INFLUENCE OF ARMORED VEST SIZING

ON MARKERS OF SPRINT

PERFORMANCE

By

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ABSTRACT

Load carriage up to 150 lbs in the form of an armored vest and backpack is common for active duty military personnel. While the effects of load carriage on the performance of military-specific tasks has been well studied, no investigation has been made of the effects of armored vest sizing on task performance. The purpose of this study was to assess the effects of wearing oversized armored vests on sprint time and vest movement variables associated with sprinting 15 meters from standing and prone starting positions. Twenty two subjects (11 men and 11 women) performed the sprints wearing their best-sized vest (BS), a vest one size too large (OS1), and a vest two sizes too large (OS2). Subjects performed four sprints for each of the three vest conditions (BS, OS1, OS2), two from a standing position and two from a prone position, for a total of 12 maximal sprints. Split and total sprint times were collected and recorded using a timing pad and two timing gates. Vest movement was collected and recorded at 32 Hz and summarized in 1-second intervals as counts/second with two uniaxial accelerometry-based activity monitors mounted to the anterior side of the vests for testing. Collected variables were analyzed using multivariate two-factor repeated measures ANOVAs and Tukey's post-hoc test, all performed at the 0.05 alpha level. No differences were found for vest movement variables by condition ($P>0.05$). Vest movement was greater ($P<0.01$) when starting in a standing position than a prone position. When analyzed by gender, no significant main effects of vest condition on sprint time were found for men ($P>0.05$), but women were slower ($P<0.01$) when wearing the OS2 vest than the either the BS or OS1 vest. For all subjects, sprint time was slower ($P<0.01$) when starting in a prone position than a standing position. In conclusion, oversized armored vests impaired sprint performance in women. Further research is required to clarify whether gender or body size is more important in determining potential detriments to sprint performance when wearing oversized armor.

CHAPTER ONE

INTRODUCTION

An Introduction to the Problem

Standard loads carried by military ground-combat troops can include a rifle, an operations kit, a loaded backpack, and an armored vest. With the added weight and bulk of a full ground-combat load comes an increased potential for fatigue and injury, and the risk of a decrement in soldiers' ability to safely and efficiently perform assigned duties (Knapik, Reynolds & Harman 2004). The fact that load carriage affects the normal metabolic and kinematic demands on the body, and these changes, in turn, affect task performance, has been well studied. Research has shown that, compared to wearing no armor, wearing an armored vest was detrimental to performance in range of motion tasks (Bensel, Fink & Mellian 1980), upper-body strength measures, such as pull-ups and flexed arm hang (Ricciardi, Deuster & Talbot 2008), and obstacle course performance (Hasselquist et al. 2008). Additionally, wearing an armored vest has been shown to increase metabolic demand, measured as the rate of oxygen consumption (VO_2), during treadmill walking at both slow and moderate paces (Ricciardi, Deuster & Talbot 2008). While it seems clear that armored vests generally have negative effects on task performance, it is also understood that the ballistic protection offered by armored vests makes them a necessary component of modern-day military life. A review of the literature, however, did not reveal any evaluation of the importance of vest sizing to task performance. It is the goal of this study to assess the relationship between vest sizing and task performance.

For military applications, a common methodological strategy used to study load carriage is to assess a person's ability to perform a particular task with a load, usually in the form of a weighted backpack or body armor, as compared to their ability to perform the same task in an unloaded state. Unfortunately, in the case of armored vests, it is very rare for researchers to describe how armored vests are sized to individual subjects. Readers are left to assume that subjects attempting a loaded task are doing so with an armored vest that is the most appropriate size for their body size and shape. Naturally, it would follow that a similar assumption may be made concerning the actual military personnel whom the research is eventually intended to benefit. However, anecdotal evidence from interviews and conversations with military personnel, as well as many popular press articles on the subject, suggest that the reality is more nuanced.

Recently, military-affiliated popular press articles have cited the frustration of female soldiers unable to find armor that fits their bodies (Leipold 2011), as well as the acknowledgement of a growing need for a new armor sizing system to accommodate the increasing number of military personnel who would benefit from shortened vests (e.g. small-short, medium-short, etc.) (Randolph 2013). Anecdotal reports suggest, however, that due to limited vest availability, soldiers are not always assigned their best-sized vest. To ensure adequate ballistic protection when the best-sized vest is not available, soldiers are presumably assigned the next largest vest in stock. Consequently, armored vests worn by soldiers are almost always either best-sized or oversized, but are rarely or never undersized. As such, it is important to understand how wearing an oversized armored vest affects task performance. For the purpose of this study, best-sized armor is defined as the armored vest that most closely complies with the available sizing guidelines.

The issue of vest access can be compounded by the issue of best-fit knowledge. According to conversations with retired military personnel, most of the actual fitting of armored vests for military personnel is left to the platoon leader or company commander. While the platoon leader or company commander knows the required tasks and know how much ballistic coverage they want for each member of their team, they may not have the specific anatomical knowledge required to be absolutely certain that each person is getting full coverage for their vital organs without any extra unnecessary coverage. If the available or assigned vest is too small, the major potential repercussion, namely insufficient ballistic coverage for vital organs, can be fatal. What is less obvious, however, are the repercussions associated with carrying out military tasks while wearing an armored vest that is too large.

