tasks. National Guard soldiers have an exceptionally demanding training schedule in the months prior to the deployment. It is a difficult and time consuming process to separate these men and women from their civilian professions and prepare them with the necessary skills required for a year-long combat deployment. As such, this investigation was designed to minimally impact the soldiers' lives and training schedule while collecting valid data.

Subjects

This study was approved by the Arizona National Guard State Surgeon as well as the Arizona State University Institutional Review Board. Prior to screening, all volunteers were medically cleared for deployment by the Arizona National Guard Medical Command and completed informed consent.

Additionally, all participants were screened using the Physical Activity Readiness Form and American College of Sports Medicine/American Heart Health/Fitness Facility Preparticipation Screening Questionnaire (American College of Sports Medicine, 2010) prior to testing and completed informed consent.

Initial interest in participating in this study was exceptionally high. However, because of the aforementioned demands on soldiers' time, several soldiers were not able to complete all components of testing. A total of sixty soldiers were successfully recruited, screened, and completed pre-deployment testing. In order to prevent the introduction of any potential bias no incentives for participation were offered to the volunteers. It was emphasized to the unit leaders that no favoritism be demonstrated to soldiers participating in this study and no potential for financial or career benefit be given to any soldier participating in this study.

Inclusion/Exclusion Criteria. To be considered for this study, soldiers had to be on orders to a combat zone. All races and both males and females were eligible for this study. Eligible soldiers were determined to be free of uncontrolled chronic disease or exceptional physical limitations. Soldiers were considered cleared for deployment by the AZNG after completing the medical

screening conducted during the Soldier Readiness Program. Male soldiers greater than 45 years old or, female soldiers greater than 55 years old or those having severe physical limitations that would prevent successful completion of testing, or uncontrolled chronic disease (i.e. hypertension, diabetes, sleep apnea, asthma) were not considered eligible for this investigation. Soldiers on orders for less than 6 months or greater than 15 months were not included.

Data Collection

Variables. Pre-deployment physical fitness testing was completed in one to three testing days in a standardized fashion that were appropriate for use in a population of soldiers. Logistics of scheduling of the testing was done in consideration of the other training tasks required of the soldiers. The tests were chosen based on their ease of completion, soldier familiarity, and transportability. Because some of the testing was completed at the location of the soldiers' military training, the investigation team had to select assessment tools that would provide valid data but were possible to be transported and set up in alternate locations.

Body Composition. Body composition (percent body fat and fat free mass) was measured using air displacement plethysmography (Bod Pod, Life Measurement, Inc.) It has been reported that the test-retest reliability of the Bod Pod is between .92 and .99 (McCroory et al., 1995; Collins et al.; Maddalozzo, Cardinal, & Snow, 2002). The Bod Pod can be considered highly correlated to hydrostatic weighing (.96) and dual energy x-ray absorptiometry (.89-.94) in terms of predicting percent body fat (Dixon et al., 2005; Ball & Altena, 2004; Maddalozzo, Cardinal, & Snow, 2002).

Calibrations of the Bod Pod and electronic scale were performed prior to each testing session. Between each soldier a standard two-point calibration was performed. This included the measurement of an empty chamber, followed by the measurement of the calibration cylinder.

Soldiers were asked to abstain from eating for the two hours prior to their arrival at the testing facility. Soldiers wore form-fitting, non-cotton, compression shorts with a non-cotton, lycra cap to compress the hair to the head as snugly as possible thereby minimizing excess surface area. Soldiers were also asked to remove all jewelry prior to testing. The soldiers were instructed to sit in the Bod Pod, maintain normal respirations, keep their hands in their laps, and refrain from moving. Body composition assessments were performed prior to other physical fitness tests in order to prevent an elevation in body temperature. Soldiers' body volumes were measured at least two times to ensure that measurements were within 150 ml. In the event that the volumes were inconsistent a third measurement was performed and the two closest volumes were averaged.

Muscular Strength. Strength was determined using the 1 repetition maximal (RM) bench press and back squat. Protocol for the 1RM testing followed the guidelines set forth by the National Strength and Conditioning Association (NSCA) and the American College of Sports Medicine (ACSM) (American College of Sports Medicine 2010, National Strength and Conditioning Association, 2008). The 1RM bench press was used to assess upper body strength, while the 1RM back squat was used to assess lower extremity strength. The 1RM testing was selected for use based on the ability to perform testing in a

variety of locations, ease of administration to trained or untrained individuals, and its previous use to identify maximal strength in soldiers (Nindl et al., 2002)

1RM bench press. The test-retest reliability of the 1RM bench press test has proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .93-.99 (Doan et al, 2002; Levinger et al., 2009; Hoeger et al., 1990). Soldiers performed this test after a block of instruction provided by one of the investigation team. They were asked to grasp the bar at approximately shoulder width and lift it off of the rack. Spotters were in place throughout the testing. Soldiers then performed each repetition by lowering the bar to within one inch of the chest and then raising the bar until the elbows reached full extension. Soldiers first performed 10 repetitions of approximately 40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

1RM back squat. The test-retest reliability of the 1RM back squat test has also proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .92-.97 (Blazevich, Gill, & Newton, 2002; Harris et al., 2000). Soldiers performed this test after a block of instruction provided by one of the investigation team. Spotters were in place behind the soldiers throughout the testing period. Soldiers positioned the bar across the shoulders before lifting it off of the rack. They were then asked to lower their bodies by

bending at the knees and hips while maintaining a straight back. A repetition was counted when the soldier was within approximately 10 degrees of getting the upper leg parallel to the floor. Soldiers first performed 10 repetitions of approximately 40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

Muscular Endurance. Muscular endurance was assessed by completion of a push-up and sit-up test in accordance with the United States Army Physical Fitness Test protocol. This testing method was selected because it is similar to that described by the ACSM but is more familiar to the soldiers because of its inclusion in the Army Physical Fitness Test (American College of Sports Medicine, 2010, Department of the Army, 1992). Push-ups and sit-ups have been used to assess muscular endurance in previous research which evaluated occupational fitness to include firefighters and military service members (Knapik et al., 1990; Misner, Boileau, & Plowman, 1989). Test-retest reliability for a timed push-up test has been reported to be .93, while the sit-up has been reported to be .88-.94 (Knudson, 1995; Invergo, Ball, & Looney, 1991).

Push-up. Soldiers were instructed to take the ready position which required them to be positioned with their hands on the floor approximately shoulder width apart. Male and female soldiers were required to perform the

event with their toes in contact with the floor, head and eyes directed forward, hips in extension, spine parallel to the floor, and elbows in extension. Neither males nor females were allowed to perform the push-up with their knees in contact with the floor. Soldiers were instructed to do as many push-ups as possible in the two minute period without putting their knees in contact with the floor or removing their hands from the floor. A push-up was counted if the elbows were brought to flexion of 90 degrees or greater and then returned to full extension, while keeping the body elevated on the toes. The test was discontinued if the soldier dropped to the knees or reached volitional fatigue (Department of the Army, 1992).

Sit-up. Soldiers were asked to assume the start position which required the soles of the feet and shoulder blades to be in contact with the floor, while the knees were flexed to approximately 90 degrees. The hands were to be behind the head, but not required to have the fingers interlocked. After the command was given to begin and the timer started, a sit-up repetition was counted if the soldier kept their hands behind their head, bringing the base of their spine to at least a vertical position and then returning the shoulder blades to the floor. The test was discontinued at the end of two minutes or if the soldier reached volitional fatigue prior to the end of the two minutes (Department of the Army, 1992).

Power. Lower extremity power was assessed using a Wingate anaerobic cycle test (Nieman, 2008). The Wingate is considered a reliable and reproducible assessment of power maintaining a correlation coefficient of .89-.98 (Bar-Or, 1987). The Wingate test has been used in multiple military studies to evaluate

power due to its simplicity of use and ability for untrained individuals to successfully complete the test with brief familiarization (Knapik et al., 1995; Knapik et al., 1990; Murphy et al., 1987). The Wingate has been used for the assessment of power in men and women alike from numerous occupations other than military service, such as firefighting (Misner, Boileau, & Plowman, 1989).

The 30 second Wingate was completed on an Ergomedic Peak Bike 894E, Monark. Soldiers were given detailed instructions and familiarized with the cycle prior to completion. Prior to starting the test the seat height and handle bars were adjusted appropriately. After a warm-up period soldiers were instructed to pedal at their maximal speed without resistance. Once the maximal speed was achieved the soldier pressed the button located on the handlebars, which then increased the resistance on the wheel to .075 kilograms per kilogram of body weight. The soldiers continued an all out bout of pedaling for 30 seconds followed by a resistance free cool down period prior to dismounting the bike (Nieman, 2008).

Flexibility. Flexibility was assessed using three different tests; sit and reach, shoulder elevation, and trunk extension. Lower extremity flexibility was determined using the sit and reach test (SNR). The SNR test is simple to administer and has demonstrated exceptional test-retest reliability ($r=.98-.99$) in multiple investigations (Gabbe et al., 2004; Simoneau, 1998). The SNR has also been found to be valid measure of hamstring flexibility (Baltaci et al., 2003; Simoneau, 1998; Liemohn, Sharpe, & Wasserman, 1994).

Shoulder flexibility was determined by the shoulder elevation test. Trunk flexibility was determined by the trunk extension test. These expedient field tests

were selected based on their ease of administration and their potential ability to provide a snapshot of soldiers' upper extremity and trunk flexibility. Although not many published studies have utilized the trunk flexibility and shoulder elevation tests, normative values have been established (Acevedo & Starks, 2003; Johnson & Nelson, 1986).

Sit and Reach. Soldiers were asked to remove their shoes and sit on the floor. They were asked to place the soles of their feet against the SNR box with the back of the leg and knee flat against the floor. They were then asked to place one hand on top of the other and slowly reach forward with extended arms pushing the slide as far forward as possible. Subjects were given two attempts and the highest score was recorded (American College of Sports Medicine, 2010; Acevedo & Starks, 2003).

Trunk Extension. Trunk flexibility was determined by using the trunk extension test. This test is intended to assess the flexibility of the core muscles of the abdominal region. First the trunk was measured by having the soldier sit with their back flat against the wall and legs extended. A yard stick was placed between the legs of the soldier. The trunk length was determined by the distance between the floor and the suprasternal notch. Following the trunk measurement, the soldier laid in the prone position with his or her hands behind the back. The soldier was asked to rise up their head and neck as high as possible while extending the spine, but keeping the feet in contact with the floor. At the peak of trunk elevation, the tester measured the distance from the floor to the suprasternal notch. The soldier was given two attempts and the highest value was recorded.

The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1986):

$$\text{trunk extension score} = \text{back extension (in.)} \times 100 / \text{trunk length (in.)}$$

Shoulder Elevation. The shoulder elevation test was used to assess the flexibility of the chest and shoulder muscles. First the length of the arm was determined by having the soldier hold a yard stick in closed fists of both hands with arms fully extended. A measurement was taken from the acromion process to the proximal edge of the stick. The soldier was then asked to lie in the prone position with the stick still grasped in the hands and the elbows extended. The fists were initially in contact with the floor until the soldier was given the command to elevate the hands as high as possible. At this point a measurement was taken from the floor to the level of the yard stick. This was followed by a measurement of the soldier's ability to elevate the arms, while the chin remained in contact with the ground. The elbows were to be kept in extension while the tester measured from the floor to the bottom of the stick. The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1986):

$$\text{shoulder elevation score} = \text{shoulder elevation (in.)} \times 100 / \text{arm length (in.)}$$

Cardiorespiratory Fitness. Soldiers' cardiorespiratory fitness (VO₂ peak) was estimated with indirect calorimetry while completing a treadmill test. Indirect calorimetry was completed using a metabolic cart (AEI Technologies, Pittsburgh, PA). A modified version of the Bransford and Howley protocol was selected in order to allow the soldiers to run at a self-selected pace (Morgan et al.,

1991; Bransford & Howley, 1977). Incremental treadmill tests have been used successfully to assess cardiorespiratory fitness in multiple military studies (Sharpe et al., 2008; Nindl et al., 2002; Knapik et al., 1990)

Soldiers were first fitted with a Polar heart rate monitor, Hans Rudolph head gear and two-way non-rebreather valve. They were then given individual instruction to select a running pace that they would normally complete the 2 mile run for the Army Physical Fitness Test (Department of the Army, 1992). After a brief warm-up, the initial two-minute period was completed at 0% grade. The grade was incrementally increased by one percent every minute following this initial two minute period until the soldier reached volitional fatigue. Criteria for adequate testing included the following: RER > 1.00 or heart rate + or - 10 beats per minute of age predicted maximum heart rate (Sharp et al., 2008).

Analysis – Analysis of data were performed with PASW 18.0. Descriptive statistics were compiled and then used for comparison with previously reported physical fitness values of active duty soldiers.

RESULTS

Data were collected on sixty subjects who ultimately deployed to the Middle East. Of the sixty soldiers who completed testing all completed anthropometrics, body composition, and flexibility measures. One soldier was unable to complete push-ups and one did not complete sit-ups. One soldier did not complete the bench press and four did not complete the back squat. Five were unable to complete Wingate testing. One did not complete VO₂ peak testing.

Failure to complete testing was either due to an existing injury that prohibited the soldier from that specific test or conflicts with other training requirements.

The overall mean age was 26.7 ± 6.9 yr while the mean age of the males and females was 26.6 ± 6.9 yr and 26.9 ± 7.2 . Overall mean height was 174.2 ± 7.3 cm. Mean height for males was 175.7 ± 6.2 cm and 163.1 ± 5.2 for females. Overall mean weight was 83.4 ± 16.9 kg. Mean weight for males was 85.7 ± 16.2 and 66.4 ± 11.9 kg for females. Mean fat mass (FM) for the group was 22.7 ± 8.9 percent (%). The females had a measured FM of 26.5 ± 4.4 % while males were measured at 22.2 ± 9.2 %. The physical fitness testing results are reported in Table 2.

Table 2.2. Pre-deployment Descriptive Statistics

	<i>Combined</i> (n=60)	<i>Male</i> (n=53)	<i>Female</i> (n=7)
General Measures			
<i>Age (years)</i>	26.7 (6.9)	26.6 (6.9)	26.9 (7.2)
<i>Height (cm)</i>	174.2 (7.3)	175.7 (6.2)	163.1 (5.2)
<i>Weight (kg)</i>	83.4 (16.9)	85.7 (16.2)	66.4 (11.9)
<i>BMI (kg/m²)</i>	27.4 (7.8)	27.7 (4.9)	24.9 (3.3)
<i>Fat Mass (%)</i>	22.7 (8.9)	22.2 (9.2)	26.5 (4.4)
Absolute Strength			
<i>1RM Bench (kg)</i>	82.2 (29.9)	88.0 (27.0)	39.3 (6.0)
<i>1RM Squat (kg)</i>	104.6 (29.0)	111.6 (23.6)	56.2 (11.0)
Relative Strength			
<i>1RM Bench (kg/kg body wt)</i>	.98 (.26)	1.03 (.23)	0.60 (.07)
<i>1RM Squat (kg/kg body wt)</i>	1.27 (.28)	1.33 (.25)	0.85 (.17)
Muscular Endurance			
<i>Push-ups (reps)</i>	50 (18)	52 (17)	31 (13)
<i>Sit-ups (reps)</i>	53 (14)	54 (15)	51 (14)
Power			
<i>Peak Power (watts)</i>	660.9 (177.8)	690.9 (156.4)	361.2 (61.8)
Flexibility			
<i>Sit-and-reach (cm)</i>	30.0 (8.9)	28.4 (8.1)	41.7 (4.8)
<i>Trunk Extension (cm)</i>	117.1 (25.2)	117.1 (24.6)	117.6 (31.5)
<i>Shoulder Elevation (cm)</i>	145.5 (50.3)	138.4 (43.4)	200.4 (66.6)
Cardiorespiratory			
<i>VO₂ Peak (ml/kg/min)</i>	48.9 (8.8)	49.7 (8.7)	42.2 (7.6)

Values are means and standard deviation (SD)

DISCUSSION

This investigation assesses components of physical fitness that were not previously evaluated in the recent literature. This includes evaluation of flexibility using the sit and reach, but also the shoulder elevation and trunk extension measures. There are no current Army standards for these types of assessments, however standard values have previously been published for the general population. When looking at the mean score for sit and reach in men and

women based on mean age, the men would be considered “Fair” while the women achieved an evaluation of “Excellent” according to the most current standards published by the American College of Sports Medicine (American College of Sports Medicine, 2010). For trunk extension testing the men and women in this study both achieved a rating of “Above average.” However, for shoulder elevation the male soldiers were categorized as “Below average,” while the female soldiers were considered “Average” (Acevedo & Starks, 2003).

Although soldiers commonly complete the Army Physical Fitness Test (APFT) prior to deployments, neither of the Sharp et al. or Lester et al. investigations published results of the muscular endurance assessments using the APFT. According to the field manual used for the administration of the APFT, males and females that are 22-26 years old, a minimum of 50 sit-ups is required to meet the minimum standard. For men in the same age group a minimum of 40 push-ups is required while women are only required to complete 17 repetitions. Using the Army’s one hundred point scale for the push-up event, the males achieved a score of 74/100 points and the females achieved a score of 79/100 points. Using a similar scale for the sit-up event, the males achieved a score of 65/100 points and the females achieved a score of 61/100 points. The mean of men and women in this study showed that they meet current Army standards, based on the mean age and respective gender (Department of the Army, 1992).

Sharp et al. utilized a vertical jump to assess lower extremity power and a ball put for upper extremity power. Lester et al. assessed lower extremity power with squat jump and upper extremity power using a bench throw. This

investigation team felt it important to assess lower extremity power because of the importance while performing combat duties. Soldiers are frequently expected to perform short bouts of running at maximal speeds while under load in an effort to escape harm. It was agreed upon by this investigation team that the best evaluation of power to assess a soldier's performance under the previously described scenario could be done with the Wingate cycle test. Ideally, future researchers will select a similar technique in order to compare data between populations using similar tests.

Components of testing from this investigation that are similar to testing techniques from the Sharp et al. and Lester et al. investigations included body composition, muscular strength, and cardiorespiratory fitness. Based on a comparison of the reported data the AZNG soldiers have demonstrated that they are as physically prepared for the combat experience as their active duty counterparts. See Table 3 for a comparison of these results.

Table 3. AZNG Soldiers Compared to Previous Investigations

	<i>Overall</i> (n=60)	<i>Male</i> (n=53)	<i>Female</i> (n=7)	<i>Sharp et al.</i> (n=110)	<i>Lester et al.</i> (n=73)
General Measures					
<i>Age (years)</i>	26.7 (6.9)	26.6 (6.9)	26.9 (7.2)	23.1 (4.7)	24 (5)
<i>Height (cm)</i>	174.2 (7.3)	175.7 (6.2)	163.1 (5.2)	177.5 (6.7)	174 (7)
<i>Weight (kg)</i>	83.4 (16.9)	85.7 (16.2)	66.4 (11.9)	83.3 (14.7)	76.6 (10.2)
<i>Body Fat (%)</i>	22.7 (8.9)	22.2 (9.2)	26.5 (4.4)	17.7 (6.4)	18.9 (5.5)
Strength					
<i>1RM Bench (kg)</i>	82.2 (29.9)	88.0 (27.0)	39.3 (6.0)	*	79.1 (17.4)
<i>1RM Squat (kg)</i>	104.6 (29.0)	111.6 (23.6)	56.2 (11.0)	*	99.7 (20.9)
Cardiorespiratory					
<i>VO₂ Peak (ml/kg/min)</i>	48.9 (8.8)	49.7 (8.7)	42.2 (7.6)	50.8 (6.1)	48.6 (5.1)

Values are means and standard deviation (*SD*)

*no comparable data were collected

Body Composition - The AZNG males did demonstrate a higher body fat percentage (22.2%) than what was reported by Sharp et al. (17.7%) and Lester et al. (18.9%). The higher body fat percentage in this population may be partially explained as a function of age. The mean age of the males in this study was 27 years old while Sharp et al. and Lester et al. reported respective mean ages of 23 and 24 years old. The females in this study were of the same age but demonstrated a mean body fat percentage of 26.5% for which there is no comparable data.

Research suggesting that the Bod Pod systemically predicts body fat percentage lower than hydrostatic weighing but higher than dual energy x-ray absorptiometry (DEXA) is controversial (Ball & Altona, 2004; Collins et al., 1999). The difference in measuring technique could result in a difference of approximately 2%. The difference in techniques used to measure body composition could certainly account for the differing results between the three studies. While the Bod Pod was utilized for this study, Sharp et al. 2008 and Lester et al. 2010 both used the DEXA to estimate body composition.

Muscular Strength - The combined mean scores of the men for absolute strength were actually higher than those reported by Lester et al. for the 1RM bench and squat (82.2 kg and 104.6 kg). Not only was the mean scores of males alone higher, but the combined mean scores of males and females also were higher.

This discrepancy in reported strengths amongst the males may be partially explained by an overall increased size in this population of males in the AZNG.