A review of the literature did not reveal any studies evaluating the metabolic or kinematic effects of wearing an oversized vest. We undertook this exploratory study to assess the relationship between armor sizing and sprint performance. Specifically, we evaluated whether wearing an oversized vest had a negative effect on markers of sprint performance.

Purpose

The purpose of this study was to determine the influence of the added mass and bulk of an oversized armored vest on markers of vest movement and sprint performance.

Research and Statistical Hypotheses

Research Hypothesis

Wearing an oversized vest during a sprinting task increased vest movement in the lateral and vertical directions, negatively influencing markers of sprint performance.

Statistical Hypotheses

The null hypothesis was that there were no significant differences between markers of vest movement or sprint performance when wearing a best-sized vest (BS), an oversized vest one size too large (OS1), or an oversized vest two sizes too large (OS2). The alternative hypothesis was that there was at least one significant difference between the test conditions.

$$H_0: \mu_{BS} = \mu_{OS1} = \mu_{OS2}$$

$$H_a: \mu_{BS} \neq \mu_{OS1} \neq \mu_{OS2}$$

Where: μ_{BS}, μ_{OS1}, and μ_{OS2} were population means for the dependent variables of interest. These variables included measures of vest movement, as well as split and completion times for a series of 15-meter sprints from prone and standing positions.

Significance

Although a considerable amount of research has focused on the effects of load carriage on the performance of military specific tasks, there is always an underlying assumption that if the load is in the form of an armored vest, it is the best-sized vest for the subject. Ideally, active duty military personnel also have access to their best-sized armored vests; however, this may not always be the case. With the January 2013 decision of the US Secretary of Defense to allow women in ground-combat roles comes a pressing need to be absolutely certain that available armor provides the best possible protection while minimizing the deleterious effects of load carriage for all ground-combat troops. This study examined the effects of oversized armored vests on markers of sprint performance with the goal of underscoring the functional importance of best-sized armor.

Assumptions

1. Subjects reported any illness, injury or any other factor limiting their eligibility to participate in the study.
2. Subjects abided by provided guidelines for pre-testing exercise, nutrition and hydration.
3. Subjects comprehended and followed all written and verbal instructions to the best of their ability.

Delimitations

1. This study was delimited to performance of 15-meter sprints from prone and standing positions.
2. This study was delimited to use of standard Marine-issue Scalable Plate Carriers (SPC) with plated body armor.
3. Armored vests can be fit to the body in many ways. The present study was delimited to the use of fitting guidelines developed and implemented by trained personnel from a local backpack company specializing in military contracts (Mystery Ranch, LTD, Bozeman, MT).
4. This study was delimited to healthy subjects free of contraindications to sprinting exercise from the Bozeman, MT area, who were 18 to 45 years of age and who had a torso length ≤ 42.5 cm.

Limitations

1. Best-fit guidelines used for this study to assign each subject to their BS vest may not be uniform across subjects due to differences in subject body shape.
2. Performance of one military-specific task (e.g., a sprint) at a time does not reflect the nonstop performance of a chain of tasks required in actual combat.
3. The available convenience sample of volunteer subjects may not be representative of the actual target active-duty ground troop population.
4. Summarizing vest movement data for an approximately 4-second sprint in 1-second intervals could result in large margins of error.

Operational Definitions

Armored Vest / Vest:	Marine-issue Scalable Plate Carrier with Small Arms Protective Inserts (ballistic plates).
Best-sized (BS):	The armored vest that most closely complies with the torso-length based sizing requirements developed by Mystery Ranch.

Definitions

Counts:	Unit of measure designed to represent the average intensity and duration of all acceleration measures during each 1-second (Actical Version 3.10; 2012 Koninklijk Philips Respironics N.V.)
Military-Specific Tasks:	Tests of performance meant to simulate tasks specific to functioning in a ground-combat unit.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Introduction

Many researchers have attempted to describe the relationship between load carriage and task performance. Sometimes task performance is the end result, as in Pandorf et al.'s (2002) measurement of obstacle course performance or Treloar and Billing's (2011) measurement of break contact drill performance. Alternatively, tasks may be performed simply to observe an associated result of load carriage on the body. The latter was the case for Heller, Challis, and Sharkey (2009), who assessed postural sway as a result of load carriage, and for Epstein, Rosenblum, Burstein, and Sawka (1988) who examined the effects of prolonged load carriage on energy cost. Whether measuring actual performance, or an associated result of load carriage, researchers have consistently demonstrated that heavy loads result in increased metabolic demands, altered body kinematics and decreased task performance.

Numerous studies have focused on the effects of body armor on task performance; however, the emphasis of these studies has been on the added weight or bulk of the armor, not the sizing or fit of the armor. While all active duty military personnel should have access to their best-sized armored vest, the importance of wearing an under- or over-sized vest on functional performance is poorly understood. The differences in body size and shape between men and women provide one example of a way in which it may be important to clarify the influences of sizing on task performance. The recent decision by the US Secretary of Defense to allow women in ground-combat roles emphasizes the importance of having properly sized body armor available to all ground-troops, and this study is an attempt to highlight possible performance decrements resulting from poorly sized armor.

Given the lack of available research exploring the impact of armored vest sizing on task performance, this review will instead highlight metabolic, kinematic, and performance effects of load carriage on soldiers today.

Metabolic Demands

Researchers (Hasselquist, Bensel, Corner, Gregorczyk & Schiffman 2008; Knapik, Harman & Reynolds 1996; Pandolf, Giovani & Goldman 1977; Ricciardi, Deuster & Talbot 2008) have reported that an increase in load carriage leads to an increased metabolic demand, measured as the rate of oxygen uptake (VO_2). Ricciardi et al. (2008) found that moderately paced walking (3.6 mph [women] and 3.8 mph [men] at 10% grade) with a 10 kg armored vest caused an average increase in VO_2 of 6.0 ml/kg/min, or 17.2%. Other indicators of metabolic demand, heart rate and respiratory rate, were also assessed by Ricciardi et al. (2008) and were found to increase with load carriage. Furthermore, research undertaken in our own lab (Whalen, Pribanic & Heil 2013) showed that a 586-meter overground hike at 3.5 miles/hr wearing a hip-belt anchored armored vest increased VO_2 by an average of 456.8 ml/min, or 37.3%, and heart rate by an average of 13 beats/min, or 11.8%, compared to the same hike with no vest. Most researchers studying the metabolic demands of load carriage have focused on short (< 1 hour) periods of loaded walking and have found there to be a relatively systematic relationship between the weight of the load carried and the energy cost to the subject. Epstein et al. (1988), however, studied prolonged load carriage and found that even if speed and grade were kept constant, the energy cost of loaded walking for over two hours began to increase with time. As it is typical for military personnel to march, carrying anywhere from 44 to 61 kg, for up to eight hours at a time (Bachkosky et al. 2007), fatigue can quickly become a limiting factor for these soldiers.

Altered Kinematics

Movement Kinematics

Researchers studying walking gait under load carriage have shown that additional weight leads to increased ground contact time, as measured by an increase in both stance phase time and double support time (Park et al. 2011). Additionally, load carriage also contributes to decreases in stride length and increases in stride rate (LaFiandra et al. 2003). The conclusion reached by both research teams was that the altered gait was an attempt by subjects to maintain stability and balance while walking.

Static Kinematics

Load carriage also affects body movement in the area of postural sway. Heller et al. (2009) and Shiffman et al. (2006) both showed large increases in center of pressure (CoP) excursions in the anterior/posterior and medial/lateral directions as a result of standing in place with a heavy load. In addition to an increase in CoP excursions, Schiffman et al. (2006) noted a decrease in random sway as subjects were forced to exert a greater than normal amount of control over the load to maintain balance.

Injury Risk

As noted by many researchers (Birrell & Haslam 2010; Knapik et al. 1996; Park et al. 2011), altered kinematics and increased ground striking forces resulting from load carriage increased the potential for injury to hips, legs, feet, and toes. According to Larsen et al. (2011), over a third of military personnel report non-combat injuries, most of which are musculoskeletal. The implications of these reports are clear. One can hardly expect military personnel to perform their best when they are hobbled by blisters, metatarsalgia, knee pain, lower back pain and rucksack palsy (Knapik et al. 1996).

Performance of Military-Specific Tasks

Available testing equipment generally limited research on load carriage to walking or running tests on a treadmill, as well as standing or walking tests over a force plate. Additionally, short duration (< 1 hour) treadmill walking was not a good approximation of long marches or a good surrogate for more explosive, material-handling, mobility and maneuverability-based tasks (Larsen et al. 2011). In order to better test the impacts of load carriage on actual military personnel, some researchers have attempted to simulate more realistic conditions in the lab by creating obstacle courses and batteries of military-specific tasks.

Researchers testing obstacle course performance (Hasselquist et al. 2008; Pandorf et al. 2002) concluded that increasing load carriage had a significant negative impact on the completion of an obstacle course containing segments simulating military tasks. Some of these tasks included shimmying across pipes, jumping hurdles and climbing over walls. Time to course completion for the obstacle course designed by Pandorf et al. (2002) increased by an average of 17.4 seconds, or 47.7%, when load carriage increased from 14 kg to 27 kg. Additionally, as load increased, the added weight and bulk of the largest load prevented some subjects from completing the low-crawl obstacle at all (Pandorf et al. 2002).

Another military-relevant task significantly impacted by load carriage was the performance of a break contact drill (BCD) (Treloar & Billing 2011). The BCD is a maneuver implemented by the Australian Army to retreat when contact with the enemy is not desired. It consists of short sprints interspersed with kneeling or prone cover fire. Treloar and Billing (2011) tested the ability of subjects to complete a BCD unloaded and then loaded with 21.6 kg. The loaded condition increased mean 30-meter sprint time by an average of 2.0 seconds, or 31.5%.

A third way to assess the effects of load carriage on military-relevant tasks is to perform a battery of discrete tests meant to simulate situations experienced by military personnel. These discrete tests have included tests of hand grip strength, pull ups or hang time, stair-stepping (Ricciardi et al. 2008), maximum distance walk or run, repetitive box lift and carry, sprints (Hasselquist et al. 2008), maximal uphill walking, balance activity, shuttle runs, rope pull, dummy drag (DeMaio et al. ND), agility runs, long jumps, reaction movements to the left and right, and ladder climbs (Martin & Nelson 1985). Generally, the results from these studies show decrements in performance with increases in load carried. There were a few exceptions, including hand-grip strength (Ricciardi et al. 2008), rope pull and dummy drag (DeMaio et al. ND), none of which resulted in a decrease in performance with load carriage. Lastly, Knapik et al. (1990) found that a maximal effort road march carrying 46 kg for 20 kilometers resulted in significant decreases in performance in post-march marksmanship and grenade throwing ability.