The males in this research had a mean weight of 85.7 kg with respective absolute upper and lower body strength of 88.0 and 111.6 kg. Lester et al. reported a mean weight of 76.6 kg and respective absolute upper and lower body strength of 79.1 and 99.7 kg. When these values are evaluated from a relative perspective (kilograms lifted/kilograms of body weight), the values are nearly identical at 1RM bench (1.03 v 1.03 kg/kg body wt) and 1RM squat (1.33 v 1.30 kg/kg body wt).

Cardiorespiratory Fitness - The combined average of men and women for VO₂ peak (48.9 ml/kg/min) was similar to that reported by Sharp et al. (50.8 ml/kg/min) and Lester et al. (48.6 ml/kg/min) for active duty males. Thus the subjects in this study have demonstrated that they have cardiorespiratory fitness similar to that of the active duty counterparts.

PRACTICAL APPLICATIONS

This study expands the small pool of knowledge pertaining to physical fitness of male and female National Guard soldiers from a variety of occupations. These data will help differentiate fitness levels between the active duty and reserve components. This investigation also includes the evaluation of flexibility, which was previously excluded from the research. These results not only provide military leaders with a better understanding of baseline physical readiness and the effectiveness of current pre-combat training of National Guard soldiers, but also provide fitness professionals and strength coaches an understanding of the needs of their military clients. Objective assessments of pre-deployment fitness levels

will help military leaders in the field manipulate training before deployments to facilitate desired goals for the individual and the unit.

Utilization of this data is also in keeping with the National Strength and Conditioning Association's Tactical Strength and Condition program goals. This data can be used by fitness professionals as they become intimately involved in the pre-deployment training of men and women who serve in a reserve or National Guard capacity. It is the same men and women who frequent the gym or seek personal training that are being asked to deploy to foreign lands. This is just one of many reasons that the NSCA has developed the Tactical Strength and Conditioning program. The program in conjunction with the data presented here can help guide fitness professionals in the training of civilians who will be deploying as soldiers.

Additional research is needed to understand the influence that pre-deployment fitness levels has on performance while serving in combat. According to the Medical Surveillance Monthly Report (May 2010), approximately 25% of the 133,000 soldiers returning from deployment, reported that their health is worse now than before deployment. These high number of subjective assessments indicating poor health may be a result of changed or reduced fitness that occurs during deployment. Again, future research is needed to explore this possible relationship.

Finally, this study indicates that it is feasible to utilize National Guard soldiers in military research. While the demanding training schedules required during the pre-deployment training creates a challenge to data collection, these

difficulties can be overcome by a flexible investigation team who are willing to adapt and respond to the lifestyle of these National Guard soldiers. Clearly an investigation team who cares to test and research National Guard soldiers need to be flexible and willing to accommodate the demands of these soldiers.

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Chapter 3

DIFFERENTIAL EFFECTS ON PHYSICAL FITNESS IN ARIZONA NATIONAL GUARD MEN AND WOMEN FOLLOWING A COMBAT DEPLOYMENT

INTRODUCTION

Physical fitness for soldiers is not only a necessity, but also a required activity that is assessed regularly (Department of the Army, 1992). While training in a stateside environment military units have time dedicated for maintaining or improving physical fitness. This is typically done in groups and is directed by a unit leader. Soldiers are expected to complete the Army Physical Fitness Test (APFT) every six months in order to continually assess their current level of fitness.

However, while serving in combat, soldiers frequently have more autonomy to perform physical fitness training but are still expected to maintain the standards dictated by regulations. This is not only done to assess a soldier for career progression but also as a means of survival while conducting their job in an extreme environment. Deployed soldiers are expected to continue physical fitness training independently around the duties of their occupation. This can frequently be influenced by the tempo of operations or availability of a fitness facility and equipment. In rare occasions, small groups may train under the direction of their immediate supervisor. Regardless of the situation and environment, soldiers are expected to maintain their fitness at the highest level possible. Upon return from deployment soldiers, are typically given a grace period before completing the

APFT to allow correction of any fitness deficiencies that may have occurred during the course of the deployment. This period of time provides soldiers an ample opportunity to ensure that they meet the physical fitness standards described in the regulations, but it does not permit an accurate assessment of how combat deployments affect a soldier's physical fitness (Department of the Army, 1992).

Currently there are a limited number of publications that have evaluated the effects of long-term combat deployments on soldier physical fitness. Much of the previous research was conducted in training environments over a short time frame (Nindl et al., 2007; Patton et al., 1989; Murphy et al., 1984). Even in these settings, decreases in fitness and job performance in high intensity training environments were detected (Nindl et al., 2007; Murphy et al., 1984). Fortunately, in recent years there have been two publications that specifically address changes in physical fitness for soldiers deployed to a combat environment. Both investigations demonstrated declines in cardiorespiratory function and increases in fat mass (Lester et al., 2010; Sharp et al., 2008). Published results for changes in strength and power are conflicting. Sharp et al. demonstrated decreased upper extremity power with no change in strength, while Lester et al. reported that upper and lower body strength as well as power increased significantly.

Both articles included only male subjects from the active duty component of the Army (Lester et al., 2010; Sharp et al., 2008). Neither of the previous studies included members of the reserve components of the military (National

Guard and Reserves). Additionally, these studies only evaluated men from combat arms occupations. Examples of combat arms occupations include infantry, field artillery, air defense artillery, aviation, special forces, corps of engineers, and armor. Combat arms units are considered the front-line warfighting occupations. Combat support and sustainment units are designed to support the combat arms units and occupations in their mission. There are a number of occupations within the combat support and sustainment branches that are serving in the same combat environments in a different capacity that have not been represented in previous research (Lester et al., 2010; Sharp et al., 2008). Examples of these combat support and sustainment branches include military police, military intelligence, transportation and ordinance to name a few.

It was the intent of this study to assess the effects of combat deployments on physical fitness of soldiers in the Arizona National Guard (AZNG) in an effort to determine if the reserve component of soldiers would experience similar changes to those seen in the active duty units. Additionally, this research included both men and women who performed a variety of military occupations not limited to combat arms. By including multiple occupations a more heterogeneous group of subjects were recruited. This provided a sample that is more representative of the AZNG, instead of a single occupational field.

METHODS

Overview

This investigation evaluated the effects of combat deployments on physical fitness measures in soldiers. The “treatment group” consists of soldiers

who deployed to a combat setting (Middle East). The primary aim of the study was to determine the effects of a long term (approximately 1 year) combat deployment on physical fitness levels (body composition, strength, endurance, power, flexibility, and aerobic capacity) in soldiers. The study was approved by the institutional review board at Arizona State University as well as by the Arizona National Guard State Surgeon’s Office.

Study Participants

The research team successfully recruited, consented, screened, and completed pre-deployment testing on 60 soldiers. The majority (97%) of the study participants were recruited from different units, including the 363rd Explosive Ordnance Detachment (EOD), 1404th Transportation Company (TC), and 855th Military Police (MP). Multiple occupations were represented within each unit (see Table 1.). All participants were screened using the American College of Sports Medicine/American Heart Health/Fitness Facility Preparticipation Screening Questionnaire prior to the initial testing (American College of Sports Medicine, 2010).

Table 3.1. Participating Units by Occupation

<i>Unit</i>	<i>Occupation</i>	<i>No.</i>
1404 th Transportation Company	Motor Transport Operator	27
	Light Wheel Vehicle Mechanic	6
	Supply and Logistics	4
363 rd Explosive Ordnance Detachment	Explosive Ordnance Specialist	9
	Supply and Logistics	2
855 th Military Police Company	Military Police	4
Miscellaneous	Human Resource Specialist	1
	Health Care Provider	1

In order to be included in this research, participants agreed to complete physical fitness assessments during the unit pre-mobilization phase and immediately upon their return to the United States. Eligible soldiers were considered to be free of uncontrolled chronic disease (i.e. hypertension, asthma, diabetes) or any exceptional physical limitations that would prevent the completion of the physical fitness testing. All races and gender were eligible for this study. Prior to being screened by investigators, soldiers were cleared for deployment by the AZNG upon completing the medical screening conducted during the Soldier Readiness Program.

Male soldiers greater than 40 years old and female soldiers greater than 45, having severe physical limitations that would prevent successful completion of testing, or uncontrolled chronic disease (i.e. HTN, diabetes, sleep apnea, asthma) were not considered eligible for this investigation. The research team did not feel that valid assessments of the effects of combat on physical fitness in those who have significant physical limitations could be completed. Soldiers on orders for less than 10 months or greater than 15 months were not included.

Primary outcomes for this study were the measurements of individual body composition, flexibility, muscular strength, muscular endurance, anaerobic power, and aerobic fitness. The independent variable being assessed during this investigation was a long term (10-15 months) combat deployment. Combat itself can affect soldiers in many different ways ranging from physical to emotional side effects. In most instances, deployed soldiers have significant autonomy while deployed with their physical fitness training. This autonomy is largely due to the

unit's operations tempo and the individual soldier's duty requirements. Soldiers enrolled in the study were encouraged to conduct themselves while deployed in accordance with their respective unit requirements. The intention of this study was to assess the effects of combat on a soldier's physical performance without an additional intervention. During the ongoing conflicts soldiers maintain a significant amount of autonomy when it comes to their physical fitness training. This study was intended to determine if this autonomy may be influencing their physical fitness.

No incentives for participation were offered. There were no financial or career benefits from participating in this study. It was emphasized to the unit leaders that no favoritism be demonstrated to soldiers participating in this study. This was in an effort to reduce the introduction of potential bias.

Pre-deployment and post-deployment data collection was conducted in a standardized methodology as described below. The investigation team selected assessment methods that were considered to be the most appropriate for use in a population of soldiers and were deemed valid and reliable in this sample. Additionally, feasibility for completion of all testing in a fashion that would not interfere with soldier training tasks had to be considered.

Body composition. Body composition (percent body fat and fat free mass) was measured using air displacement plethysmography (Bod Pod, Life Measurement, Inc.) This has been shown to be a valid and reliable measure (McCrorry et al., 1995). Subjects wore form-fitting, non-cotton, lycra compression shorts with a non-cotton, lycra cap to compress the hair to the head

as snugly as possible thereby minimizing excess surface area. Body composition assessments were performed prior to other physical fitness tests in order to prevent an elevation in body temperature.

Muscular strength. Strength was determined using the 1 repetition maximal (RM) bench press and back squat. Protocol for the 1RM testing followed the guidelines set forth by the National Strength and Conditioning Association (NSCA) and the American College of Sports Medicine (ACSM). Soldiers progressively increased the load while decreasing repetitions before they were given up to three attempts to achieve a maximal lift (American College of Sports Medicine, 2010; National Strength and Conditioning Association, 2008).

Muscular Endurance. Muscular endurance was assessed by completion of a push-up and sit-up test in accordance with the United States Army Physical Fitness Test protocol. This testing method was selected because it is similar to that described by the ACSM but is more familiar to the soldiers because of its inclusion in the Army Physical Fitness Test (American College of Sports Medicine, 2010; Department of the Army, 1992). A push-up was counted if the elbows were brought to flexion of 90 degrees or greater and then returned to full extension, while keeping the body elevated on the toes. For the sit-up test soldiers were required to keep their hands behind their head, bring the base of their spine to a vertical position and then return the shoulder blades to the floor. For each of the events, the soldier was given two minutes to complete as many repetitions as possible (Department of the Army, 1992).

Power. Lower extremity power was assessed using the Wingate anaerobic cycle test (Nieman, 2007). The 30 second Wingate was completed on an Ergonomic Peak Bike 894E, Monark. Soldiers were given detailed instructions and familiarized with the cycle prior to completion. The soldiers completed an all out bout of pedaling for 30 seconds with a resistance of .075 kilograms per kilogram of body weight (Nieman, 2007).

Flexibility. Flexibility was assessed using three different tests. Lower extremity flexibility was determined using the sit-and-reach test. Soldiers were given two attempts to reach forward with both hands with the knees in extension while in a seated position (American College of Sports Medicine, 2010). Trunk flexibility was determined by using the trunk extension test. This test required a measurement of the length of the trunk followed by measurement of the soldier's ability to raise their upper trunk and head while lying in a prone position (Acevedo, 2003). Shoulder flexibility was determined using the shoulder elevation test. First the length of the arm was determined, followed by a measurement of the soldier's ability to elevate the arms over their head while lying in the prone position, with chin in contact with the ground, and elbows locked in extension (Acevedo, 2003).

Cardiorespiratory fitness. Subject's cardiorespiratory fitness (VO_2 peak) was estimated using indirect calorimetry while completing a graded exercise treadmill test. A modified Bransford and Howley protocol was selected in order to allow the soldiers to run at a self-selected pace. Soldiers were instructed to select the pace that they would normally complete the 2 mile run for

the Army Physical Fitness Test (Department of the Army, 1992; Bransford & Howley, 1977). Grade was incrementally increased by one percent every minute following the initial two minute period until the soldier reached volitional fatigue. Criteria for adequate testing included the following: RER > 1.00 or heart rate + or - 10 beats per minute of age predicted maximum heart rate (Sharp et al., 2008). Indirect calorimetry was completed using a metabolic cart (AEI Technologies, Pittsburgh,PA).

Data were evaluated for normal distributions and then analyzed for statistically significant difference between pre and post-deployment measures using paired t-tests or Wilcoxon Sign Rank.

RESULTS

Of the 60 soldiers who completed pre-deployment testing (PRE), 54 (M=47, F=7) completed post-deployment testing (POST). Three of the soldiers did not complete the required time of deployment and three soldiers withdrew from testing during the post-deployment period. Of the three soldiers who did not complete the required length of deployment, one was sent home due to a non-combat injury while the other two were sent home at the discretion of their unit commander. The overall mean age was 26.7 ± 6.9 yr while the mean age of the males and females was 26.6 ± 6.9 yr and 26.9 ± 7.2 . Overall mean height was 174.2 ± 7.3 cm. Mean height for males was 175.7 ± 6.2 cm and 163.1 ± 5.2 for females.

Significant improvements were detected for the overall group between PRE and POST measures in fat mass (22.5 ± 8.6 v 20.0 ± 2.5 percent fat mass,

p<.001), relative strength for bench and squat (.98±.27 v 1.08±.29 kg/kg bodyweight, p<.001 and 1.27±.28 v 1.45±.36 kg/kg bodyweight, p<.001), push-ups and sit-ups (51±17 v 60±19 reps, p<.001 and 54±14 v 60±13 reps, p=.001). These changes reflect improvement in fat mass (11%), in relative strength for the bench press (10%) and back squat (14%), and muscular endurance improvements as demonstrated by the push-ups (18%) and sit-ups (11%).

However, significant declines were noted in VO₂ peak (48.2±8.0 v 43.0±8.0 ml/kg/min, p<.001), and trunk extension (117.9±26.2 cm v 110.0±23.4, p=.002). The change in VO₂ peak represents a decline of 11% in aerobic capacity, while decline in trunk extension is a decline of 7%. See figure 3.1 for percentage change for each variable presented in order of greatest decline to greatest improvement. No significant differences were detected in peak power, sit and reach, or shoulder elevation. See table 2 for a summary of all results.

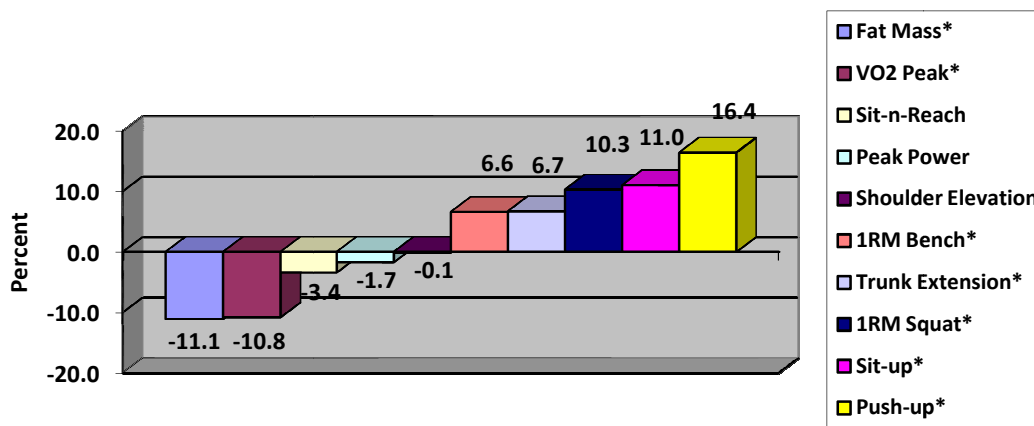


Figure 3.1. Change in fitness variables expressed as percent, *designates significance (p<.05)

Table 3.2. Overall summary of pre and post deployment measures

	<i>N</i>	<i>Pre- deployment</i>	<i>Post- deployment</i>	<i>Diff</i>	<i>Sig</i>
General Measures					
<i>Weight (kg)</i>	54	82.9 (15.8)	81.3 (1.9)	- 1.6	.004
<i>BMI (kg/m²)</i>	54	27.2 (4.5)	26.7 (3.8)	- 0.5	.004
<i>Fat Mass (%)</i>	52	22.5 (8.6)	20.0 (2.5)	- 2.5	<.001
Relative Strength					
<i>1RM Bench (kg/kg bodyweight)</i>	54	.98 (.27)	1.08 (.29)	+ .1	<.001
<i>1RM Squat (kg/kg bodyweight)</i>	49	1.27 (.28)	1.45 (.36)	+ .18	<.001
Muscular Endurance					
<i>Push-ups (reps)</i>	52	51.2 (17.5)	59.6 (18.9)	+ 8.4	<.001
<i>Sit-ups (reps)</i>	52	54.5 (14.5)	60.5 (13.0)	+ 6.0	.001
Power					
<i>Peak Power (watts)</i>	48	674.0 (180.3)	662.6 (211.0)	- 11.4	.56
Flexibility					
<i>Sit-and-reach (cm)</i>	53	30.0 (9.1)	29.0 (8.9)	- 0.4	.24
<i>Trunk Extension(cm)</i>	53	117.9 (26.2)	110.0 (23.4)	- 7.9	.002
<i>Shoulder Elevation(cm)</i>	53	144.3 (50.0)	144.1 (38.9)	- 0.1	.95
Cardiorespiratory					
<i>VO₂ Peak (ml/kg/min)</i>	49	48.2 (8.0)	43.0 (8.0)	- 5.2	.00

Values are means and standard deviation (*SD*)

Gender specific changes were also evaluated. This analysis demonstrated significant changes for men in all areas except for power and two measures of flexibility (sit and reach, shoulder elevation). Although a small population (n=7), the women showed significant change in weight, body mass index, push-ups, and sit-ups. Women demonstrated a trend towards significance in relative strength on the bench press (p=.066). The results for pre and post deployment measures by gender are summarized in Table 3.

Table 3.3. By gender changes in pre and post deployment fitness

	Male Pre	Male Post (n=47)	Female Pre	Female Post (n=7)
General Measures				
Weight (kg)	85.3(14.9)	83.8(12.6)*	66.4(11.9) ⁺	64.3(11.3)*
BMI (kg/m ²)	27.6(4.6)	27.1(3.9)*	24.9(3.3) ⁺	24.1(3.2)*
Fat Mass (%)	21.9(8.9)	19.7(7.7)*	26.5(4.4)	21.9(3.2)
Relative Strength				
1RM Bench (kg/kg body wt)	1.04(.24)	1.13(.26)*	0.60(.07)	0.69(.11)
1RM Squat (kg/kg body wt)	1.34(.23)	1.51(.34)*	0.85(.17)	1.05(.18)
Muscular Endurance				
Push-ups (reps)	53.8(16.2)	61.7(18.0)*	30.7(13.2)	43.2(18.9)*
Sit-ups (reps)	54.9(14.6)	60.7(13.0)*	51.2(14.4)	58.7(13.9)*
Power				
Peak Power (watts)	710.4(151.8) ⁺	698.1(189.2)	361.2(61.8)	357.2(130.4)
Flexibility				
Sit-and-reach (cm)	28.2(8.4)	27.2(7.6)	41.7(4.8)	41.1(5.3)
Trunk Extension (cm)	117.9(25.7)	108.7(23.4)*	117.6(31.5)	117.1(24.4)
Shoulder Elevation (cm)	135.6(41.7)	138.9(34.8)	200.4(66.6)	177.0(50.0)
Cardiorespiratory				
VO ₂ Peak (ml/kg/min)	49.1 (7.7)	43.6(8.0)*	42.2 (7.6) ⁺	39.2(7.5)

Values are means and standard deviation (SD)

*Changes between pre and post-deployment values were significant ($p < .05$)

⁺Non-parametric analysis performed for data that were not normally distributed

DISCUSSION

This is a novel study because it provides previously unknown descriptive data on physical fitness changes following combat experience in the reserve component of the armed forces. Considering that AZNG reserves have very different lifestyles as compared to an active duty service member, one might expect to see differences in pre-deployment physical fitness and /or differences in the changes that may occur following deployments between reserves as compared to active duty service members. While active duty service members typically meet four to five times per week for organized group physical fitness training, the

reserve soldiers may only meet for one weekend per month. However, prior to deployment a reserve unit may train on a daily basis for the three months prior to deployment known as the pre-mobilization period. The results from this study indicate physical fitness was changed following combat deployments in AZNG soldiers. However, these changes were comparable to those reported for active duty soldiers.

Overall, the pre-deployment fitness levels of these AZNG soldiers were very similar to the reported comparable fitness levels of the active duty Army soldiers measured by Sharp et al. and Lester et al. The AZNG demonstrated significant increase in upper and lower body strength (7% and 10%) similar to what was reported by Lester et al (7% and 8%). Additionally, the AZNG had declines in aerobic capacity similar to what was reported by the other two investigation teams. All three investigations found declines in VO₂ peak of varying degrees, ranging from -4.5% to -13% (See Figure 3.2.).

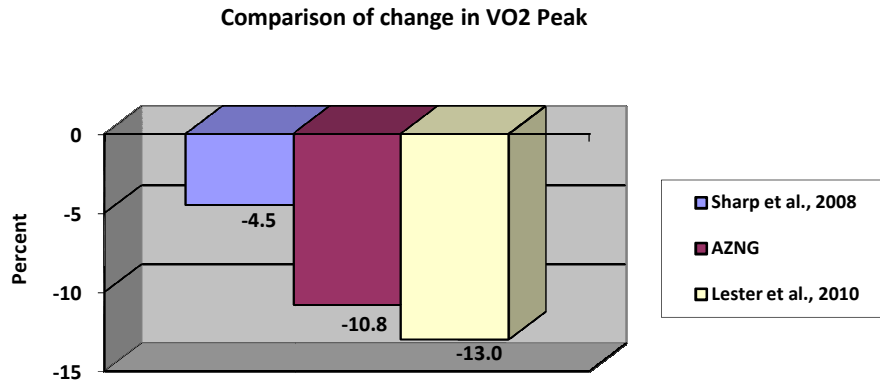


Figure 3.2. Comparison of change in VO₂ Peak between AZNG and those reported in the literature on active duty soldiers

These findings could be interpreted in a number of ways. Based on the reported active duty soldiers' pre-deployment fitness levels the participating members of the AZNG were equally prepared for deployment when speaking in terms of cardiorespiratory fitness. However, seeing the decline in their aerobic capacity with an increase in strength could be the result of an emphasis being placed on cardiorespiratory training prior to deployment without the same emphasis being maintained through the extent of the deployment. These differences could also be the result of more time being spent on resistance training at the expense of cardiorespiratory training during the course of the deployment. There was not a rigid or structured training program associated with this investigation. Soldiers deployed to a combat zone were expected to exercise in accordance with the guidelines that their chain of command provides. The investigation team understands that the most soldiers were expected to work-out in an autonomous environment.

The changes in AZNG fitness levels likely reflect the individual choices about which types of training that the soldiers chose to conduct during deployment. It appears that decreased aerobic capacity is a common trend amongst soldiers during combat deployments. The reasoning for this is not well understood and raises more questions. Are soldiers not motivated to perform aerobic training independently? Perhaps those in command indicate that there is no value for maintaining or increasing aerobic fitness. Do soldiers perceive that the fitness facilities do not have suitable equipment for aerobic training available? Are the environmental conditions on the bases not suitable for performing aerobic training outside? Knowing how important aerobic fitness is to overall health and combat readiness, clearly more research should be done to determine why this decline in cardiorespiratory fitness is occurring during deployment.

This population of reserve component soldiers did show some differences in how the deployments affected their physical fitness when compared to the two previous studies. While increased strength was noted in this study and by Lester et al., Sharp et al. reported no significant difference strength which was assessed an incremental lifting machine. Lester et al. and Sharp et al. both reported increased FM over the course of the deployment. The AZNG actually improved body composition by decreasing measurable FM. Improved body composition as a result of deployment is difficult to explain. Complicating this finding is that there is a difference amongst the populations that have been studied. Lester et al. reported an increase in FM by 9% while Sharp et al. reported an increase of 11% as measured by DEXA. Obviously, changes in FM can be influenced by the

meals provided to soldiers while deployed. However, it is difficult to explain why the active duty population increased FM while the AZNG decreased FM, but all soldiers were eating food from similar dining facilities. Most likely, as civilians prior to deployment these soldiers were eating more calories at home prior to deployment. Once deployed, the food choices as compared to “homecooking” may not have been as palatable to them. In addition, part of the decrease in FM in AZNG soldiers may be explained by the prohibition of alcohol while deployed. In this instance, the pre-deployment mean level of body fat as measured by the Bod Pod of the men was at the upper limits of acceptable (22%) and the post deployment mean was well within the acceptable limits of the Army’s tape test which determines body fat percentage based on neck and waist circumference. The women in this study were well within the standards for allowable body fat (32%) based on the mean pre and post deployment measurements (Department of the Army, 2006).

This study is the first to include muscle endurance and flexibility as a component of physical fitness testing in deployed soldiers. The AZNG soldiers demonstrated significant increases in both the push-up (16%) and sit-up (11%) events. Based on the mean number of repetitions and the mean age of the men and women in this study, both genders achieved a passing score in both the push-up (M=40, F=17) and sit-up (M/F=50) events by the APFT standards before and after deployment (Department of the Army, 1992).

Flexibility is not currently a component of the APFT. Although the soldiers in this study demonstrated very little change in flexibility over the course

of the deployment, this study allows us to compare the results of participating soldiers to previously published values. The male's mean pre and post-deployment scores in the sit and reach place them between the 30th-50th (25-31 cm) percentile, while the women fall between the 50th-70th percentile (41-53 cm) (Acevedo, 2003). The scores for the shoulder elevation are similar by placing the males between the 30th-50th percentile (135-175 cm) and the females in the 50th-70th (173-216 cm) (Acevedo, 2003; Johnson & Nelson, 1986). Although trunk extension was the only component of flexibility where the soldiers demonstrated significant change, the pre and post deployment levels both fell within the range of the 70th-90th percentile (M=109-124 cm; F=107-119 cm) (Acevedo, 2003; Johnson & Nelson, 1986).

This study demonstrates that soldiers change in physical fitness while deployed in combat regions. Soldiers' strength, endurance, and body composition improved, but their cardiorespiratory fitness declined, while power and flexibility were essentially unchanged. The culmination of current research is demonstrates a trend of declining cardiorespiratory fitness amongst all groups evaluated. More data is needed to resolve the conflicting reports previously reported in changes in strength, power, and body composition, as well as to understand the components that are not well represented (endurance and flexibility). More research is also needed to better explain the changes specific to reserve soldiers. Clearly, more detailed information on the type, intensity and frequency of physical activity/exercise which occur during deployment are needed to explain these changes to physical fitness. In summary, these results provide healthcare

professionals and military leaders a better understanding of how current deployment conditions are affecting physical fitness. This information can be utilized to alter training prior to and during deployments in order to achieve desired levels of fitness.

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Chapter 4

RELATIONSHIPS OF PHYSICAL FITNESS LEVELS AND UTILIZATION OF MEDICAL RESOURCES IN DEPLOYED ARIZONA NATIONAL GUARD SOLDIERS

INTRODUCTION

It has long been understood that higher levels of physical fitness can have protective effects against occupational injury (Craig et al., 2006; Biering-Sorenson, 1984; Cady et al., 1979). This relationship has also been demonstrated in the military setting, typically amongst recruits in basic training or non-deployed units (Gardner et al., 1996; Reynolds et al., 1994; Knapik et al., 1993; Jones et al., 1988). These previous investigations have demonstrated that increased levels of cardiorespiratory fitness, strength, endurance, and flexibility reduce the risk of musculoskeletal injury (Reynolds et al., 1995; Knapik et al., 1993; Biering-Sorenson, 1984; Cady et al., 1979). Some of the research has even indicated that higher levels of activity and cardiorespiratory fitness reduce the prevalence of illness (Gardner et al., 1996; Jones et al., 1988). The authors of this investigation have been unable to find any publications that evaluated the relationship of physical fitness and injury or illness in military service members who are performing their duties in a combat zone. It is understood that physical fitness levels will have little to no effect on prevalence of combat related injuries. However, the relationship between physical fitness levels and a soldier's utilization of medical resources for non-combat related injury or illness has yet to be explored. Due to the long duration of the current military deployments the

effects of the pre-deployment fitness levels on medical resource utilization must be considered, but the potential relationship between the changes in fitness which occurs during the deployment or even the post-deployment fitness levels must also be explored.

Currently there are a limited number of publications that have evaluated the effects of long-term combat deployments on soldier physical fitness (Lester et al., 2010; Sharp et al., 2008). Some of the previous research was conducted in training environments which simulated combat environments for days to weeks (Nindl et al., 2007; Patton et al., 1989; Murphy et al., 1984). Even in these settings, decreases in fitness and job performance in high intensity training environments were detected (Nindl et al., 2007; Murphy et al., 1984). In recent years, two publications have specifically evaluated changes in physical fitness for soldiers deployed to a combat environment. Both investigations demonstrated declines in cardiorespiratory function and increases in fat mass (Lester et al., 2010; Sharp et al., 2008). Published results for changes in strength and power are conflicting. Sharp et al. demonstrated decreased upper extremity power with no change in strength, while Lester et al. reported that upper and lower body strength as well as power increased significantly. Neither of these two previous investigations determined what the effects or the implications of the physical fitness changes could be.

It was the intent of this study to assess the effects of combat deployments on physical fitness of soldiers in the Arizona National Guard (AZNG) and to then determine if a relationship exists between this levels and soldiers' utilization of

medical resources for non-combat related injury or illness. Additionally, this research included both men and women who performed a variety of military occupations not limited to combat arms. By including multiple occupations a more heterogeneous group of subjects were recruited. This provided a sample that is more representative of the AZNG, instead of a single occupational component.

METHODS

The primary aim of the study was to determine the effects of a long term (approximately 1 year) combat deployment on physical fitness levels (body composition, strength, endurance, power, flexibility, and aerobic capacity) in soldiers and then explore the potential relationship between these changes and the utilization of medical resources. The study was approved by the institutional review board at Arizona State University as well as by the Arizona National Guard State Surgeon's Office. No incentives for participation were offered. There were no financial or career benefits from participating in this study. It was emphasized to the unit leaders that no favoritism be demonstrated to soldiers participating in this study.

Primary outcomes for this study were the measurements of individual body composition, muscular strength, muscular endurance, peak power, cardiorespiratory fitness, and flexibility. The independent variable assessed during this investigation was a long term (10-15 months) combat deployment. Combat itself can have a variety of affects on soldier ranging from physical to emotional side effects. Under the current deployment circumstances, most

deployed soldiers have significant autonomy while deployed when it comes to their physical fitness training. This autonomy is largely due to the unit's operations tempo and the individual soldier's duty requirements. It was not the intention of this study to remove this existing autonomy by requiring the soldiers to perform specific physical fitness training while deployed. Soldiers enrolled in this study were encouraged to conduct themselves while deployed in accordance with their respective unit requirements. The study was designed to assess the effects of combat on a soldier's physical performance without an additional intervention in order to determine if the autonomy maintained by the soldiers may be influencing their physical fitness.

Pre-deployment and post-deployment data collection was conducted in a standardized methodology as described below. The investigation team selected assessment methods that were considered to be the most appropriate for use in a population of soldiers and were deemed valid and reliable in this sample. Additionally, feasibility for completion of all testing in a fashion that would not interfere with soldier pre-deployment training tasks had to be considered.

STUDY PARTICIPANTS

The research team successfully recruited 60 soldiers to complete pre-deployment testing, 54 of whom completed post-deployment testing. A control-group consisting of 15 AZNG soldiers who serve in a full-time capacity, but were not deployed was also enrolled. Of the 15 soldiers, 11 completed testing after a 12 month period of serving in the state of Arizona. All volunteers read and signed an informed consented prior to being screened using the American College of

Sports Medicine/American Heart Health/Fitness Facility Preparticipation Screening Questionnaire prior to the initial testing. Subjects also signed a Health Insurance Portability and Accountability Act (HIPAA) release forms, allowing for the review of deployment medical records.

In order to be enrolled in this research, participants agreed to complete physical fitness assessments during the unit pre-mobilization phase and immediately upon their return to the United States. Eligible soldiers were considered to be free of uncontrolled chronic disease (i.e. hypertension, asthma, diabetes) or any exceptional physical limitations that would prevent the completion of the physical fitness testing. All races and gender were eligible for this study. Prior to being screened by investigators, soldiers were cleared for deployment by the AZNG upon completing the medical screening conducted during the Soldier Readiness Program.

Male soldiers greater than 40 years old and female soldiers greater than 45, having severe physical limitations that would prevent successful completion of testing, or uncontrolled chronic disease (i.e. HTN, diabetes, sleep apnea, asthma) were not considered eligible for this investigation. The research team did not feel that valid assessments of the effects of combat on physical fitness in those who have significant physical limitations could be completed. Soldiers on orders for less than 10 months or greater than 15 months were not included.

The majority of the study participants were recruited from three separate units, including the 363rd Explosive Ordinance Detachment (EOD), 1404th Transportation Company (TC), and 855th Military Police (MP). Additionally,

two additional soldiers were recruited as the only participant from their respective units. Multiple occupations were represented within each unit (see Table 1.). All participants were screened using the American College of Sports Medicine/American Heart Health/Fitness Facility Preparticipation Screening Questionnaire prior to the initial testing (American College of Sports Medicine, 2010).

Table 4.1. Units and Occupations Represented

<i>Unit</i>	<i>Occupation</i>	<i>No.</i>
1404 th Transportation Company	Motor Transport Operator	27
	Light Wheel Vehicle Mechanic	6
	Supply and Logistics	4
363 rd Explosive Ordinance Detachment	Explosive Ordinance Specialist	9
	Supply and Logistics	2
855 th Military Police Company	Military Police	4
Miscellaneous	Human Resource Specialist	1
	Health Care Provider	1

BODY COMPOSITION

Body composition (percent body fat and fat free mass) was measured using air displacement plethysmography (Bod Pod, Life Measurement, Inc.) It has been reported that the test-retest reliability of the Bod Pod is between .92 and .99 (McCrary et al., 1995; Collins et al.; Maddalozzo, Cardinal, & Snow, 2002). The Bod Pod can be considered highly correlated to hydrostatic weighing (.96) and dual energy x-ray absorptiometry (.89-.94) in terms of predicting percent body fat (Dixon et al., 2005; Ball & Altena, 2004; Maddalozzo, Cardinal, & Snow, 2002). Research suggesting that the Bod Pod systemically predicts body fat percentage lower than hydrostatic weighing but higher than dual energy x-ray

absorptiometry is controversial (Ball & Altona, 2004; Collins et al., 1999). The difference in measuring technique could result in a difference of approximately 2%.

Calibrations of the Bod Pod and electronic scale were performed prior to each testing session. Between each soldier a standard two-point calibration was performed. This included the measurement of an empty chamber, followed by the measurement of the calibration cylinder.

Soldiers were asked to abstain from eating for the two hours prior to their arrival at the testing facility. Soldiers wore form-fitting, non-cotton, compression shorts with a non-cotton, lycra cap to compress the hair to the head as snugly as possible thereby minimizing excess surface area. Soldiers were also asked to remove all jewelry prior to testing. The soldiers were instructed to sit in the Bod Pod, maintain normal respirations, keep their hands in their laps, and refrain from moving. Body composition assessments were performed prior to other physical fitness tests in order to prevent an elevation in body temperature. Soldiers' body volumes were measured at least two times to ensure that measurements were within 150 ml. In the event that the volumes were inconsistent a third measurement was performed and the two closest volumes were averaged.

MUSCULAR STRENGTH

Strength was determined using the 1 repetition maximal (RM) bench press and back squat. Protocol for the 1RM testing followed the guidelines set forth by the National Strength and Conditioning Association (NSCA) and the American College of Sports Medicine (ACSM) (American College of Sports Medicine

2010, National Strength and Conditioning Association, 2008). The 1RM bench press was used to assess upper body strength, while the 1RM back squat was used to assess lower extremity strength. The 1RM testing was selected for use based on the ability to perform testing in a variety of locations, ease of administration to trained or untrained individuals, and the previous use to identify maximal strength in soldiers (Nindl et al., 2002)

1RM bench press. The test-retest reliability of the 1RM bench press test has proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .93-.99 (Doan et al, 2002; Levinger et al., 2009; Hoeger et al., 1990). Soldiers performed this test after a block of instruction provided by one of the investigation team. They were asked to grasp the bar at approximately shoulder width and lift it off of the rack. Spotters were in place throughout the testing. Soldiers then performed each repetition by lowering the bar to within one inch of the chest and then raising the bar until the elbows reached full extension. Soldiers first performed 10 repetitions of approximately 40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

1RM back squat. The test-retest reliability of the 1RM back squat test has also proven to be high in trained and untrained individuals, maintaining a correlation coefficient between .92-.97 (Blazevich, Gill, & Newton, 2002; Harris

et al., 2000). Soldiers performed this test after a block of instruction provided by one of the investigation team. Spotters were in place behind the soldiers throughout the testing period. Soldiers positioned the bar across the shoulders before lifting it off of the rack. They were then asked to lower their bodies by bending at the knees and hips while maintaining a straight back. A repetition was counted when the soldier was within approximately 10 degrees of getting the upper leg parallel to the floor. Soldiers first performed 10 repetitions of approximately 40-50% of their perceived maximal lift. The weight was increased incrementally and the subjects performed sets of 8, 5, and 3 repetitions. A 3-5 minute rest period between each set was provided (Weir, Wagner, & Housh, 1994; National Strength and Conditioning Association, 2008). The soldiers then had 3 attempts to establish their 1RM bench press with 3-5 minutes between each attempt.

MUSCULAR ENDURANCE

Muscular endurance was assessed by completion of a push-up and sit-up test in accordance with the United States Army Physical Fitness Test protocol. This testing method was selected because it is similar to that described by the ACSM but is more familiar to the soldiers because of its inclusion in the Army Physical Fitness Test (American College of Sports Medicine, 2010, Department of the Army, 1992). Push-ups and sit-ups have been used to assess muscular endurance in previous research which evaluated occupational fitness to include firefighters and military service members (Knapik et al., 1990; Misner, Boileau, & Plowman, 1989). Test-retest reliability for a timed push-up test has been

reported to be .93, while the sit-up has been reported to be .88-.94 (Knudson, 1995; Invergo, Ball, & Looney, 1991).

Push-up. Soldiers were instructed to take the ready position which required them to be positioned with their hands on the floor approximately shoulder width apart. Male and female soldiers were required to perform the event with their toes in contact with the floor, head and eyes directed forward, hips in extension, spine parallel to the floor, and elbows in extension. Neither males nor females were allowed to perform the push-up with their knees in contact with the floor. Soldiers were instructed to do as many push-ups as possible in the two minute period without putting their knees in contact with the floor or removing their hands from the floor. A push-up was counted if the elbows were brought to flexion of 90 degrees or greater and then returned to full extension, while keeping the body elevated on the toes. The test was discontinued if the soldier dropped to the knees or reached volitional fatigue (Department of the Army, 1992).

Sit-up. Soldiers were asked to assume the start position which required the feet and shoulder blades to be in contact with the floor, while the knees were flexed to approximately 90 degrees. The hands were to be behind the head, but not required to have the fingers interlocked. After the command was given to begin and the timer started, a sit-up repetition was counted if the soldier kept their hands behind their head, bringing the base of their spine to at least a vertical position and then returning the shoulder blades to the floor. The test was

discontinued at the end of two minutes or if the soldier reached volitional fatigue prior to the end of the two minutes (Department of the Army, 1992).

POWER

Lower extremity power was assessed using a Wingate anaerobic cycle test (Nieman, 2008). The Wingate is considered a reliable and reproducible assessment of power maintaining a correlation coefficient of .89-.98 (Bar-Or, 1987). The Wingate test has been used in multiple military studies to evaluate power due to its simplicity of use and ability for untrained individuals to successfully complete the test with brief familiarization (Knapik et al., 1995; Knapik et al., 1990; Murphy et al., 1987). The Wingate has been used for the assessment of power in men and women alike from numerous occupations other than military service, such as firefighting (Misner, Boileau, & Plowman, 1989).

The 30 second Wingate was completed on an Ergomedic Peak Bike 894E, Monark. Soldiers were given detailed instructions and familiarized with the cycle prior to completion. Prior to starting the test the seat height and handle bars were adjusted appropriately. After a warm-up period soldiers were instructed to pedal at their maximal speed without resistance. Once the maximal speed was achieved the soldier pressed the button located on the handlebars, which then increased the resistance on the wheel to .075 kilograms per kilogram of body weight. The soldiers continued an all out bout of pedaling for 30 seconds followed by a resistance free cool down period prior to dismounting the bike (Nieman, 2008).

FLEXIBILITY

Flexibility was assessed using three different tests; sit and reach, shoulder elevation, and trunk extension. Lower extremity flexibility was determined using the sit and reach test (SNR). The SNR test is simple to administer and has demonstrated exceptional test-retest reliability ($r=.98-.99$) in multiple investigations (Gabbe et al., 2004; Simoneau, 1998). The SNR has also been found to be valid measure of hamstring flexibility (Baltaci et al., 2003; Simoneau, 1998; Liemohn, Sharpe, & Wasserman, 1994).