Load Distribution

While little research has focused on load distribution on armored vests, there is a considerable amount of research available concerning load distribution related to backpacks (Knapik et al. 1997; Lloyd & Cooke 2000; Malhotra & Gupta 1965). Lloyd and Cooke (2000) found a double pack set-up, with weight distributed between the front and back, to result in significantly lower energy expenditure during uphill walking. When comparing incidence of blister formation during long marches using a double pack or a regular backpack, Knapik et al. (1997) found that a double pack set-up resulted in fewer blisters. While these findings are focused on backpacks, the double pack set-up is somewhat comparable to an armored vest, given that the weight is more evenly distributed around the torso.

Parallels may also exist between the placement of a load in a backpack and the distribution of weight in an armored vest, which may be size dependent. Energy costs for loads placed higher in a pack and close to the body were lower than energy costs for loads placed lower in a pack and further away from the body (Obusek et al. 1997). Similarly, Bloom and Woodhull-McNeal (1987) and Johnson et al. (2001) found that loads placed low in a pack were associated with increased forward body lean over loads placed higher in a pack. The increased forward body lean is the result of more forward body rotation through the hips and ankles in an effort to move the pack center of mass over the feet (Johnson et al. 2001). Bloom and Woodhull-McNeal (1987) assessed postural changes associated with internal versus external frame backpacks, and while they discovered that loads placed higher in a pack (the case for the external frame backpacks) resulted in less forward body lean, they also resulted in greater movement of the pack.

Sizing

No research was found explaining the performance-related sizing effects of armored vests or ballistic armor of any kind. However, some research on sizing strategies and non-performance related effects of sizing does exist for other forms of personal protective equipment (PPE). Hsiao (2013) noted that fall-arrest harness sizing systems can force workers to choose a harness that fits one part of their body, but not another (e.g., fits at torso but not thigh), contributing to potential work-related injury. Likewise, in an interview given to Professional Safety magazine, Fargo (2013) outlined the increased risk of injury for female workers whose assigned work gloves and protective eyewear and footwear were originally sized for men. Additionally, in an article for Industrial Safety and Hygiene News, Tsiropoulos (2011) explained that one of the major factors contributing to PPE noncompliance (i.e., workers choosing not to wear PPE even when it is technically required) was that the PPE had a poor fit.

Summary

Military load carriage, and the associated metabolic demands and altered kinematics, have had a detrimental effect on performance of military-specific tasks. While there is essentially no information available about the effects of armored vest sizing on military-specific tasks, there is a considerable amount of information available about the effects of load carriage on metabolic variables, kinematic variables and performance of military-specific tasks, as well as information available about the effects of load placement relative to the torso. It is the goal of this study to test the effects of armored vest sizing variations in the context of the existing information concerning metabolic, kinematic and performance variables.

CHAPTER THREE

INFLUENCE OF ARMORED VEST SIZING ON MARKERS OF SPRINT PERFORMANCE

Contribution of Authors and Co-Authors

Manuscript in Chapter 3

Author: Lisa M. Whalen

Contributions: Assisted with study design, implemented subject recruitment and data collection, processed data, and wrote manuscript.

Co-Author: Daniel P. Heil

Contributions: Conceived of study design, analyzed data, discussed results and implications, and was primary editor of the manuscript at all stages.

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Abstract

Load carriage up to 150 lbs in the form of an armored vest and backpack is common for active duty military personnel. While the effects of load carriage on the performance of military-specific tasks has been well studied, no investigation has been made of the effects of armored vest sizing on task performance. The purpose of this study was to assess the effects of wearing oversized armored vests on sprint time and vest movement variables associated with sprinting 15 meters from standing and prone starting positions. Twenty two subjects (11 men and 11 women) performed the sprints wearing their best-sized vest (BS), a vest one size too large (OS1), and a vest two sizes too large (OS2). Subjects performed four sprints for each of the three vest conditions (BS, OS1, OS2), two from a standing position and two from a prone position, for a total of 12 maximal sprints. Split and total sprint times were collected and recorded using a timing pad and two timing gates. Vest movement was collected and recorded at 32 Hz and summarized in 1-second intervals as counts/second with two uniaxial accelerometry-based activity monitors mounted to the anterior side of the vests for testing. Collected variables were analyzed using multivariate two-factor repeated measures ANOVAs and Tukey's post-hoc test, all performed at the 0.05 alpha level. No differences were found for vest movement variables by condition ($P>0.05$). Vest movement was greater ($P<0.01$) when starting in a standing position than a prone position. When analyzed by gender, no significant main effects of vest condition on sprint time were found for men ($P>0.05$), but women were slower ($P<0.01$) when wearing the OS2 vest than the either the BS or OS1 vest. For all subjects, sprint time was slower ($P<0.01$) when starting in a prone position than a standing position. In conclusion, oversized armored vests impaired sprint performance in women. Further research is required to clarify whether gender or body size is more important in determining potential detriments to sprint performance when wearing oversized armor.

Introduction

Depending on rank and position, active duty military ground troops can be expected to carry upwards of 150 pounds on their upper bodies (Knapik & Reynolds 2010). This load commonly includes an armored vest and a backpack containing equipment and supplies. With these loads in mind, a considerable amount of research has focused on the metabolic demands and the kinematic and performance effects of soldier load carriage.