Shoulder flexibility was determined by the shoulder elevation test. Trunk flexibility was determined by the trunk extension test. These expedient field tests were selected based on their ease of administration and their potential ability to provide a snapshot of soldiers' upper extremity and trunk flexibility. Although not many published studies have utilized the trunk flexibility and shoulder elevation tests, normative values have been established (Acevedo & Starks, 2003; Johnson & Nelson, 1969).

Sit and Reach. Soldiers were asked to remove their shoes and sit on the floor. They were asked to place the soles of their feet against the SNR box with the back of the leg and knee flat against the floor. They were then asked to place one hand on top of the other and slowly reach forward with extended arms pushing the slide as far forward as possible. Subjects were given two attempts and the highest score was recorded (American College of Sports Medicine, 2010; Acevedo & Starks, 2003).

Trunk Extension. Trunk flexibility was determined by using the trunk extension test. This test is intended to assess the flexibility of the core muscles of the abdominal region. First the trunk was measured by having the soldier sit with their back flat against the wall and legs extended. A yard stick was placed between the legs of the soldier. The trunk length was determined by the distance between the floor and the suprasternal notch. Following the trunk measurement, the soldier laid in the prone position with his or her hands behind the back. The soldier was asked to rise up their head and neck as high as possible while extending the spine, but keeping the feet in contact with the floor. At the peak of trunk elevation, the tester measured the distance from the floor to the suprasternal notch. The soldier was given two attempts and the highest value was recorded. The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1969):

$$\text{trunk extension score} = \text{back extension (in.)} \times 100 / \text{trunk length (in.)}$$

Shoulder Elevation. The shoulder elevation test was used to assess the flexibility of the chest and shoulder muscles. First the length of the arm was determined by having the soldier hold a yard stick in closed fists of both hands with arms fully extended. A measurement was taken from the acromion process to the proximal edge of the stick. The soldier was then asked to lie in the prone position with the stick still grasped in the hands and the elbows extended. The fists were initially in contact with the floor until the soldier was given the command to elevate the hands as high as possible. At this point a measurement was taken from the floor to the level of the yard stick. This was followed by a

measurement of the soldier's ability to elevate the arms, while the chin remained in contact with the ground. The elbows were to be kept in extension while the tester measured from the floor to the bottom of the stick. The scores were calculated using the following equation (Acevedo & Starks, 2003; Johnson & Nelson, 1969):

$$\text{shoulder elevation score} = \text{shoulder elevation (in.)} \times 100 / \text{arm length (in.)}$$

CARDIORESPIRATORY FITNESS

Peak cardiorespiratory function can be defined as the "the maximal capacity to transport and utilize oxygen during exercise" (Powers & Howley, 2007, p.58). An incremental treadmill test is preferred for the measurement of peak oxygen consumption, as it requires the use of large muscle mass (Weber et al., 1988). Incremental treadmill tests have been used successfully to assess cardiorespiratory fitness in multiple military studies (Sharpe et al., 2008; Nindl et al., 2002; Knapik et al., 1990)

Soldiers' cardiorespiratory fitness (VO₂ peak) was estimated with indirect calorimetry while completing a treadmill test. Indirect calorimetry was completed using a metabolic cart (AEI Technologies, Pittsburgh, PA). A modified version of the Bransford and Howley protocol was selected in order to allow the soldiers to run at a self-selected pace (Morgan et al., 1991; Bransford & Howley, 1977).

Soldiers were first fitted with a Polar heart rate monitor, Hans Rudolph head gear and two-way non-rebreather valve. They were then given individual instruction to select a running pace that they would normally complete the 2 mile run for the Army Physical Fitness Test (Department of the Army, 1992). After a

brief warm-up, the initial two-minute period was completed at 0% grade. The grade was incrementally increased by one percent every minute following this initial two minute period until the soldier reached volitional fatigue. Criteria for adequate testing included the following: RER > 1.00 or heart rate + or - 10 beats per minute of age predicted maximum heart rate (Sharp et al., 2008).

MEDICAL RECORDS INVENTORY

Screening of deployment medical records was conducted in order to inventory number of visits to the medical facility that were related to non-combat injury or illness. Screening exams, immunizations, and mandatory visits were not counted during the inventory. A total number of visits for each subject were determined by each category of the visit. This number of visits was then compared to the physical fitness outcome measures in order to determine the relationship between the fitness variables and medical resource utilization. Medical visits were categorized in a similar fashion to what has been reported in previous literature and also had a reasonable potential of influencing a relationship with physical fitness (Zouris, Wade, & Magno, 2009; Sanders et al., 2005). Categories are listed in Table 2. Medical records of the control group were not screened, as the investigation was only evaluating whether they would experience similar changes in fitness levels as those soldiers who were deployed.

Table 4.2. Medical Records Categorization

Respiratory
Gastrointestinal
Musculoskeletal Injury
Back
<i>Lower Back</i>
<i>Upper Back</i>
<i>Neck</i>
Upper Extremity
<i>Shoulders</i>
<i>Arm</i>
<i>Wrist/Hand</i>
Lower Extremity
<i>Hip</i>
<i>Knee</i>
<i>Ankle/Foot</i>
Behavioral Health
Total Visits

Medical records review occurred at Medical Command, Papago Military Reservation. Electronic medical records were reviewed at a designated computer terminal. No records were allowed to leave the facility. Only an inventory of records reviewed was maintained for data analysis. Records were initially inventoried with a high level of specificity that included a greater number of categories. After completion of the inventory, categories were appropriately collapsed for analysis. For example, lower back, upper back, and neck were consolidated into one category titled back.

ANALYSIS

Data were evaluated for normal distributions. The deployed and non-deployed groups were analyzed for differences at the time of pre-deployment for differences using an independent t-test. Both groups were then analyzed for

statistically significant difference between pre and post-deployment measures using paired t-tests or Wilcoxon Sign Rank. Spearman Rho correlations were conducted to evaluate for significant relationships between physical fitness variables and medical categories in the soldiers who deployed. The neck, upper, and lower back categories were collapsed into one category titled back. The shoulder, elbow, and wrist/hand categories were collapsed into one category titled upper extremity. The hip, knee, and ankle/foot categories were collapsed into one category titled lower extremity. Additional analysis included the division of soldiers into tertiles for each physical fitness variable to determine whether segments of the population utilized medical resources more than others based on the measured change in fitness variables. The data were analyzed via MANOVA to compare utilization of medical resources by tertiles. Significant resource utilization-by-tertile interactions were further assessed by Scheffe post hoc tests.

RESULTS

PRE-DEPLOYMENT ANALYSIS

No significant differences were detected between the deployed soldiers and the non-deployed group at the time of pre-deployment measures. See table 3 for a comparison of groups.

Table 4.3. Comparison of deployed soldiers versus control group at time of pre-deployment

	<i>Deployed (n=60)</i>	<i>Non-deployed (n=15)</i>	<i>Sig</i>
General Measures			
<i>Weight (kg)</i>	83.4 (16.9)	75.9(12.9)	.11
<i>BMI (kg/m²)</i>	27.4 (4.8)	25.8 (3.4)	.22
<i>Fat Mass (%)</i>	22.7 (9.0)	24.5 (5.6)	.33
Relative Strength			
<i>1RM Bench (kg/kg bodyweight)</i>	0.98 (.26)	0.94 (.35)	.63
<i>1RM Squat (kg/kg bodyweight)</i>	1.27 (.28)	1.26 (.34)	.97
Muscular Endurance			
<i>Push-ups (reps)</i>	50.1 (17.7)	47.7 (22.1)	.65
<i>Sit-ups (reps)</i>	53.3 (14.4)	58.3 (11.0)	.22
Power			
<i>Peak Power (watts)</i>	660.9 (177.8)	553.0 (194.8)	.06
Flexibility			
<i>Sit-and-reach (cm)</i>	30.0 (8.9)	25.1 (10.7)	.07
<i>Trunk Extension(cm)</i>	117.1 (25.1)	110.6 (20.9)	.36
<i>Shoulder Elevation(cm)</i>	145.6 (50.2)	152.8 (69.5)	.65
Cardiorespiratory Fitness			
<i>VO₂ Peak (ml/kg/min)</i>	48.9 (8.8)	48.2 (6.0)	.77

Values are means and standard deviation (SD)

PRE TO POST-DEPLOYMENT CHANGE

Of the 60 deployed soldiers who completed pre-deployment testing, 54 (M=47, F=7) completed post-deployment testing. Three of the soldiers did not complete the required time of deployment and three soldiers withdrew from testing during the post-deployment period. Of the three soldiers who did not complete the required length of deployment, one was sent home due to a non-combat injury while the other two were sent home at the discretion of their unit commander. Of the 15 soldiers in the control group, 11 completed the post-

deployment testing. One soldier became pregnant during the experimental period and three were lost to follow-up.

Significant improvements were detected from pre to post-deployment measures in weight, body mass index, fat mass, relative strength, and muscular endurance for deployed soldiers. Significant declines were detected in cardiorespiratory fitness and one measure of flexibility (trunk extension) in deployed soldiers. There was no significant change seen in peak power or the other components of flexibility, sit-and-reach or shoulder elevation. See table 4 for a summary of the pre and post-deployment measures with percentage of change reflected. Differences between smoking status and gender were also analyzed to determine the level of influence. There were no significant differences in the percentage of change in fitness levels between smokers and non-smokers or between genders.

Table 4.4. Overall mean (SD) of pre and post-deployment measures for deployed AZNG soldiers

	<i>N</i>	<i>Pre-deployment</i>	<i>Post-deployment</i>	<i>Percent Change</i>	<i>Sig</i>
General Measures					
<i>Weight (kg)</i>	54	82.9 (15.8)	81.3 (13.9)	-1.9	.004
<i>BMI (kg/m²)</i>	54	27.2 (4.5)	26.7 (3.8)	-1.8	.004
<i>Fat Mass (%)</i>	52	22.5 (8.6)	20.0 (7.4)	-11.1	<.001
Relative Strength					
<i>1RM Bench (kg/kg bodyweight)</i>	54	0.98 (0.27)	1.08 (.29)	10.2	<.001
<i>1RM Squat (kg/kg bodyweight)</i>	49	1.27 (.28)	1.45 (.36)	14.2	<.001
Muscular Endurance					
<i>Push-ups (reps)</i>	52	51.2 (17.5)	59.6 (18.9)	16.4	<.001
<i>Sit-ups (reps)</i>	52	54.5 (14.5)	60.5 (13.0)	11.0	.001
Power					
<i>Peak Power (watts)</i>	48	674.0 (180.3)	662.6 (211.0)	-1.7	.56
Flexibility					
<i>Sit-and-reach (cm)</i>	53	30.0 (9.1)	29.0 (8.9)	-3.3	.24
<i>Trunk Extension(cm)</i>	53	117.9 (26.2)	110.0 (23.4)	-6.7	.002
<i>Shoulder Elevation(cm)</i>	53	144.3 (50.0)	144.1 (38.9)	-0.1	.95
Cardiorespiratory Fitness					
<i>VO₂ Peak (ml/kg/min)</i>	49	48.2 (8.0)	43.0 (8.0)	-10.8	<.001

Values are means and standard deviation (SD)

The control group consisting of non-deployed AZNG soldiers demonstrated no statistically significant changes in any of the tested categories. See table 5 for a summary of the control group measures.

Table 4.5. Overall mean (SD) of physical fitness measures for the non-deployed AZNG soldiers

	<i>N</i>	<i>Pre-deployment</i>	<i>Post-deployment</i>	<i>Sig</i>
General Measures				
<i>Weight (kg)</i>	11	77.8 (10.3)	77.7 (10.4)	.98
<i>BMI (kg/m²)</i>	11	25.8 (2.9)	25.8 (2.9)	.94
<i>Fat Mass (%)</i>	11	23.0 (5.5)	23.3 (5.4)	.63
Relative Strength				
<i>1RM Bench (kg/kg bodyweight)</i>	11	0.97 (0.34)	1.04 (0.41)	.13
<i>1RM Squat (kg/kg bodyweight)</i>	11	1.29 (0.34)	1.33 (0.39)	.46
Muscular Endurance				
<i>Push-ups (reps)</i>	11	53.4 (21.3)	54.5 (19.8)	.65
<i>Sit-ups (reps)</i>	11	61.5 (9.9)	63.7 (12.1)	.34
Power				
<i>Peak Power (watts)</i>	11	571.6 (186.0)	552.3 (182.4)	.23
Flexibility				
<i>Sit-and-reach (cm)</i>	11	24.2 (12.1)	24.0 (10.4)	.83
<i>Trunk Extension(cm)</i>	11	105.2 (19.4)	104.2 (16.0)	.75
<i>Shoulder Elevation(cm)</i>	11	153.0 (68.2)	153.8 (63.5)	.93
Cardiorespiratory Fitness				
<i>VO₂ Peak (ml/kg/min)</i>	10	49.9 (5.9)	47.1 (4.7)	.10

Values are means and standard deviation (SD)

CORRELATIONS

There were no significant correlations detected between the different medical categories and pre-deployment scores, post-deployment scores, or change in fitness amongst measures of relative strength, muscular endurance, or peak power. Significant negative correlations were detected amongst percentage of fat mass at pre-deployment and post-deployment in respiratory visits as well as between change in fat mass and gastrointestinal visits. This would indicate that higher levels of fat mass at pre and post-deployment was associated lower number of respiratory visits. However, a greater decline in fat mass during deployment

was also associated with a higher number of gastrointestinal visits. Sit-and-reach scores at post-deployment and the percentage of change were both negatively correlated to the number of lower extremity visits. This indicates that soldiers with greater hamstring and low back flexibility at post-deployment had a lower number of visits related to the lower extremity. Similarly, the percentage of change in shoulder elevation score was negatively correlated to upper extremity visits. A significant positive correlation was detected between pre-deployment trunk extension and back visits. Interestingly, higher trunk flexibility scores were associated with more back visits.

Cardiorespiratory fitness maintained the most and the strongest correlations. Percentage of change of the soldiers VO_2 peak was negatively correlated to back and behavioral health visits, while nearly reaching significance for total visits ($r=-0.27$, $p=.058$). The post-deployment VO_2 peak scores were negatively correlated to behavioral health and total number of visits.

There were a number of other correlations that nearly reached significance to include; sit-ups versus back visits ($r=-0.26$, $p=.059$) at post-deployment, change in push-ups versus upper extremity visits ($r=-0.26$, $p=.056$), change in peak power versus respiratory visits ($r=.28$, $p=.052$), and change in VO_2 peak versus total visits. See Table 6 for a summary of evaluated relationships.

Table 4.6. Correlation between Fitness Variables at Different Assessments and Medical Visits

	<i>Pre- deployment r=</i>	<i>Post- deployment r=</i>	<i>Change in Fitness (%) r=</i>
Body Composition (% Fat Mass)			
<i>Gastrointestinal</i>	.09	-.08	-.37*
<i>Total</i>	.05	-.01	-.19
Relative Strength (Bench press)			
<i>Upper Extremity</i>	-.11	-.04	.04
<i>Total</i>	-.11	-.03	.17
Relative Strength (Back squat)			
<i>Back</i>	.26	.25	.11
<i>Lower Extremity</i>	.08	.09	.17
<i>Total</i>	-.09	-.02	.15
Muscular Endurance (Push-ups)			
<i>Upper Extremity</i>	.14	-.01	-.27
<i>Total</i>	-.17	-.04	.24
Muscular Endurance (Sit-ups)			
<i>Back</i>	-.08	-.26	-.22
<i>Lower Extremity</i>	-.21	-.19	.15
<i>Total</i>	-.24	-.20	.13
Peak Power			
<i>Respiratory</i>	-.26	-.09	.28
<i>Lower Extremity</i>	-.05	-.10	.04
<i>Total</i>	-.10	-.11	.11
Flexibility (Sit-and-reach)			
<i>Back</i>	.15	.09	-.03
<i>Lower Extremity</i>	-.05	-.28*	-.33*
<i>Total</i>	.08	.05	-.03
Flexibility (Trunk Extension)			
<i>Back</i>	.32*	.22	-.16
<i>Total</i>	.21	.13	-.14
Flexibility (Shoulder Elevation)			
<i>Upper Extremity</i>	.15	-.09	-.36*
<i>Total</i>	.01	-.03	-.04
Cardiorespiratory Fitness (VO₂ Peak)			
<i>Respiratory</i>	.11	-.13	-.17
<i>Back</i>	.17	-.11	-.31*
<i>Lower Extremity</i>	-.06	-.21	.11
<i>Behavioral Health</i>	-.15	-.32*	-.28*
<i>Total</i>	-.13	-.45**	-.27

*Significant, $p \leq .05$

**Significant, $p \leq .001$

TERTILES VERSUS UTILIZATION OF MEDICAL RESOURCES

Soldiers were categorized into tertiles based on their percentage of change in each variable (body composition, relative strength, muscular endurance, peak power, flexibility, and cardiorespiratory fitness). Analysis was then performed to ensure each of the tertiles was significantly different in the percentage of change for the respective physical fitness variable being evaluated. These tertiles were then evaluated for significant differences in their utilization of medical resources by category. Significant differences between tertiles were then evaluated with a Scheffe post hoc analysis.

Body Composition. There were significant differences between tertiles based on the percentage of change in peak power which occurred during the deployment (Figure 4.1). The mean percentage of change to body fat in the first, second, and third tertiles were respectively 9.7 (95% CI, 6.0 to 13.5), -11.3 (95% CI, -15.0 to -7.7), and -25.6 (95% CI, -29.4 to -21.8).

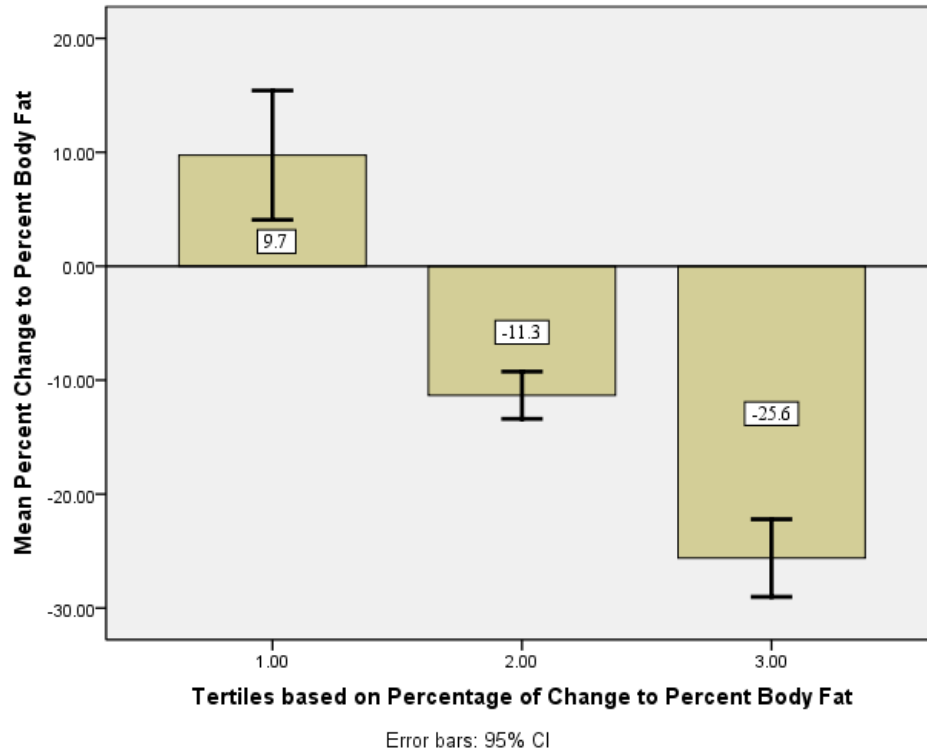
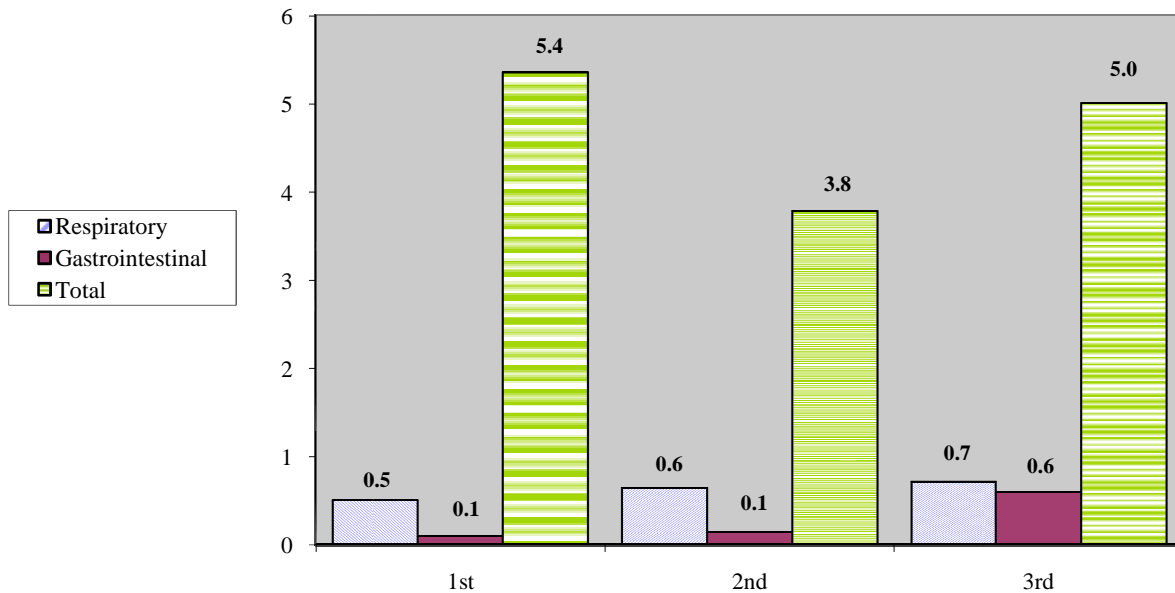


Figure 4.1. Change in Percent Body Fat by Tertiles

Although the percentage of fat-mass at pre and post-deployment measures maintained a significant negative correlation with respiratory visits ($r=-0.33$, $p=.017$ and $r=-0.40$, $p=.003$) there was no difference between tertiles based on change in fat mass versus respiratory visits. Percentage of change in fat mass was also negatively correlated to the number of gastrointestinal visits ($r=-0.37$, $p=.008$), and this is supported by a trend of an increased number of gastrointestinal visits associated with a higher percentage of decline in fat mass (0.1 v 0.1 v 0.6 , $p=.09$). There was no significant difference between tertiles based on percentage of fat mass change in total visits (Figure 4.2).



**no significance differences detected between tertiles*

Figure 4.2. Tertiles by change in fat mass versus respiratory, gastrointestinal, and total visits

Relative Strength. There were significant differences between tertiles based on the percentage of change in relative strength as measured by the bench-press and back-squat which occurred during the deployment (Fig. 4.3a and Fig 4.3b). The mean percentage of change in bench-press in the first, second, and third tertiles were respectively -3.6 (95% CI, -6.8 to -0.5), 6.7 (95% CI, 3.5 to 10.0), and 23.7 (95% CI, 20.4 to 27.0). The mean percentage of change in back-squat in the first, second, and third tertiles were respectively -10.5 (95% CI, -15.1 to -5.9), 9.0 (95% CI, 4.6 to 13.5), and 26.7 (95% CI, 22.1 to 31.3).

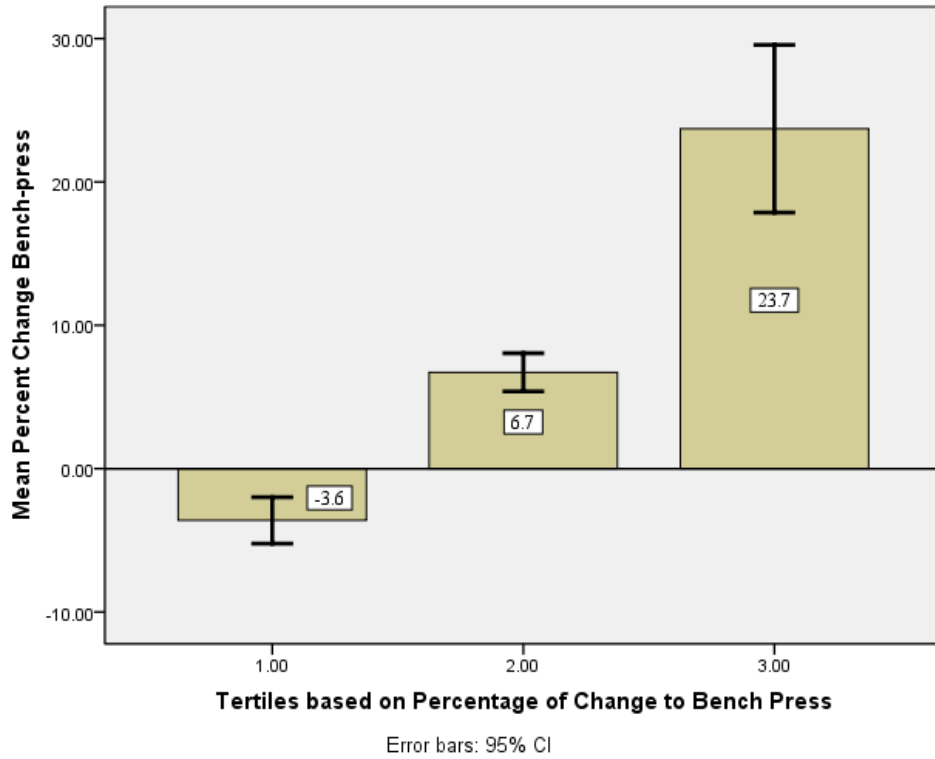


Figure 4.3a. Change in Relative Strength (Bench-press) by Tertiles

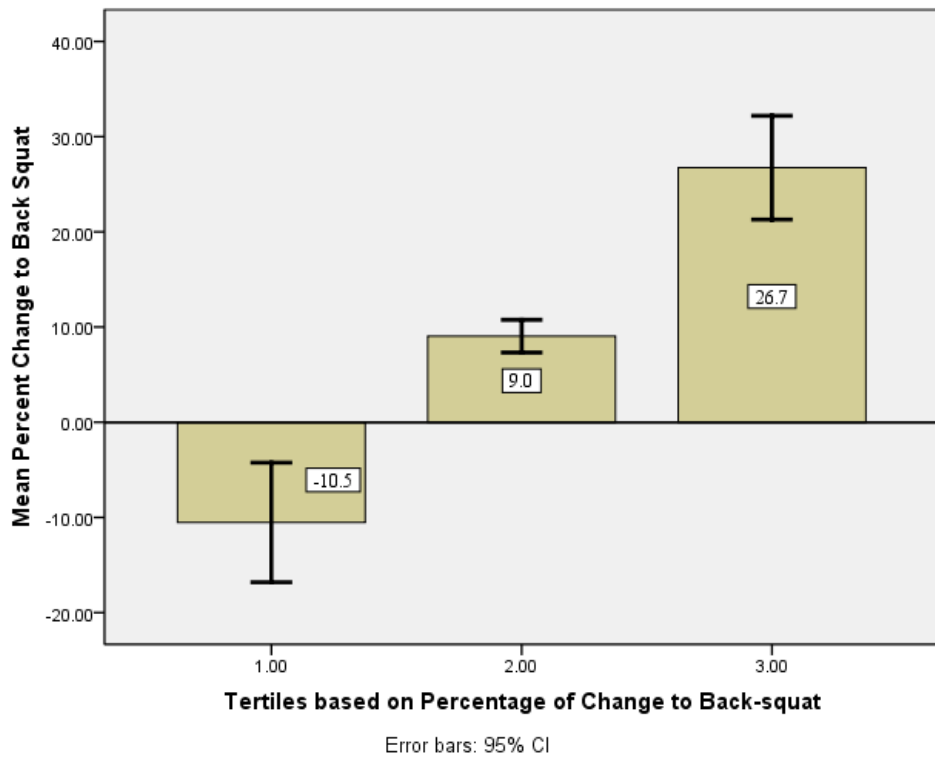


Figure 4.3b. Change in Relative Strength (Back-squat) by Tertiles

There were no significant differences between tertiles based on percentage of change in relative strength as measured by the bench-press for upper extremity and total visits. Although, not significant it does appear that the number of total visits does increase with greater improvements of upper extremity strength. (Fig 4.4).

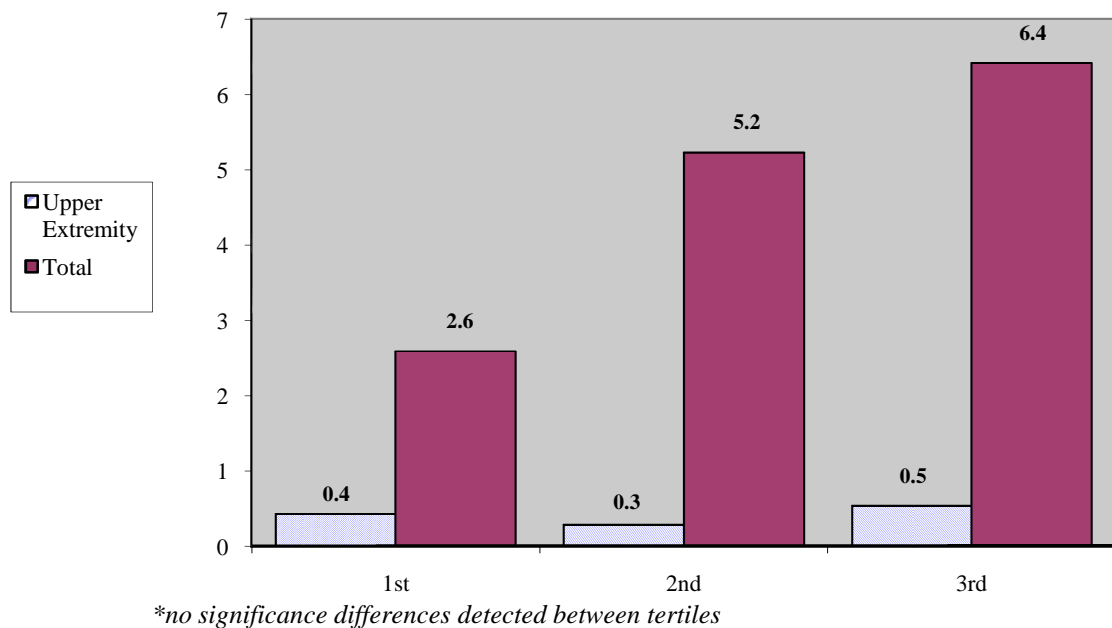


Figure 4.4. Tertiles by change in bench-press versus upper extremity and total visits

There were no significant differences in tertiles based on change in relative strength as measured by the back-squat for the back, lower extremity, and total visits. It does appear that there may have been gradual increases in the number of lower extremity visits associated with greater increases in lower extremity strength (Fig. 4.5).

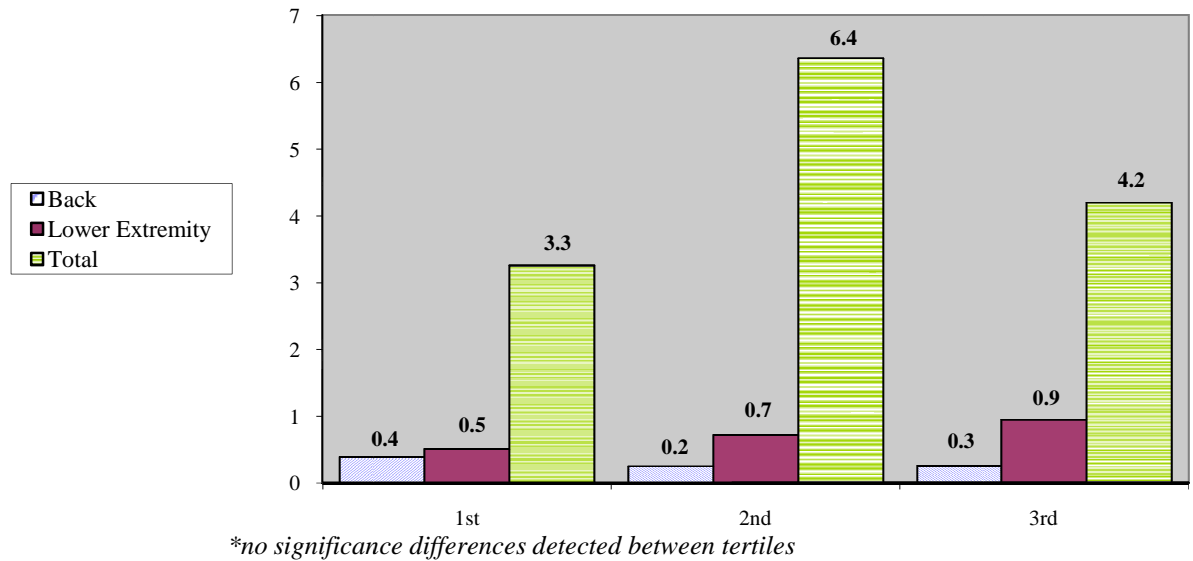


Figure 4.5. Tertiles by change in back-squat versus back, lower extremity, and total visits

Muscular Endurance. There were significant differences between tertiles based on the percentage of change in muscular endurance as measured by push-ups and sit-ups, which occurred during the deployment (Fig. 4.6a and Fig 4.6b). The mean percentage of change in the push-up in the first, second, and third tertiles were respectively -5.4 (95% CI, -11.0 to 0.2), 16.6 (95% CI, 11.1 to 22.0), and 49.0 (95% CI, 43.4 to 54.6). The mean percentage of change in the sit-up in the first, second, and third tertiles were respectively -11.9 (95% CI, -21.6 to -2.1), 11.3 (95% CI, 1.8 to 20.7), and 50.0 (95% CI, 40.3 to 59.8).

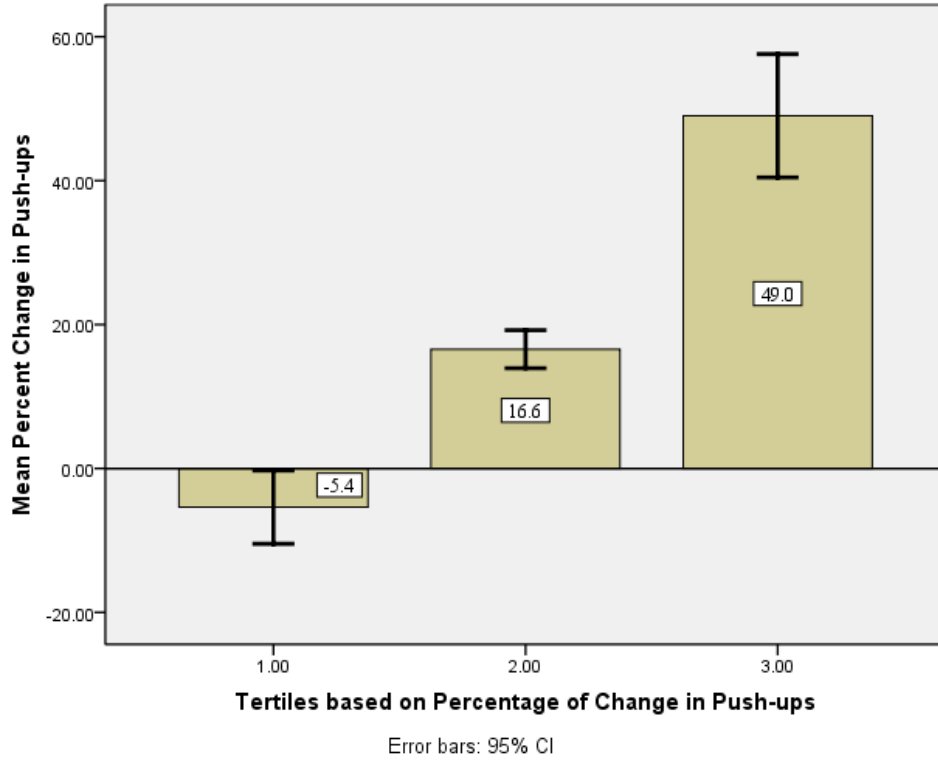


Figure 4 6a. Change in Muscular Endurance (Push-up) by Tertiles

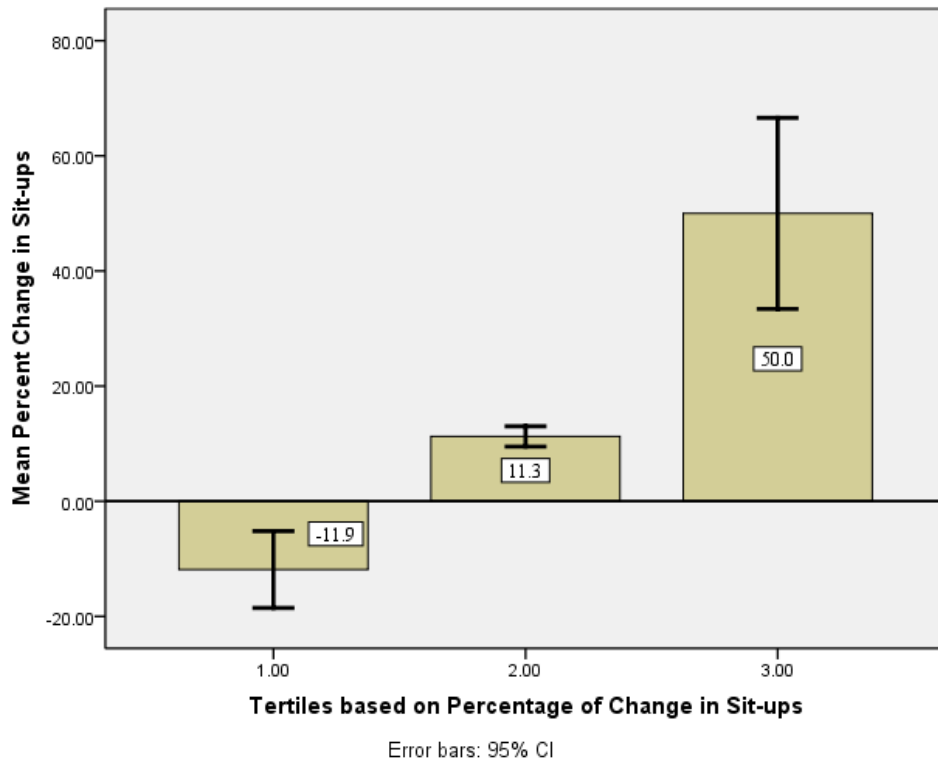


Figure 4 6b. Change in Muscular Endurance (Sit-up) by Tertiles

There were no significant differences between tertiles based on percentage of change in push-ups for upper extremity and total visits (Fig. 4.7). Similar to relative strength as measured by the bench-press, there appears to be an increase in total number of visits associated with increases in upper extremity muscular endurance as measured by the push-up event.

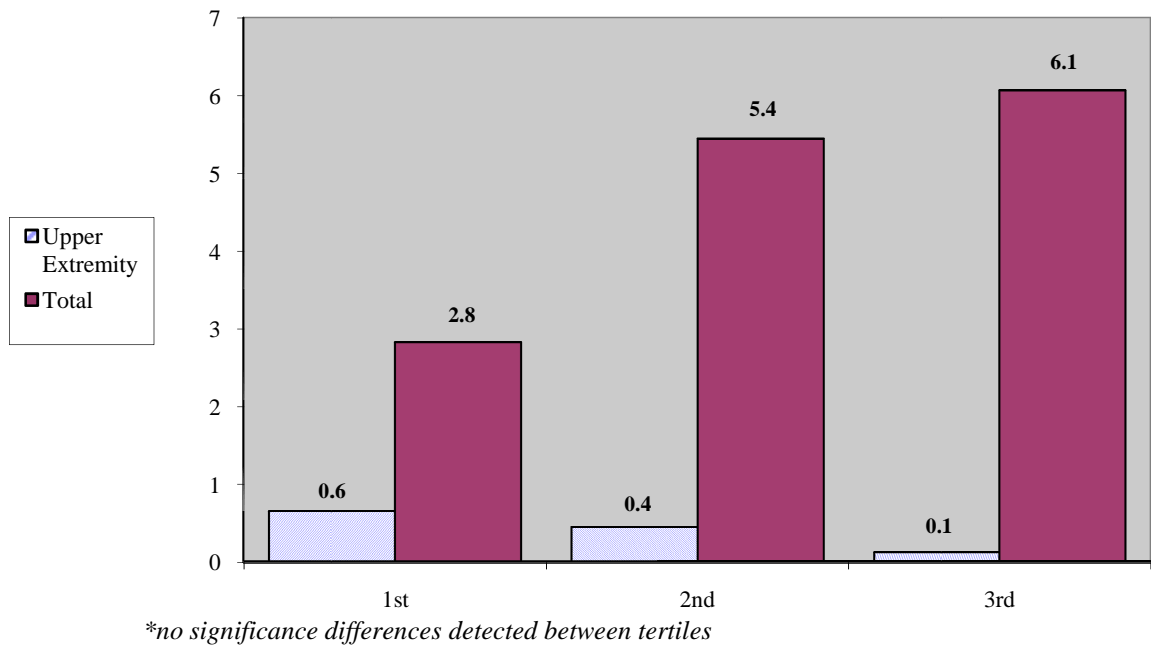
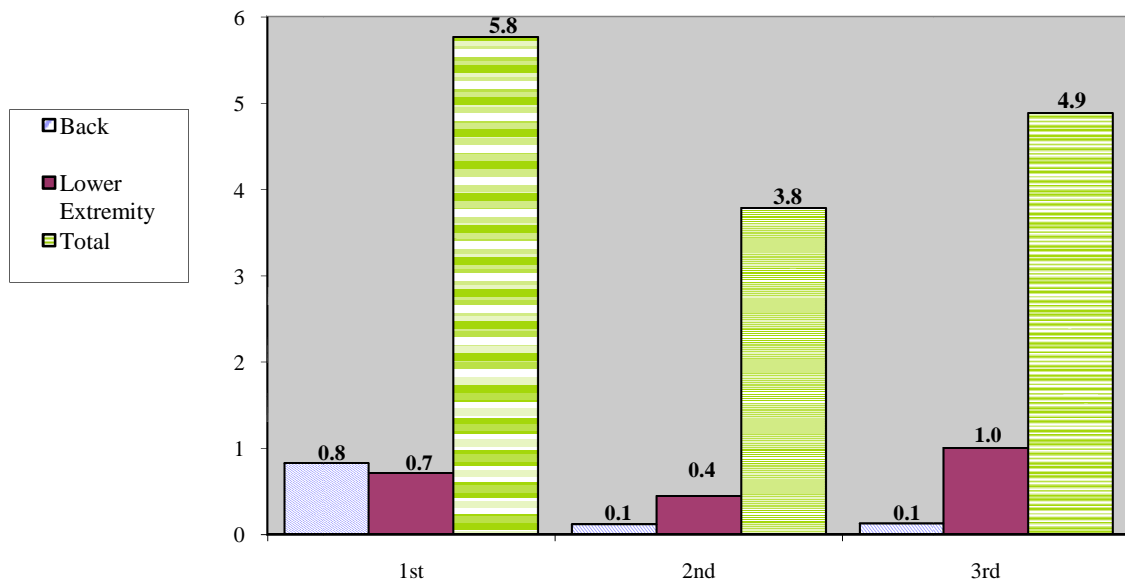


Figure 4. 7. Tertiles by change in push-up versus upper extremity and total visits

There were significant differences between tertiles based on change in sit-ups for the lower extremity, and total visits. There was significant difference detected amongst tertiles in the number of back visits (.80 v .11 v .12, $p=.05$). Those soldiers who had the greatest decline in sit-ups had a significantly higher number of medical visits related to the back (Fig. 4.8).