A clear relationship has been shown to exist between increased load carriage and a decline in various types of task performance. For example, research involving obstacle courses demonstrated decreased performance with increased load carriage requirements (Hasselquist et al. 2008; Pandorf et al. 2002). Increasing load carriage also contributed to performance decrements for specific tasks mirroring existing military maneuvers (Treloar & Billing 2011), as well as a series of discrete tasks meant to simulate actions required by military personnel (DeMaio et al. ND; Hasselquist et al. 2008; Martin & Nelson 1985; Ricciardi et al. 2008).

In addition to decrements in task performance, increased load carriage has also been associated with increased metabolic demand. Ricciardi, Deuster, & Talbot (2008) showed an increase in the rate of oxygen uptake (VO_2) with increased load carriage accompanying moderately paced walking with an armored vest. Similarly, Whalen, Pribanic, & Heil (2013) found that overground hiking wearing a hip-belt anchored armored vest increased VO_2 and heart rate compared to the same hike with no vest.

In addition to task performance and metabolic demand, body kinematics also undergo changes when a heavy load is carried on the torso. Increases in both ground contact time while walking (Park et al. 2011) and center of pressure excursions in the anterior/posterior and medial/lateral directions (Heller et al. 2009; Shiffman et al. 2006) were shown to accompany increased load carriage.

One aspect of armored vest load carriage that has not been carefully examined, however, is the influence of armored vest sizing on task performance. Ideally, all military personnel will always have access to their best-sized armored vest (i.e., the vest that is the most appropriate size for an individual's body size and shape). Anecdotal reports suggest, however, that soldiers are not always assigned their best-sized vest due to limited vest availability. To ensure adequate ballistic protection when the best-sized vest is not available, soldiers are presumably assigned the next largest vest in stock. Consequently, armored vests worn by soldiers are almost always either best-sized or oversized, but are rarely or never undersized. As such, it is important to understand how wearing an oversized armored vest affects task performance.

The purpose of this study was to examine the effects of wearing an oversized vest on markers of sprint task performance, specifically sprint time and vest movement variables. It was initially hypothesized that in comparison to wearing a best-sized vest, wearing an oversized vest would cause increases in both sprint time and vest movement variables. Additionally, it was of interest to evaluate these variables for possible gender differences.

Methodology

Subjects

The sample population consisted of 11 men and 11 women from the Bozeman, MT, area who were 18 – 46 years of age, with a torso length ≤ 42.5 cm long, and who were healthy and free of contraindications to sprinting exercise. Each subject performed sprints wearing BS, OS1, and OS2 vests. In order for subjects to have an OS1 and OS2 size available, their BS vest needed to be either a size small or medium. The small vest fit torso lengths up to 38.25 cm and the medium vest fit torso lengths up to 42.5 cm. For this reason, subjects were delimited to those with a torso length up to 42.5 cm.

Procedures

Study Design: Each subject completed one habituation visit and one testing visit in the Romney Gymnasium on the Montana State University – Bozeman (MSU) campus. The study used a repeated measures crossover design in which subjects performed two sets of sprints, one set from a standing position and one set from a prone position, for each of three conditions. These conditions included wearing a best-sized vest (BS), an oversized vest one size too large (OS1), and an oversized vest two sizes too large (OS2). Sprint tests were performed from a standing position and a prone position to clarify the effects of vest sizing on quick changes in body positioning.

Subject Instructions: Subjects arrived for the habituation and testing visits wearing clothes appropriate for sprint exercise (e.g., appropriate workout shoes and clothing). Subjects were informed to eat and drink as though preparing for a high intensity workout, refrain from ingesting caffeine for at least three hours, refrain from ingesting alcohol for at least 24 hours, and refrain from high intensity or long duration exercise for at least 24 hours prior to their testing visit.

Habituation Visit: The habituation visit was completed before the testing visit to allow subjects to become accustomed to wearing and sprinting in the armored vests. These visits began with a 10-minute introductory time during which the subjects filled out paperwork and asked questions. Subjects then completed a standardized warm-up, which began with two minutes of walking and three minutes of jogging at their own pace around the periphery of the gym. The final part of the warm-up was four 15-meter submaximal sprints wearing no vest. The first two sprints, one from a standing position and one from a prone position, were performed at a self-determined 70% effort. The last two sprints, one from a standing position and one from a prone position, were performed at a self-determined 85% effort. Two minutes of rest were given after each sprint.

After the warm-up, subjects completed six 15-meter habituation sprints. The first two sprints, one from a standing position and one from a prone position, were performed at a self-determined 85% effort and wearing the subject's best-sized vest. The next four sprints, two from a standing position and two from a prone position, were performed maximally, still wearing the best-sized vest. During maximal (100% effort) sprints, subjects sprinted with the goal of covering 15 meters as quickly as possible. Two minutes of rest were given after each sprint. For the maximal sprint portion of the habituation visit, the two sprints from a standing position and the two sprints from a prone position were performed consecutively. The set of sprints (standing or prone) with which each subject started was counterbalanced across subjects. Habituation visits lasted about 40 minutes.