**significance differences detected between 1st and 2nd tertile, $p=.05$*

Figure 4.8. Tertiles by change in sit-up versus back, lower extremity, and total visits

Peak Power. There were significant differences between tertiles based on the percentage of change in peak power which occurred during the deployment (Figure 4.9). The mean percentage of change in peak power in the first, second, and third tertiles were respectively -17.0 (95% CI, -24.8 to -9.1), -3.2 (95% CI, -11.1 to 4.7), and 15.9 (95% CI, 8.1 to 23.8).

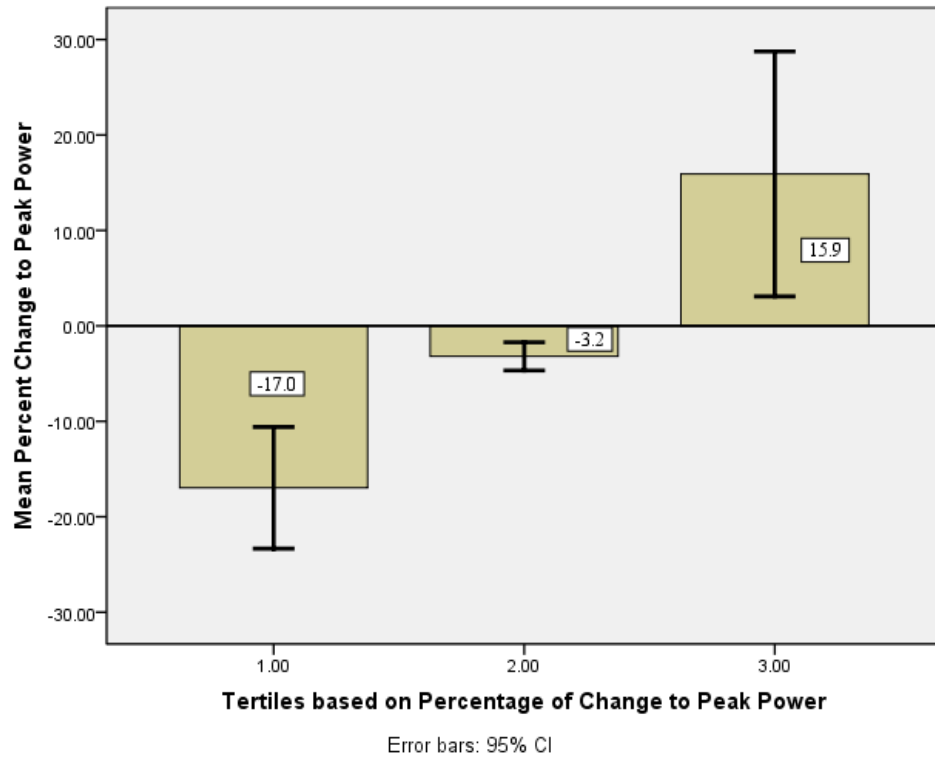


Figure 4.9. Change in Peak Power by Tertiles

There were no significant differences between tertiles based on percentage of peak power change when comparing respiratory, lower extremity, or total visits (Figure 4.10). Although, significance was not reached, the soldiers in the third tertile who increased their peak power by a mean of 16%, had nearly a 72% increase in the total number of visits over the first two tertiles, both of whom declined in their peak power.

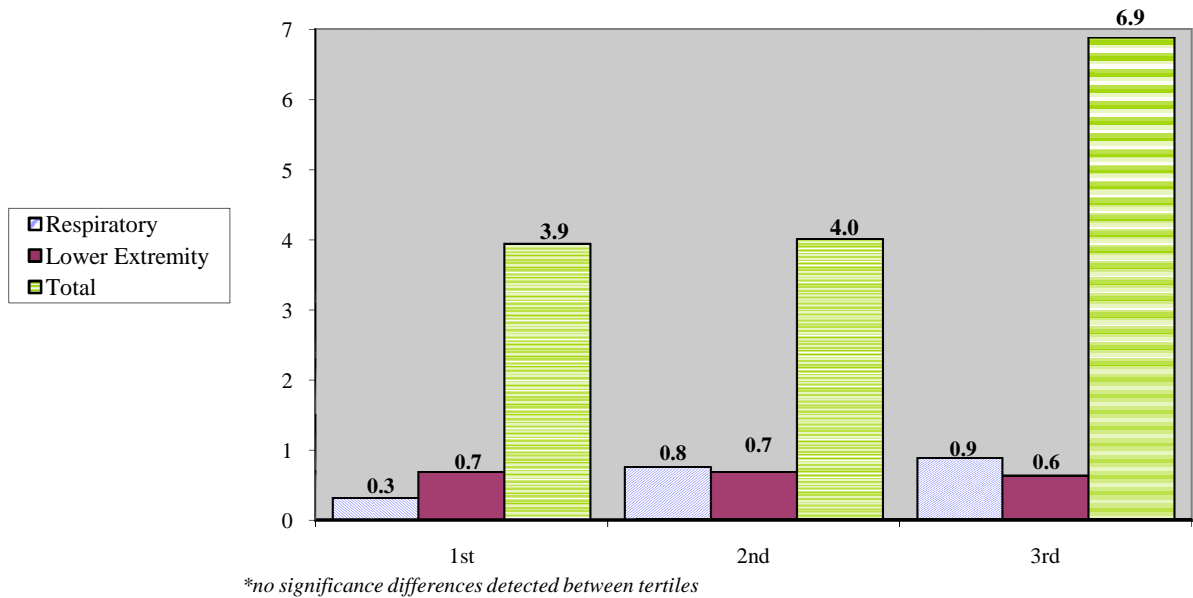


Figure 4.10. Tertiles by change in peak power versus respiratory, lower extremity, and total visits

Cardiorespiratory Fitness. There were significant differences between all three quartiles in their respective percentage of change in cardiorespiratory fitness as determined by the VO₂ peak testing (Fig 4.11). The mean percentage of change in cardiorespiratory fitness in the first, second, and third tertiles were respectively -27.5 (95% CI, -34.9 to -20.2), -11.9 (95% CI, -19.0 to -4.7), and 13.0 (95% CI, 5.6 to 20.3).

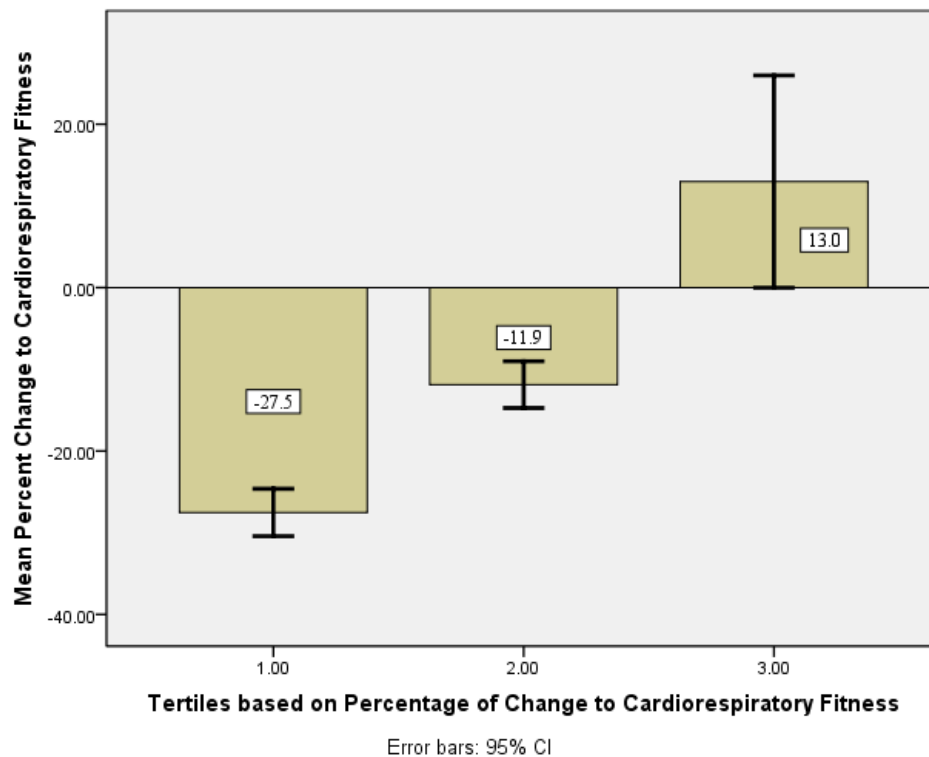
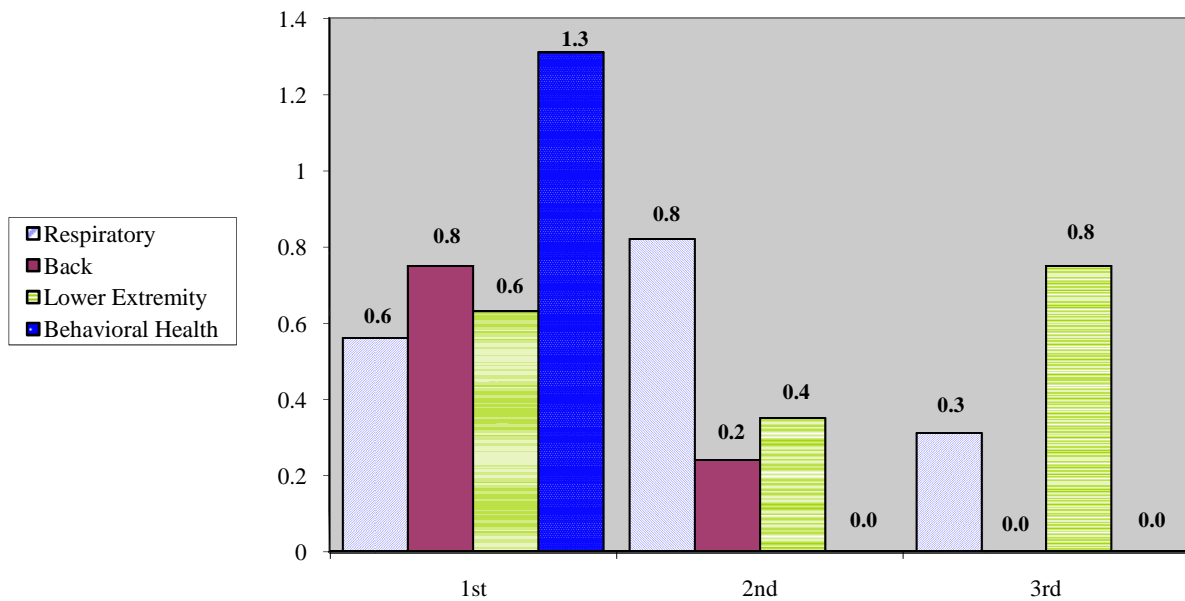


Figure 4.11. Change in Cardiorespiratory Fitness by Tertiles

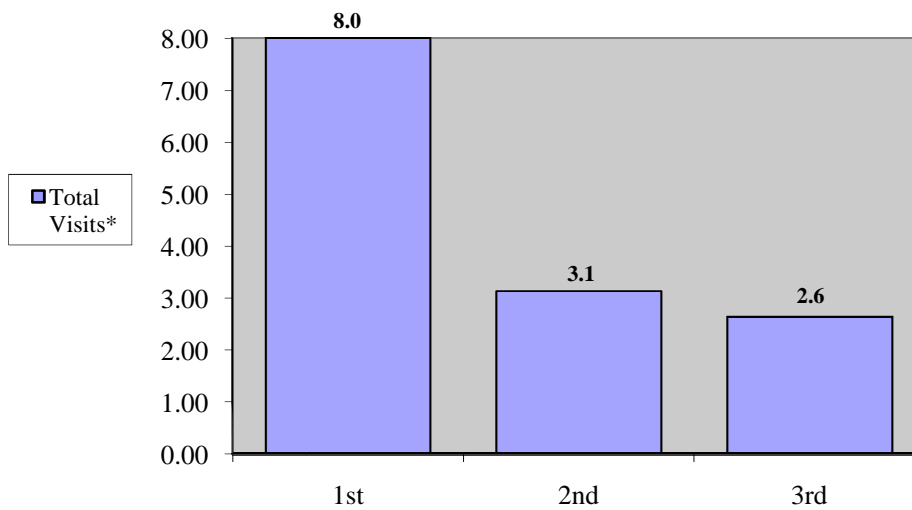
There were no significant differences between tertiles based on percentage change in VO₂ peak for respiratory or lower extremity visits. Significance was approached between tertiles in the number of back visits (.75 v .24 v .00, p=.06), showing that the tertile with the greatest declines in VO₂ peak also had the highest number of back visits. Differences between tertiles for back visits were not statistically significant but a trend is apparent. As the decline in cardiorespiratory function increases, the number of back visits also increases. Differences between tertiles for behavioral health visits were not statistically significant, but it should be mentioned that all of the behavioral health visits occurred in soldiers falling in the tertile with the most significant declines (Fig 4.12).



**no significance differences detected between tertiles*

Figure 4.12. Tertiles by change in cardiorespiratory fitness versus respiratory, back, lower extremity, and behavioral health visits

There were significant differences detected between tertiles in the number of total visits (8.00 v 3.12 v 2.63 total visits, $p=.05$). Those soldiers who had the greatest decline in VO_2 peak had more than twice as many total visits when compared to the other two tertiles (Fig 4.13).



(*significance between 1st and 3rd tertiles, $p=.05$)

Figure 4.13. Cardiorespiratory Fitness versus Total Number of Visits by Tertiles,

Flexibility. There were significant differences between tertiles based on the percentage of change in peak power which occurred during the deployment (Fig. 4.14a, Fig. 4.14b, and Fig. 4.14c). The mean percentage of change in the sit-and-reach in the first, second, and third tertiles were respectively -24.3 (95% CI, -30.9 to -17.8), -2.7 (95% CI, -9.3 to 3.9), and 26.9 (95% CI, 20.1 to 33.6). The mean percentage of change in the shoulder elevation in the first, second, and third tertiles were respectively -23.0 (95% CI, -29.3 to -16.7), 1.5 (95% CI, -5.0 to 8.0), and 37.5 (95% CI, 31.2 to 43.8). The mean percentage of change in the trunk extension in the first, second, and third tertiles were respectively -19.5 (95% CI, -25.5 to -13.5), -8.4 (95% CI, -14.6 to -2.2), and 12.2 (95% CI, 6.2 to 18.2).