Testing Visit: After the habituation visit, each subject returned to the gym between one and fourteen days later to complete a testing visit. Testing visits were comprised of a warm-up period and a testing period. The warm-up period for the testing visit was identical to the warm-up period for the habituation visit with the exception of the vest worn for the submaximal sprints. During the habituation visit, submaximal sprints were undertaken wearing no vest. For the testing visit, subjects completed the submaximal sprints while wearing the vest assigned to their first testing condition.

After the warm-up, subjects performed four sprints for each of the three vest conditions (BS, OS1, OS2), two from a standing position and two from a prone position, for a total of 12 maximal sprints. Two minutes of rest were given after each sprint. For each condition in the testing period, the two sprints from a standing position and the two sprints from a prone position were performed consecutively. The set of sprints (standing or prone) with which each subject started was counterbalanced across subjects. Additionally, the order of vest conditions for testing was counterbalanced across subjects. Testing visits lasted about 50 minutes.

Sprint Test Administration: The standing starting position was characterized by an upright torso, hands at the sides, one foot up to, but not on, the starting line with the knee of the lead foot slightly flexed and about 2/3 of the subject's weight on the lead foot. In contrast, the prone starting position was characterized by a prone push-up position with the entire length of the anterior side of the body resting on the ground and the most distal points of the fingertips up to, but not on, the starting line. Subjects' hands were shoulder-width apart with the most distal points of their fingertip in line with their clavicles.

Each sprint began with instructions to the subject to get into the starting position (standing or prone). Subjects remained in the starting position without moving or talking for five seconds. After this five second stationary period, subjects were instructed to move just enough to depress a timing pad with their lead foot (standing position) or right hand (prone position), which initiated an audible three-beep countdown by the timing system. At the third beep, subjects sprinted as fast as possible through the 15-meter mark before slowing down and coming to a full stop about five meters beyond the 15-meter mark. At their stopping point, subjects again remained standing, without moving or talking, for another five seconds. After this stationary period, subjects began a walking recovery until the start of the next sprint trial. The five second stationary periods before and after each sprint established a baseline for vest movement measurements. If retesting of a sprint trial was necessary, subjects were given another two minutes of rest and allowed to repeat the sprint trial.

Instrumentation

A timing pad and two timing gates (Speedtrap 2; Brower Timing Systems, Draper, UT) were used to collect and record sprint split times for the 15-meter sprints. The timing pad was located at the start line, while the first and second gates were located 2 and 15 meters in a straight line from the start line, respectively. Depression of the timing pad initiated an audible three-beep countdown after which the timing system began recording elapsed time.

Raw accelerometry data for vertical and lateral vest movement during each sprint were collected and recorded at 32 Hz and summarized in 1-second intervals as counts/second by Actical Z-Series Activity Monitors (Respironics, Inc., Bend, OR). Each monitor was uniaxial, so two monitors, oriented perpendicularly to one another and affixed to a paddle, were mounted to the anterior side of the vests for testing.

The vests used for this study were Marine-issue Scalable Plate Carriers (SPC) sizes S – XL (Eagle Industries, Norfolk, VA) with Small Arms Protective Inserts (SAPI), sizes S – XL (ArmorWorks, Chandler, AZ) serving as the ballistic plates corresponding to each vest. Two SAPI were associated with each vest, one in the front and one in the back. A standard kit consisting of a hydration pack, an individual first aid kit, and mass equivalent to two grenades and six M16 ammunition magazines was added to each vest. One 500 g lead sheet was added to each small SAPI to bring the total mass of the small vest and plates up to regulation standards. The masses of each vest, plates, and kit combination were 14.7 kg, 15.9 kg, 16.4 kg and 17.2 kg for the S, M, L and XL vests, respectively.

Data Processing

Following each bout of testing, the Actical monitors were downloaded to a computer using proprietary software (Actical Version 3.10; 2012 Koninklijk Philips Respironics N.V.). Once downloaded, this software was then used to summarize the raw uniaxial accelerometry data into movement counts per second as described by Chen and Bassett, Jr (2005), where the number of counts is a unit of measure designed to represent the average intensity and duration of all acceleration measures during each one second. Each sprint began from a stationary position (prone or standing) and ended in a stationary standing position. Thus, after exporting these data to a spreadsheet program, vest movement during each sprint was identified as a string of positive counts lasting up to eight seconds with strings of zero counts on either side. The vest movement variables were extracted from each sprint test for each of the two Actical monitors to summarize lateral and vertical vest movements, where lateral and vertical were both with reference to the subject's torso regardless of orientation to the ground surface. Each data string was then summarized into either lateral or vertical vest movement variables (depending on whether the data was collected from the lateral monitor or the vertical monitor). The 3-second summary period was chosen because total time for the sprint test was expected to last between 4 and 6 seconds, so summarizing the first three seconds would ensure that all data collected would be contained within each sprint.

Table 3.1. Summary table of vest movement variable definitions.

VEST MOVEMENT VARIABLE (units)	ABBREVIATION	DEFINITION
Lateral Peak (counts/sec)	LP	Peak 1-second vest movement in counts in the lateral direction over the total eight seconds of collected data.
Lateral 3-second Peak (counts/sec)	L3sP	Peak 1-second vest movement in counts in the lateral direction occurring in the first three seconds of collected data.
Lateral Sum (counts)	LS	Sum total of all vest movement in counts in the lateral direction over the total eight seconds of collected data.
Lateral 3-second Sum (counts)	L3sS	Sum total of vest movement in counts in the lateral direction occurring during the first three seconds of collected data.
Lateral 5-second Sum (counts)	L5sS	Sum total of vest movement in counts in the lateral direction occurring during the first five seconds of collected data.
Vertical Peak (counts/sec)	VP	Peak 1-second vest movement in counts in the vertical direction over the total eight seconds of collected data.
Vertical 3-second Peak (counts/sec)	V3sP	Peak 1-second vest movement in counts in the vertical direction occurring in the first three seconds of collected data.
Vertical Sum (counts)	VS	Sum total of all vest movement in counts in the vertical direction over the total eight seconds of collected data.
Vertical 3-second Sum (counts)	V3sS	Sum total of vest movement in counts in the vertical direction occurring during the first three seconds of collected data.
Vertical 5-second Sum (counts)	V5sS	Sum total of vest movement in counts in the vertical direction occurring during the first five seconds of collected data.

Outcome Variables

During each habituation and testing sprint, split times at the 2-meter (T_{S2}, secs) and 15-meter (T_{S15}, secs) marks, as well as total sprint time (T_{TOT}, secs), were recorded. T_{S15} was the time it took to cover the distance between the 2-meter mark and the 15-meter mark (total distance = 13 meters). Additionally, for each testing sprint, the ten lateral and vertical vest movement variables shown in Table 3.1 were determined.

Statistical Analyses

Sprints were performed in duplicate, so to prepare the data for statistical analysis, each time and vest movement variable was averaged between the two duplicate sprints. Split and total times (T_{S2}, T_{S15}, T_{TOT}), as well as the vest movement variables (LP and VP; L3sP and V3sP; LS and VS; L3sS and V3sS; L5sS and V5sS), over three conditions (BS, OS1, OS2) for two starting positions (standing and prone), were analyzed using multivariate two-factor repeated measures ANOVAs and Tukey's post-hoc test, all performed at the 0.05 alpha level. Statistical analyses were performed using Statistix 10.0 (Analytical Software, Tallahassee, FL, USA).

Results

Subjects

The study sample (n = 22) consisted of 11 men and 11 women, with an age of (Mean±SD) 25±7 years, a BMI of 22.8±2.2 kg/m^2, and a torso length of 37.3±2.6 cm. Four subjects had a BMI in the low end of the overweight range (all BMI values were under 27.0 kg/m^2). Of those four, one declined a body fat analysis, two had under 11% body fat and one had under 19% body fat. Women had a mean height and mass of 166.7±3.8 cm and 62.0±5.3 kg, respectively. Men had a mean height and mass of 173.5±2.4 cm and 69.9±8.2 kg, respectively. Each vest mass as a percent range of mean body mass for men and women is shown in Table 3.2.

Table 3.2. Vest mass for each vest size (S, M, L, XL) as a percentage of mean body mass for men and women.

VEST SIZE	TOTAL MASS OF VEST (kg)	MASS OF VEST AS A PERCENT OF MEAN MASS OF FEMALE SUBJECTS (%)	MASS OF VEST AS A PERCENT OF MEAN MASS OF MALE SUBJECTS (%)
Small (S)	14.7	21.8 – 25.9	18.8 – 23.8
Medium (M)	15.9	23.6 – 28.0	20.4 – 25.8
Large (L)	16.4	24.4 – 28.9	21.0 – 26.6
Extra Large (XL)	17.2	25.6 – 30.3	22.0 – 27.9

Time Variables

Vest Conditions: For all subjects, all three time variables (T_{S2}, T_{S15}, T_{TOT}) showed that sprinting in a best-sized (BS) vest resulted in a faster time than sprinting in a vest two sizes too large (OS2) (Main effect P<0.02). Additionally, for total sprint time (T_{TOT}), sprinting in a vest one size too large (OS1) also resulted in a faster time than sprinting in an OS2 vest (Main effect P<0.01). With one exception (T_{S2}, prone position, BS to OS1), all time variables appeared to increase from the BS to OS1 and from OS1 to OS2 conditions (Table 3.3), though these increases were largely statistically insignificant.

Table 3.3. Summary of time elapsed for each time variable (T_{S2}, T_{S15}, T_{TOT}) for standing (S) and prone (P) starting positions. Values given as Mean±SE.

TIME VARIABLE	POSITION	VEST		
		BS	OS1	OS2
T_{S2} (sec)	S	1.21±0.02	1.24±0.03	1.25±0.03
	P	2.24±0.10	2.23±0.09	2.30±0.11
T_{S15} (sec)	S	2.42±0.05	2.43±0.05	2.45±0.05
	P	2.40±0.05	2.42±0.05	2.43±0.05
T_{TOT} (sec)	S	3.64±0.06	3.67±0.06	3.71±0.07
	P	4.64±0.15	4.66±0.14	4.73±0.15

Note: BS=best-sized vest; OS1=vest one size too large; OS2=vest two sizes too large; S=standing starting position; P=prone starting position; T_{S2}=time at the 2-meter mark; T_{S15}=split time between the 2-meter and 15-meter marks; T_{TOT}=total time at the 15-meter mark

When these same data were reanalyzed by gender, there were significant interaction effects between gender and vest condition. For men, all time variables were similar across all vest conditions (P>0.05). For women, however, T_{S2} and T_{TOT} were slower when wearing the OS2 vest than either the BS or OS1 vest (Main effect P<0.01). Additionally, T_{S15} was slower when wearing the OS2 vest than the BS vest (Main effect P=0.048), but was similar when wearing the OS1 and BS vests (Main effect P>0.05) (Figure 3.1). Across all conditions, women were slower than men for all time variables (T_{S2}, T_{S15}, T_{TOT}) (Main effect P<0.01). Total sprint times (T_{TOT}) for men and women wearing their BS vest are shown in Table 3.4.