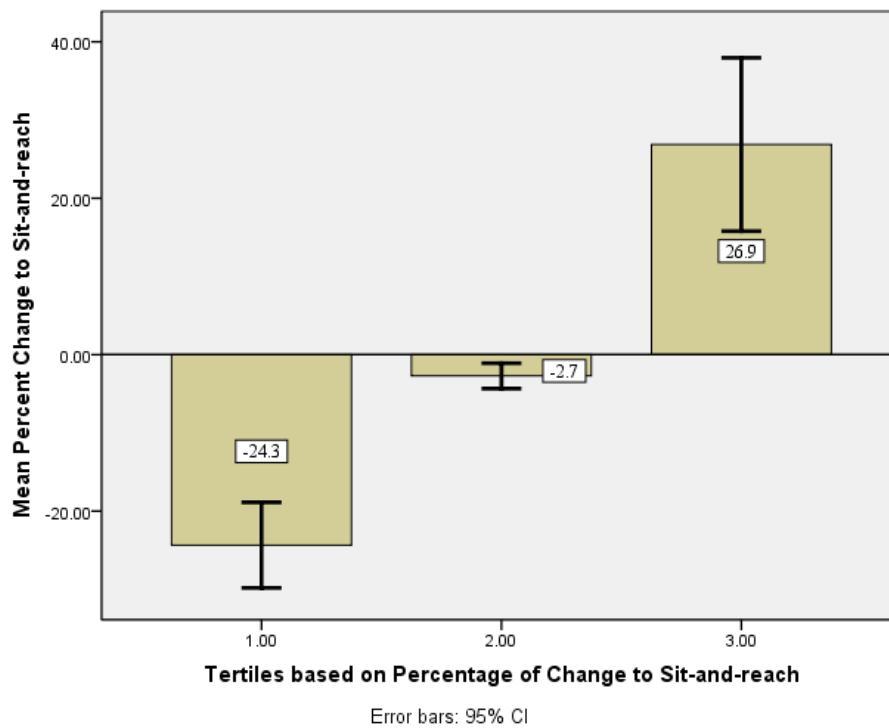


Figure 4.14a. Change in Sit-and-reach by Tertiles

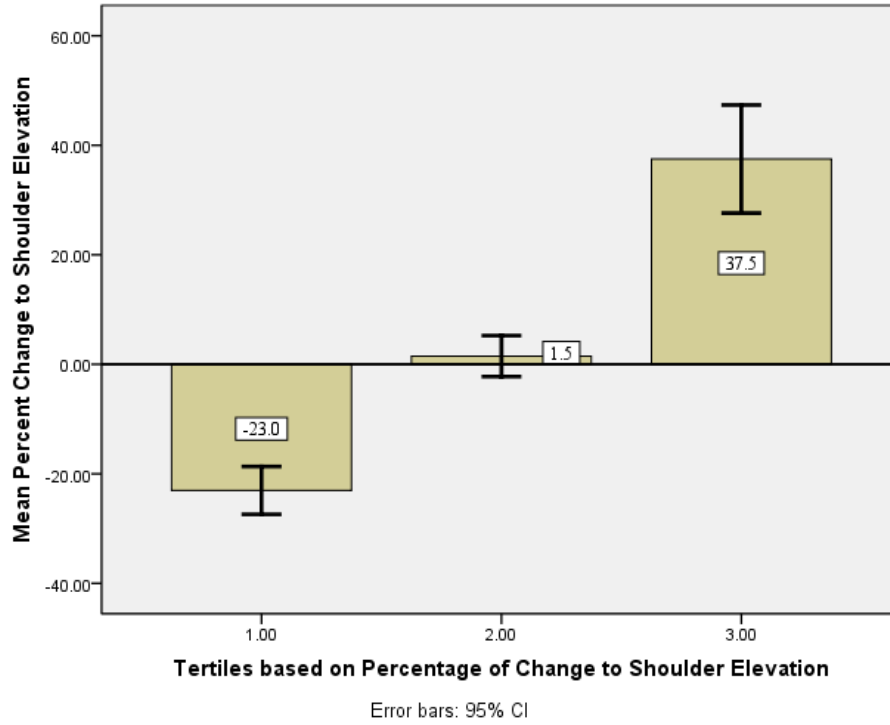


Figure 4.14b. Change in Shoulder Elevation by Tertiles

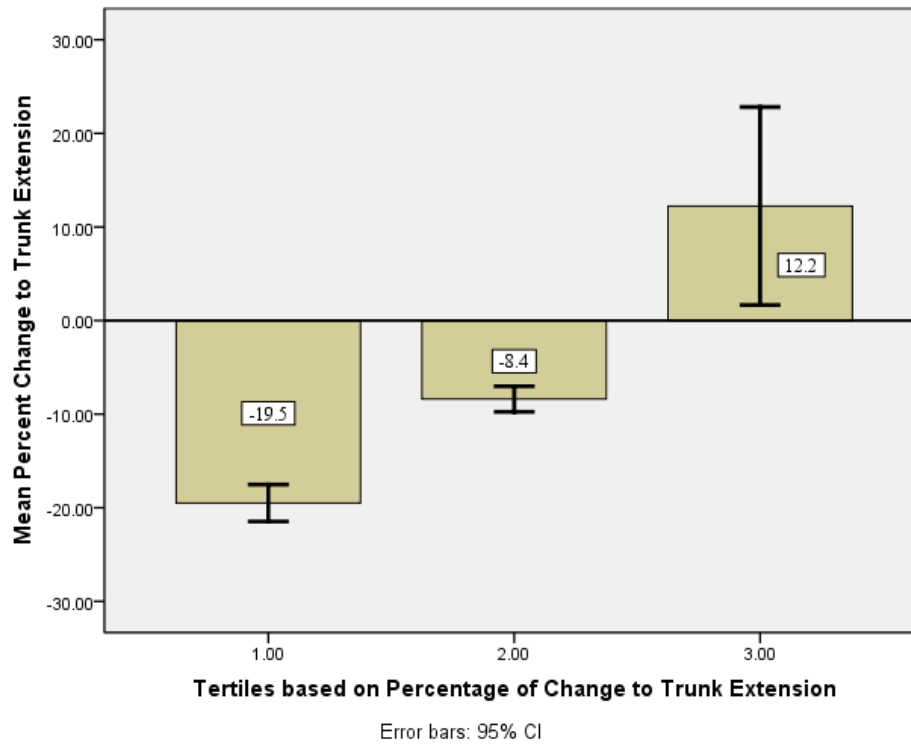
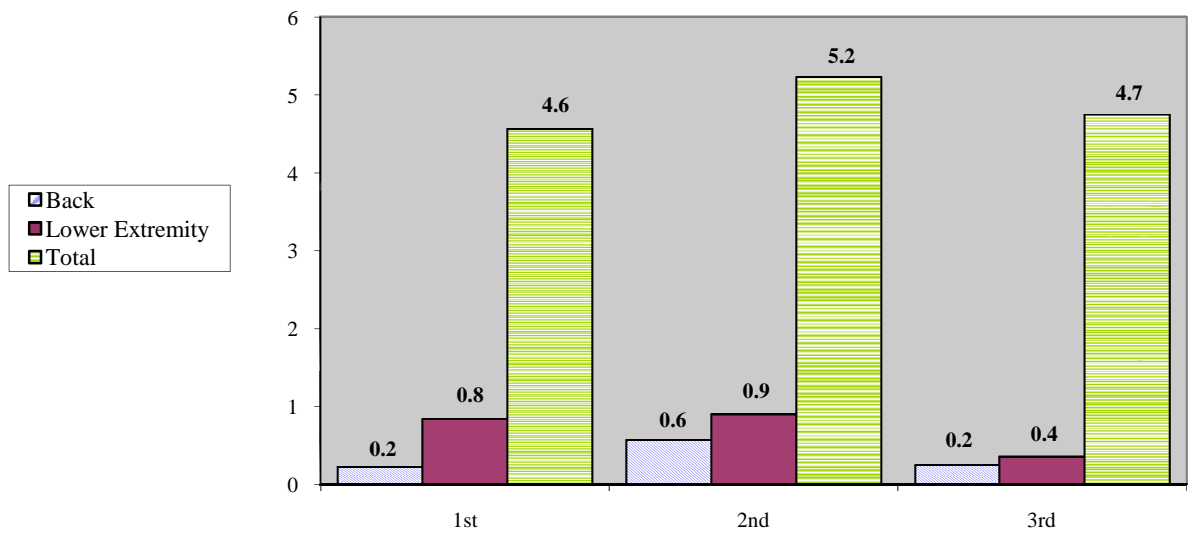


Figure 4.14c. Change in Trunk Extension by Tertiles

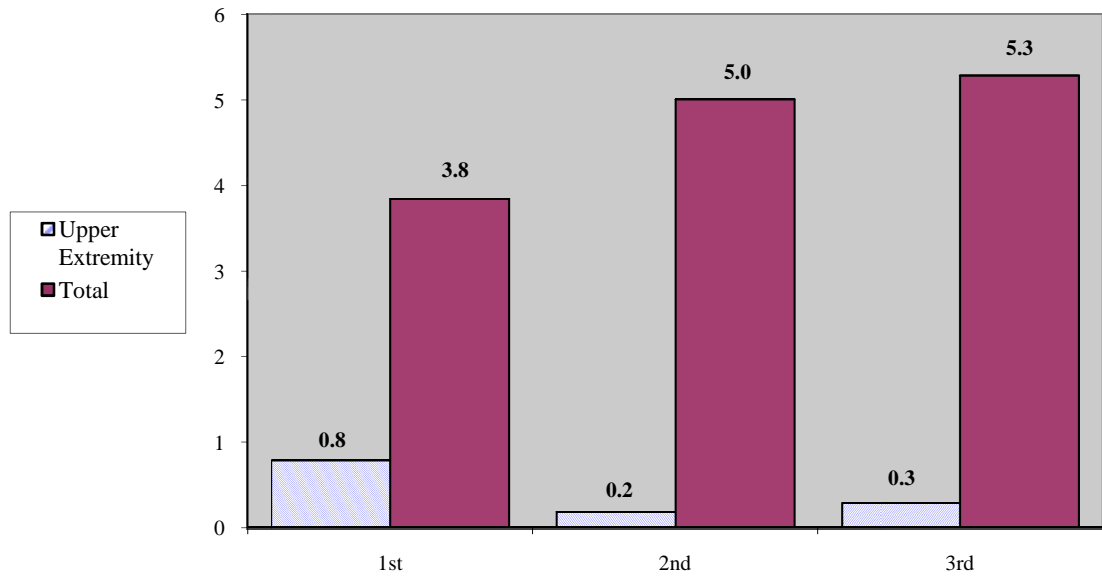
There were no significant differences between tertiles based on percentage of change in the sit-and-reach when comparing the number of lower extremity and total visits. Although sit-and-reach scores were negatively correlated with back visits at post-deployment and percentage of change, there was no significant difference between tertiles when comparing the number of back visits (Fig. 4.15).



**no significance differences detected between tertiles*

Figure 4 15. Tertiles by change in sit-and-reach versus back, lower extremity, and total visits

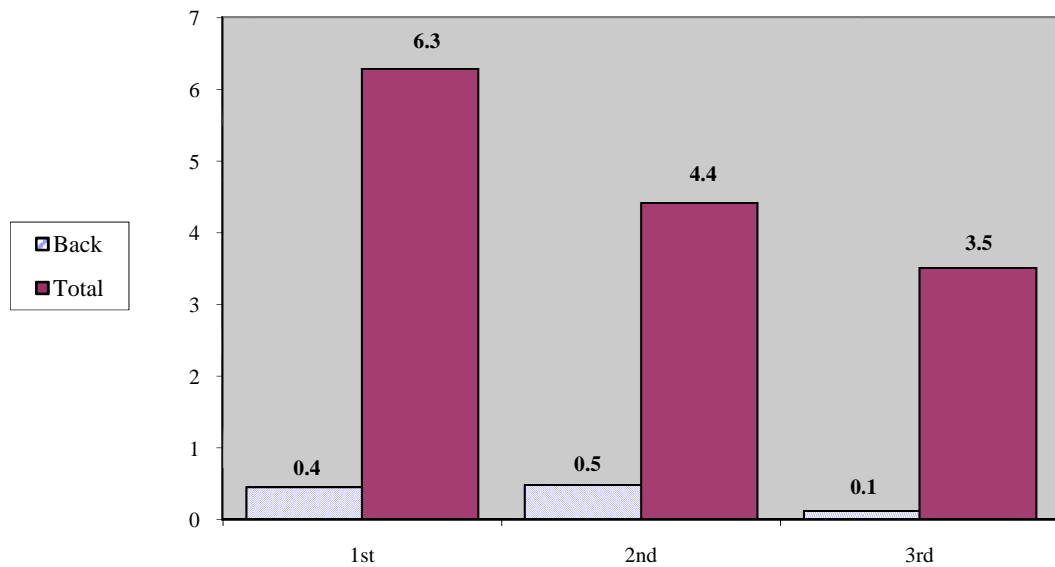
There were no significant differences between tertiles based on change in shoulder elevation when comparing the number upper extremity and total visits. Although not significant, the first tertile has a higher mean of upper extremity visits, indicating that those soldiers experiencing the greatest declines in their shoulder elevation scores also had the highest number of visits related to the upper extremity (Fig. 4.16).



**no significance differences detected between tertiles*

Figure 4.16. Tertiles by change in shoulder elevation versus upper extremity and total visits

Nor was there a significant difference in tertiles based on change in trunk extension when comparing the number of back and total visits. However a trend is noted that the number of total visits decreased with improvements in trunk extension (Fig 4.17.)



**no significance differences detected between tertiles*

Figure 4.17. Tertiles by change in trunk extension versus back and total visits

DISCUSSION

This investigation was effective in answering the two questions which were originally posed. Soldiers' physical fitness levels do change during the course of deployment. Some of these changes in physical fitness levels do maintain a relationship to soldiers' utilization of medical resources. Although it is clear that relationships do exist, this investigation cannot establish causation in most instances of these statistically significant relationships. Further research is certainly warranted to better understand the relationships that this investigation has shown to exist.

Negative changes in physical fitness levels are demonstrated by the significant declines in cardiorespiratory fitness and trunk extension. However, this group of soldiers improved their fitness in a number of different areas to include relative strength (bench press and back squat), muscular endurance (push-ups and sit-ups), and they reduced their percentage of fat mass. At this time, it can only be hypothesized as to why cardiorespiratory function declined while strength and endurance improved. This potentially is the result of soldiers' preferences, available resources while deployed, or a training environment that is not conducive to cardiorespiratory training. When left to their devices, are soldiers selecting to perform resistance training in lieu of aerobic training? Is there an abundance of equipment available for resistance training while there are limited numbers of treadmills? Is the weather, running surfaces, or safety of the soldiers a consideration that deters soldiers from performing aerobic activity

while deployed? These are questions that certainly can be answered with future research focused on physical activity levels in soldiers while they are deployed.

Significant negative relationships were detected between the percentage of change in fat mass and gastrointestinal visits ($r=-0.37$, $p=.01$), sit-and-reach scores and lower extremity visits ($r=-0.33$, $p=.02$) shoulder elevation scores and upper extremity visits ($r=-0.36$, $p=.01$), cardiorespiratory fitness and back visits ($r=-0.31$, $p=.03$) as well as behavioral health visits ($r=-0.28$, $p=.05$). The strongest correlation was actually seen between the post-deployment cardiorespiratory fitness score and total visits ($r=-0.45$, $p=.001$). Most of these correlations constitute a moderate relationship and do support that plausible relationships exist between soldiers' declining fitness and their increased utilization of medical resources. These correlation coefficients demonstrate that improved levels of physical fitness maintenance during deployment are related to a decreased use of medical resources by soldiers. By continuing to add to this current body of data, these relationships may prove to be stronger than what is reported here due to increased statistical power. Additional relationships may also become apparent with increased numbers of subjects studied.

When evaluating the relationship between increased gastrointestinal visits and increased declines in fat mass, it is suspected, but cannot be confirmed, that the decreased fat mass is a result of the gastrointestinal complaints. This could be a direct relationship in that the symptoms of the gastrointestinal illness led to a lower percentage of body fat. A more indirect relationship could also exist. As a soldier experiences more gastrointestinal distress, their choices of food intake

may have been altered in such a fashion that ultimately resulted in loss of fat mass. To establish the causative factor in this relationship body composition measures would need to be done throughout the deployment in order to determine at which point in relation to gastrointestinal complaints the declines in fat mass began.

Similarly this is also the case when looking at the negative correlations between sit-and-reach scores and lower extremity visits and shoulder elevation scores and upper extremity complaints. In both cases, it is possible that an injury of the respective extremity resulted in a decline in flexibility. However, in the instance of the sit-and-reach, there has been prospective research in occupational or training environments that demonstrated a link between a low sit-and-reach score and a higher prevalence of injury (Craig et al., 2006).

Pre-deployment trunk extension scores maintained a positive correlation to back visits ($r=.32$, $p=.02$). The fact that this measurement was done prior to any of the inventoried visits would indicate that causation exists between increased mobility and back complaints. This is supported by previous research that demonstrated increased spine mobility puts men at higher risk of first time back injury (Biering-Sorenson, 1984). The trunk extension test used in this study essentially demonstrates higher levels of abdominal and back flexibility. Scores at pre-deployment were positively correlated to back visits indicating that a more mobile back in this population of soldiers leads to higher risk of back injury.

The significant relationship between declining cardiorespiratory fitness and increased utilization of medical resources for back visits ($r=-0.31$, $p=.03$) is

consistent with previous findings in firefighters which showed much higher rates of back injury in the individuals with the lowest level of fitness. In the previous research evaluating for increased risk of back injury, three of the five components of fitness measured were directly reflective of cardiorespiratory fitness. Those with poorest overall results were at the highest risk of back injury (Cady et al., 1979).

Despite the lack of a statistically significant correlation between peak power and any of the evaluated categories of medical resources utilized, it appears that the soldiers who demonstrated the greatest increases in power also had a higher number of total medical visits. This investigation team has hypothesized that this increase in lower extremity power could be the result of their physical training or the result of required occupational tasks. Moving quickly with the load of body armor may result in improved power, while at the same time be leading to more injuries or stress related illness. This hypothesis could also explain why increases in strength offered no improvements in utilization of medical resources. Occupational activities that result in improved strength may also result in increased utilization of medical resources. These relationships could be better understood with more objective measures of physical activity of soldiers during the deployments.

Although this population of soldiers demonstrated improvements in relative strength as a whole, there were no significant correlations in strength at pre or post-deployment or change in strength and any of the inventoried medical variables. It appears that greater declines in their level of cardiorespiratory fitness

are related to higher utilization of medical resources for total purposes. This is particularly apparent in the bottom third of soldiers when categorized based on their level of change in fitness over the course of the deployment. This consistent with the finding of multiple studies that have shown that lower levels of cardiorespiratory fitness are related to higher levels of injury and illness (Reynolds et al., 1994; Pleban, Thomas, & Thompson, 1985). This data supports these previous findings by demonstrating over a 150% increase in total medical visits (8.0 v 3.1 v 2.6 total visits) when comparing the bottom third to the other two tertiles.

It is also interesting that all behavioral health visits occurred in soldiers categorized into the tertile with the most significant declines in cardiorespiratory fitness. This is consistent with previous research that demonstrated an increase in depressive symptoms associated with declines in cardiorespiratory fitness (Berlin, Kop, & Deuster, 2006). Additional research has found that higher levels of physical fitness even help attenuate the affects of stress due to sustained operations (Pleban, Thomas, & Thompson, 1985). Could it be possible for soldiers to mediate their stressors by maintaining their cardiorespiratory fitness during deployment resulting in fewer behavioral health visits? The findings of this research leads to the consideration that aerobic training is not only beneficial for overall physical health but also for one's mental health. If military leaders were made aware of this relationship between cardiovascular fitness and increases in behavioral health visits they would also maintain the potential to help attenuate some of the stressors related to deployment through their physical fitness training.

The potential exists for leaders to better identify soldiers who are struggling with behavioral health issues if they were to utilize the observation of a soldier's steep decline in cardiovascular performance as a red flag that may warrant further investigation into that soldier's behavioral health.

It would appear that these soldiers may have been performing resistance training at the expense of their aerobic training as demonstrated by the significant declines in cardiorespiratory while demonstrating improvements in strength and endurance. Seeing that strength was not correlated to the medical variables, nor was there any significance in medical utilization by tertiles based on strength, it could be perceived that military leadership may need to guide their soldiers in performing a balance of resistance training and aerobic activity in an effort to at least maintain pre-deployment levels of cardiorespiratory fitness. Conditions while deployed may not be ideal for cardiovascular exercise, but the act of running on a treadmill or riding a stationary bicycle may provide a much needed outlet for these soldiers stress.

Although some of the measured fitness variables were not significantly correlated to the medical variables, the investigation team feels that they are still valuable in the assessment of soldiers. With a larger population of soldiers more medical visits would have been inventoried and more significant correlations may have been detected. In many instances, there was clearly a trend demonstrating that greater declines in fitness resulted in higher utilization of medical resources. Due to the overall low number of visits in the specified category significant

correlations or significant differences between tertiles were not achieved. This can be remedied by further research adding to this limited collection of data.

With the results of this research made available, military leaders may be able to adjust their physical fitness training at pre-deployment and during the deployment in order to further decrease the burden on the medical resources and maintain the health of their soldiers. For example, simple changes to stretching protocols during deployments may prevent a decline in sit-and-reach scores while decreasing the number of back injuries. A more dramatic decline in medical resource utilization could be seen if leaders were able to ensure that their soldiers maintained their pre-deployment level of cardiorespiratory fitness. Lower levels of cardiorespiratory function have already been shown to be associated with higher levels of injury and illness in the training environment (Gardner et al., 1996; Reynolds et al., 1994; Knapik et al., 1993). This investigation supports the occurrence of such a relationship while deployed to a combat zone.

Clearly more research is needed to better understand the physical activity levels and training regimens of soldiers while they are deployed. This will provide insight that will help us better understand the findings of this investigation. With a better understanding of soldiers' activity levels during deployment, a clear explanation of why cardiorespiratory fitness declines, while relative strength improves can be provided. Could this finding be a result of the soldiers' occupational requirements while deployed or a result of the choices they are making during their physical training?

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Chapter 5

CONCLUSION

This study was designed to evaluate the physical fitness levels before and after a long term combat deployment in an effort to determine what types of changes are occurring in the physical fitness of soldiers. Additionally, the research was intended to explore for potential relationships between physical fitness levels or changes in physical fitness and medical resource utilization. Additionally, this data set offered the ability to make comparisons between National Guard soldiers to their active duty counterparts and to draw some general conclusions.

What makes this investigation particularly valuable is that it explores the relationship between physical fitness and medical resource utilization in a population of soldiers who are serving in an actual combat environment. The soldiers in this study are men and women living amongst the general population of civilians but also participated in the ongoing war as soldiers in the Arizona National Guard. These soldiers deployed to a foreign land and performed their duties in less than desirable conditions. The effects that have been discussed are not hypotheses or theorized, they are a true representation of how the combat experienced changed their physical fitness. This data is “real” in that there is no training scenario assumptions that need to be translated to the combat scenario because the data comes from the aforementioned combat scenario. The authors of this investigation know of no other publications that have provided similar analysis or results.

IMPLICATIONS

Comparison to Active Duty

This is a novel study because it provides previously unknown descriptive data on physical fitness in a reserve component of the armed forces. Considering that AZNG soldiers have very different lifestyles as compared to an active duty service member, one might expect to see differences in pre-deployment physical fitness levels when compared to active duty service members. While active duty service members typically meet four to five times per week for organized group physical fitness training, the AZNG soldiers may only meet for one weekend per month. In the three months prior to deployment, known as the pre-mobilization period, an AZNG unit may train on a daily basis.

Body Composition. The AZNG males did demonstrate a higher body fat percentage (22.2%) than what was reported by Sharp et al. 2008 (17.7%) and Lester et al. 2010 (18.9%) in active duty soldiers prior to serving their deployment. This higher body fat percentage in this population may be partially explained as a function of age or may be the result of differences in measuring techniques. The mean age of the males in this study was 27 years old while Sharp et al. and Lester et al. reported respective mean ages of 23 and 24 years old. The females in this study were of the same age but demonstrated a mean body fat percentage of 26.5 to which there is no comparable data. Both of the previous studies used DEXA for measuring body composition. Research has shown that there may be a difference of 2% when comparing measured fat mass (FM) using

the DEXA versus the Bod Pod (Ball & Altona, 2004; Collins et al., 1999). This could account for the differences in FM reported between this study and others.

Muscular Strength. The combined mean scores of the men for absolute strength were actually higher than those reported by Lester et al. for the 1RM bench and squat (88.0 kg and 111.6 kg vs 79.1 kg and 99.7 kg). Not only was the mean scores of males alone higher, but the combined mean scores of males and females were higher (82.2 kg and 104.6 kg). This discrepancy in reported strengths amongst the males may be partially explained by an overall increased size in this population of males in the AZNG. The males in this research had a mean weight of 85.7 kg with respective absolute upper and lower body strength of 88.0 and 111.6 kg. Lester et al. reported a mean weight of 76.6 kg and respective absolute upper and lower body strength of 79.1 and 99.7 kg. When these values are evaluated from a relative perspective (kilograms lifted/kilograms of body weight), the values are nearly identical for 1RM bench (1.03 v 1.03 kg/kg body wt) and 1RM squat (1.33 v 1.30 kg/kg body wt).

Muscular Endurance. Neither of the recent studies that assessed pre-deployment physical fitness in active duty soldiers published results of the muscular endurance assessments using the APFT. The mean of men and women in this study showed that they meet current Army standards in the push-up and sit-up events, based on the mean age and respective gender. Men between the ages of 22-26 must complete 40 push-ups and women must complete 17 push-ups to achieve the minimal passing score. Men and women between the ages of 22-26

must complete 50 sit-ups to achieve the minimal passing score (Department of the Army, 1992).

Power. Sharp et al 2008 utilized a vertical jump to assess lower extremity power and a ball put for upper extremity power. Lester et al 2010 assessed lower extremity power with squat jump and upper extremity power using a bench throw. This investigation team felt it important to assess lower extremity power because of the importance while performing combat duties. Soldiers are frequently expected to perform short bouts of running at maximal speeds while under load in an effort to escape harm. It was agreed upon by this investigation team that the best evaluation of power to assess a soldier's performance under the previously described scenario could be done with Wingate cycle test. Ideally, future researchers will select a similar technique in order to compare data between populations using similar tests.

Cardiorespiratory Fitness. The combined average of men and women for VO₂ peak (48.9 ml/kg/min) was similar to that reported by Sharp et al. (50.8 ml/kg/min) and Lester et al. (48.6 ml/kg/min) for active duty males. Thus the subjects in this study have demonstrated that they have cardiorespiratory fitness equal to that of the active duty counterparts.

Flexibility. This investigation included an evaluation of flexibility using the sit and reach, but also the shoulder elevation and trunk extension measures. Flexibility measures were not previously included in similar investigations. There are no current Army standards for these types of assessments. However, standard values have previously been published for the general population. The male's

mean pre-deployment scores in the sit and reach place them between the 30th-50th (25-31 cm) percentile, while the women fall between the 50th-70th percentile (41-53 cm) (Acevedo, 2003). The scores for the shoulder elevation are similar by placing the males between the 30th-50th percentile (135-175 cm) and the females in the 50th-70th (173-216 cm) (Acevedo 2003; Johnson & Nelson, 1986). Trunk extension values at pre-deployment measurements put both men and women within the range of the 70th-90th percentile (M=109-124 cm; F=107-119 cm) (Acevedo 2003; Johnson & Nelson, 1986).

Based on the standard values established for the general population, it appears that the males in this study maintain a below average to average level of flexibility of the upper and lower extremity while the females maintained higher levels ranging from average to above average. Military leaders can use this information to implement changes to their current training protocols that would put additional emphasis on stretching techniques in order to improve current flexibility levels.

Overall. Based on a comparison of the reported data the AZNG soldiers have demonstrated that they are as physically prepared for the combat experience as their active duty counterparts when similar measures of fitness are used for comparison.

Change in Physical Fitness

The results from this study indicate physical fitness changed during combat deployments in AZNG soldiers. Negative changes in physical fitness levels are demonstrated by the significant declines in cardiorespiratory fitness and

trunk extension. However, this group of AZNG soldiers improved their fitness in a number of different areas to include relative strength (bench press and back squat), muscular endurance (push-ups and sit-ups), and they reduced their percentage of fat mass. Some of these changes were comparable to those reported for active duty soldiers.

Body Composition. Lester et al. and Sharp et al. both report increased FM over the course of the deployment. Lester et al. reported an increase in FM by 9% while Sharp et al. reported an increase of 11% as measured by DEXA. The AZNG actually improved body composition by decreasing measurable FM. Explaining why the AZNG improved their body composition while active duty soldiers declined is difficult. Obviously, there is a difference amongst the populations that have been studied. Changes in FM could have been influenced by the meals provided to or selected by the soldiers. Determining the influence meals provided requires additional research to include dietary recall surveys while deployed in order to estimate caloric intake.

Both Lester et al. and Sharp et al. reported a lower mean FM at pre-deployment (18.9% and 17.7%) compared to what has been reported at pre-deployment in this study (22.0%). The AZNG soldiers realized an overall decline in FM while the active duty soldiers in the Lester et al. and Sharp et al. studies increased their percentage of FM. This may represent a scenario similar to a regression to the mean. Potentially, the active duty population maintained a higher level of physical activity prior to deployment than that of the AZNG soldiers. Upon deploying, the AZNG soldiers experienced a possible increase in

physical activity while the active duty soldiers may have experienced a reduction in their daily physical activity levels. This may explain why the post-deployment levels of FM in the AZNG soldiers (20.0%) were closer to the values seen by Lester et al. (19.9%) and Sharp et al (19.5%) than the aforementioned pre-deployment values.

Muscular Strength. The AZNG demonstrated significant increase in upper and lower body strength (7% and 10%) similar to what was reported by Lester et al (7% and 8%). Sharp et al. reported no significant gains in strength. This increase for the AZNG may be the function of resistance training of their own choice or it may be a side-effect of their occupational duties. As civilians, their occupation may require little to no physical activity. While performing their duties in a combat zone they may be performing activities that result in similar gains to what might be seen with a resistance training program. Additional research which provided a better estimate of soldiers' physical activity at pre-deployment and during deployment may provide an explanation as to why soldiers are getting stronger while deployed.

Muscular Endurance. This study is the first to include muscular endurance as a component of physical fitness testing in deployed soldiers. The AZNG soldiers demonstrated significant increases in both the push-up (16%) and sit-up (11%) events. Based on the mean number of repetitions and the mean age of the men and women in this study, both genders achieved a passing score in both the push-up (M=40, F=17) and sit-up (M/F=50) events by the APFT standards before and after deployment. At pre-deployment the mean number of

push-ups for the males (54 repetitions) provides them a score of 76 of 100 possible points while their post-deployment push-ups (62 repetitions) increases their score to 85 points. The women increased their number of repetitions from 31 to 43 resulting in an increase in their points from 79 to 94. Sit-up scores are not distinguished by gender. The men improved from 55 to 61 sit-ups resulting in an increase in their points from 67 to 75. The women increased their repetitions from 51 to 59 resulting in an increase in their points from 61 to 72 (Department of the Army, 1992). These scores are not only indicative of increases in soldiers' muscular endurance, but they also result in an increased chance of promotion for the soldiers who are improving their scores. Physical fitness test scores are one component that is considered when soldiers are being evaluated for promotion to a higher rank.

Cardiorespiratory Fitness. The AZNG had declines in aerobic capacity similar to what was reported by the other two investigation teams. In fact the decline of -9.9% falls in between previously reported results of declining cardiorespiratory fitness which ranged from -4.5% to -13% (Lester et al., 2010; Sharp et al., 2008). The findings of these three studies deserve future investigation as to why soldiers' cardiorespiratory fitness declined across the board. It is concerning that soldiers' were not performing cardiorespiratory training at a level that will allow them to maintain their pre-deployment cardiorespiratory fitness. Why this is this occurring? Do soldiers prefer other activities in lieu of cardiorespiratory training? Do soldiers feel that the environment or facilities is not conducive with cardiorespiratory training? After

determining why this is occurring, then military leaders may be able to implement protocols to prevent these declines in order to maintain pre-deployment fitness. This may require a decrease in the soldiers' autonomy when it comes to their physical fitness training in order to preserve or improve their health.

Flexibility. Although the soldiers in this study demonstrated very little change in flexibility over the course of the deployment, this study allows us to compare the results of participating soldiers to previously published values. For men, the mean pre and post-deployment scores in the sit and reach place them between the 30th-50th (25-31 cm) percentile, while the women fall between the 50th-70th percentile (41-53 cm) (Acevedo & Starks, 2003). The scores for the shoulder elevation are similar by placing the males between the 30th-50th percentile (135-175 cm) and the females in the 50th-70th (173-216 cm) (Acevedo & Starks, 2003; Johnson & Nelson, 1986). Although trunk extension was the only component of flexibility where the soldiers demonstrated significant change, the pre and post deployment levels both fell within the range of the 70th-90th percentile (M=109-124 cm; F=107-119 cm) (Acevedo & Starks, 2003, Johnson & Nelson, 1986).

Overall. These findings could be interpreted in a number of ways. While increased strength was noted in this study and by Lester et al., Sharp et al. reported no significant difference in strength. Declines in soldiers' cardiorespiratory fitness with an increase in strength could be the result of an emphasis being placed on cardiorespiratory training prior to deployment without the same emphasis being maintained through the extent of the deployment. These

differences could also be the result of more time being spent on resistance training at the expense of cardiorespiratory training during the course of the deployment.

There was not a rigid or structured training program associated with this investigation. Soldiers deployed to a combat zone were expected to exercise in accordance with the guidelines that their chain of command provides. The changes in AZNG fitness levels likely reflect the individual choices about which types of training that the soldiers chose to conduct during deployment. It appears that decreased aerobic capacity is a common trend amongst soldiers during combat deployments. The reasoning for this is not well understood and raises more questions. Are soldiers not motivated to perform aerobic training independently? Do soldiers perceive that the fitness facilities do not have suitable equipment for aerobic training available? Are the environmental conditions on the bases not suitable for performing aerobic training outside? Knowing how important aerobic fitness is to overall health and combat readiness, clearly more research should be done to determine why this decline in cardiorespiratory fitness is occurring during deployment.

Medical Resource Utilization

Significant negative relationships were detected between the percentage of change in fat mass and gastrointestinal visits ($r=-0.37$, $p=.01$), sit-and-reach scores and lower extremity visits ($r=-0.33$, $p=.02$) shoulder elevation scores and upper extremity visits ($r=-0.36$, $p=.01$), cardiorespiratory fitness and back visits ($r=-0.31$, $p=.03$) as well as behavioral health visits ($r=-0.28$, $p=.05$). Most of these correlations constitute a moderate relationship. These correlation

coefficients demonstrate that improved levels of physical fitness maintenance during deployment are related to a decreased use of medical resources by soldiers.

When evaluating the relationship between increased gastrointestinal visits and increased declines in fat mass, it is suspected, but cannot be confirmed, that the decreased fat mass is a result of the gastrointestinal complaints. This could be a direct relationship in that the symptoms of the gastrointestinal illness led to a lower percentage of body fat. A more indirect relationship could also exist. As a soldier experiences more gastrointestinal distress, their choices of food may have been altered in such a fashion that ultimately resulted in loss of fat mass. To establish the causative factor in this relationship, additional research is required. Food logs or dietary recall surveys could be utilized over the course of the deployment in order to evaluate the relationship of the gastrointestinal complaints and the dietary intake at the time of the complaint.

Similarly this is also the case when looking at the negative correlations between sit-and-reach scores and lower extremity visits and shoulder elevation scores and upper extremity complaints. In both cases, it is possible that an injury of the respective extremity resulted in a decline in flexibility. However, in the instance of the sit-and-reach, there has been prospective research in occupational or training environments that demonstrated a link between a low sit-and-reach score and a higher prevalence of injury (Craig et al., 2006). It is suspected in the instance of these soldiers that a combination of events occurred which led to this negative correlation. In some instances soldiers' poor flexibility led to their injury, while in other instances their injury without proper rehabilitation led their

decreased flexibility. The combination of these occurrences likely resulted in the statistically significant negative correlation. With future research, it is recommended that measurements be taken during the course of the deployment in order to establish causation between flexibility measures and injuries.

Pre-deployment trunk extension scores maintained a positive correlation to back visits ($r=.32$, $p=.02$). The fact that this measurement was done prior to any of the inventoried visits would indicate that causation exists between increased mobility and back complaints. This is supported by previous research that demonstrated increased spine mobility puts men at higher risk of first time back injury (Biering-Sorenson, 1984). The trunk extension test used in the Biering-Sorenson study was different than the trunk extension test used in this research, but both essentially measure levels of abdominal and back flexibility. Scores at pre-deployment were positively correlated to back visits indicating that a more mobile back in this population of soldiers leads to higher risk of back injury.

The significant relationship between declining cardiorespiratory fitness and increased utilization of medical resources for back visits ($r=-0.31$, $p=.03$) is consistent with previous findings in firefighters which showed much higher rates of back injury in the individuals with the lowest level of fitness. In the previous research evaluating for increased risk of back injury, three of the five components of fitness measured were directly reflective of cardiorespiratory fitness. The subjects with lowest overall results were at the highest risk of back injury (Cady et al., 1979). It is suspected that soldiers' experienced the highest number of back visits as a result of declining cardiorespiratory fitness. Soldiers in the third tertile

for cardiorespiratory fitness, who on average improved their VO₂ peak, had no medical visits related to the back.

Despite the lack of a statistically significant correlation between peak power and any of the evaluated categories of medical resources utilized, it appears that the soldiers who experienced the greatest increases in power also demonstrated a trend of a higher number of total medical visits. This investigation team has hypothesized that this increase in lower extremity power could be the result of their physical training or the result of required occupational tasks. Moving quickly with the load of body armor may result in improved power, while at the same time be leading to more injuries or stress related illness. This hypothesis could also explain why increases in strength offered no improvements in utilization of medical resources. Occupational activities that result in improved strength, may also result in increased utilization of medical resources. These relationships could be better understood with more objective measures of physical activity of soldiers during the deployments.

Although this population of soldiers demonstrated improvements in relative strength as a whole, there were no significant correlations in strength at pre or post-deployment or change in strength and any of the inventoried medical variables. It appears that greater declines in their level of cardiorespiratory fitness are related to higher utilization of medical resources for total purposes. This is particularly apparent in the bottom third of soldiers when categorized based on their level of change in fitness over the course of the deployment. This is consistent with the finding of multiple studies that have shown that lower levels

of cardiorespiratory fitness are related to higher levels of injury and illness (Reynolds et al., 1994; Jones et al., 1988; Pleban, Thomas, & Thompson, 1985). This data supports these previous findings by demonstrating over a 150% increase in total medical visits (8.0 v 3.1 v 2.6 total visits) when comparing the bottom third to the other two tertiles.

It is also interesting that all behavioral health visits occurred in soldiers categorized into the tertile with the most significant declines in cardiorespiratory fitness. This is consistent with previous research that demonstrated an increase in depressive symptoms associated with declines in cardiorespiratory fitness (Berlin, Kop, & Deuster, 2006). Additional research has found that higher levels of physical fitness even help attenuate the affects of stress due to sustained operations (Pleban, Thomas, & Thompson, 1985). Could it be possible for soldiers to mediate their stressors by maintaining their cardiorespiratory fitness during deployment resulting in fewer behavioral health visits? The findings of this research leads to the consideration that aerobic training is not only beneficial for overall physical health but also for one's mental health. If military leaders were made aware of this relationship between cardiovascular fitness and increases in behavioral health visits they would also maintain the potential to help attenuate some of the stressors related to deployment through their physical fitness training. Inversely, the potential exists for leaders to better identify soldiers who are struggling with behavioral health issues if they were to observe a steep decline in cardiovascular performance. Essentially, this decline in cardiorespiratory

performance could serve as a red flag that may warrant further investigation into that soldier's behavioral health.

An additional consideration would be that soldiers who experienced the steepest declines in cardiorespiratory function had an illness or injury that contributed to their behavioral health. The potential exists that the cause of increased medical resource utilization indirectly led to a decline in the soldiers' behavioral health status ultimately leading to additional medical visits for behavioral health. Detailed research is needed to better understand and detangle this convoluted relationship between physical fitness, total medical resource utilization and behavioral health.

It would appear that these soldiers may have been performing resistance training at the expense of their aerobic training as demonstrated by the significant declines in cardiorespiratory while demonstrating improvements in strength and endurance. Seeing that strength was not correlated to the medical variables, nor was there any significance in medical utilization by tertiles based on strength, it could be perceived that military leadership may need to guide their soldiers in performing a balance of resistance training and aerobic activity in an effort to at least maintain pre-deployment levels of cardiorespiratory fitness. Conditions while deployed may not be ideal for cardiovascular exercise, but the act of running on a treadmill or riding a stationary bicycle may provide a much needed outlet for these soldiers stress.

With the results of this research made available to military leaders, they will have the ability to adjust their soldiers' physical fitness training at pre-

deployment and during the deployment in order to further decrease the burden on the medical resources and maintain the health of their soldiers. For example, a decline in medical resource utilization may be seen if leaders were able to ensure that their soldiers maintained their pre-deployment level of cardiorespiratory fitness through the extent of their deployments. Lower levels of cardiorespiratory function have already been shown to be associated with higher levels of injury and illness in the training environment (Gardner et al., 1996; Reynolds et al., 1994; Knapik et al., 1993).

This investigation now supports the occurrence of such a relationship while deployed to a combat zone. Although it is clear that relationships do exist, this investigation cannot establish causation in most instances of these statistically significant relationships. Further research is certainly warranted to better understand the relationships that this investigation has shown to exist.

FUTURE RESEARCH

This investigation certainly does not answer all the questions that may arise when considering the relationships of physical fitness and the utilization of medical resources. It merely starts the discussion for many future investigations. This investigation has offered statistical support to previous anecdotal experiences revolving around increased utilization of medical resources and declining levels of fitness. These findings open the door for future researchers to look at individual components of physical fitness and their relationships to specific areas of medical resource utilization in deployed soldiers. There are three realms of future research that would provide additional benefit to what is provided here.

Continued Data Collection

This investigation provides a core of data that needs to be expanded. As the number of subjects continues to increase as well as statistical power more relationships between physical fitness variables and medical resource utilization may become apparent. An increased number of subjects will not only provide a clearer description of the current fitness of deploying soldiers, it will also provide the opportunity to capture more medical visits. This will allow for the development of relationships that were not statistically significant during this research due to the limited number of pertinent medical visits. With a larger population of soldiers more medical visits would have been inventoried and stronger correlations may have been detected. In many instances, there were clearly trends demonstrating that greater declines in fitness resulted in higher utilization of medical resources. Due to the overall low number of visits in the specified category, significant correlations or significant differences between tertiles were not achieved. This can be remedied by further research adding to this limited collection of data.

Physical Activity

At this time, it can only be hypothesized as to why cardiorespiratory function declined while strength and endurance improved. This potentially is the result of soldiers' preferences, available resources while deployed, or a training environment that is not conducive to cardiorespiratory training. When left to their devices, are soldiers selecting to perform resistance training in lieu of aerobic training? Is there an abundance of equipment available for resistance training

while there are limited numbers of cardiorespiratory machines (i.e. stationary bikes, elliptical machines, and treadmills)? Is the weather, running surfaces, or safety of the soldiers a consideration that deters soldiers from performing aerobic activity while deployed? These are questions that certainly can be answered with future research focused on physical activity levels in soldiers while they are deployed.

This study demonstrates that soldiers change in physical fitness while deployed in combat regions. Soldiers' strength, endurance, and body composition improved, but their cardiorespiratory fitness declined, while power and flexibility were essentially unchanged. The culmination of current research is demonstrates a trend of declining cardiorespiratory fitness amongst all groups evaluated. More data is needed to resolve the conflicting reports previously reported in changes in strength, power, and body composition, as well as to understand the components that are not well represented (endurance and flexibility). More research is also needed to better explain the changes specific to reserve soldiers. Clearly, more detailed information on the type, intensity and frequency of physical activity/exercise which occur during deployment are needed to explain these changes to physical fitness. In summary, these results provide healthcare professionals and military leaders a better understanding of how current deployment conditions are affecting physical fitness. This information can be utilized to alter training prior to and during deployments in order to achieve desired levels of fitness.

Clearly more research is needed to better understand the physical activity levels and training regimens of soldiers while they are deployed. This will provide insight that will help us better understand the findings of this investigation. With a better understanding of soldiers' activity levels during deployment, a clear explanation of why cardiorespiratory fitness declines, while relative strength improves can be provided. This finding might be the result of the soldiers' occupational requirements while deployed just as easily as it could be the result of the choices they are making during their physical training.

Behavioral Health and Cardiorespiratory Fitness

The relationship between behavioral health visits and declining cardiorespiratory function needs to be evaluated in detail. If causation between these two variables were to be established the outcomes of either could be modified. First an investigation must be completed to better understand if a declining mood state is leading to decreases in cardiorespiratory fitness or if declining cardiorespiratory fitness is leading to declining mood states. Once the relationship between these variables is clarified, the potential to use physical activity to modify behavioral health in deployed soldiers would be seen.

FINAL CONCLUSION

This research demonstrates statistically that a theory amongst professionals actually holds true. Over the course of many deployments, military practitioners have shared anecdotal experiences and observations with one another about the changes that their soldiers undergo during deployments and how the declines in physical fitness result in more frequent use of the medical

resources available. Now, these changes to physical fitness have been documented by multiple research teams offering corroboration. For the first time, relationships between declining physical fitness and increased utilization of medical resources have been established. This research merely serves as a gateway to many more investigations in an effort to better understand why these changes and relationships occur and how the combat experience can be manipulated to better preserve soldiers' overall health.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER



Office of Research Integrity and Assurance

To: Pamela Swan
EAW

From:  Carol Johnston, Chair
Biosci IRB 

Date: 04/06/2009

Committee Action: Expedited Approval

Approval Date: 04/06/2009

Review Type: Expedited F4

IRB Protocol #: 0903003780

Study Title: Evaluating the Effects of Long Term Combat Deployment on Physical Fitness in the Military

Expiration Date: 04/05/2010

The above-referenced protocol was approved following expedited review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date. You may not continue any research activity beyond the expiration date without approval by the Institutional Review Board.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Biosci IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Biosci IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