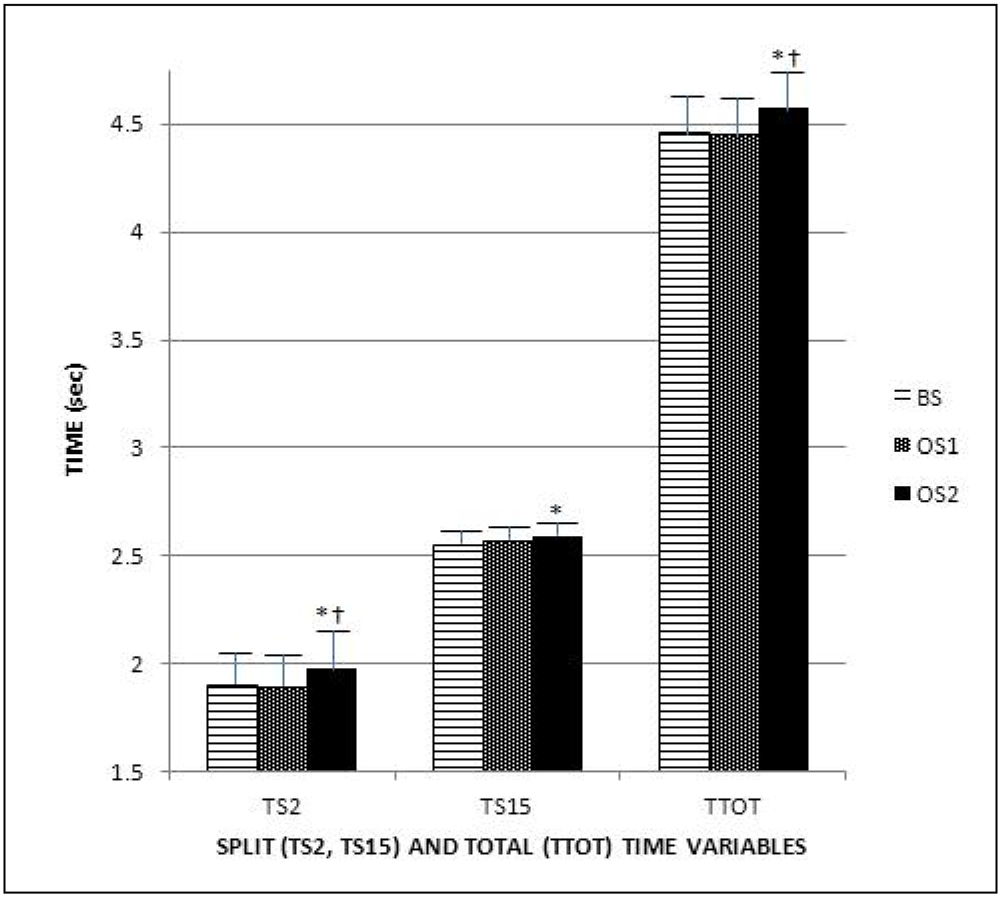

Figure 3.1. Time elapsed for each time variable (T_{S2}, T_{S15}, T_{TOT}) by vest condition (BS, OS1, OS2) for women. *denotes significant differences from BS within split. †denotes significant differences from OS1 within split

Table 3.4. Summary of total 15-meter sprint times (T_{TOT}) for men and women while wearing their BS vest. Values given as Mean±SD.

BS VEST	T_{TOT} FOR WOMEN (sec)	T_{TOT} FOR MEN (sec)
Small (S)	4.61±0.44 (n=6)	3.80±0.36 (n=7)
Medium (M)	4.31±0.15 (n=5)	3.85±0.17 (n=4)

Note: BS=best-sized vest; T_{TOT}=total time at the 15-meter mark; n=number of subjects

Position Conditions: For all subjects, T_{S2} and T_{TOT} were significantly slower when starting in a prone position than a standing position (Main effect P<0.01). Conversely,

T_{S15} was similar for both starting positions (Main effect $P>0.05$). When reanalyzed by gender, there were significant interaction effects between gender and starting position for T_{S2} and T_{TOT}. For T_{S2} and T_{TOT}, time elapsed when starting in the standing position was similar for men and women ($P>0.05$). The T_{S2} time from the standing position for both genders was faster than starting in the prone position for men ($P<0.01$), which itself was faster than T_{S2} from the prone position for women ($P<0.01$). For men, T_{TOT} from the standing position was faster than the prone position ($P<0.01$), which itself was faster than T_{TOT} from the prone position for women ($P<0.01$). There was no interaction effect between gender and starting position for T_{S15} ($P>0.05$).

Vest Movement Variables

Vest Conditions: There were no significant differences between vest conditions for the vest movement variables. Summary of lateral and vertical vest movement variables are shown in Tables 3.5 and 3.6, respectively.

Table 3.5. Summary of lateral vest movement in counts for each movement variable (LP, L3sP, LS, L3sS, L5sS) for standing (S) and prone (P) starting positions. Values given as Mean±SE.

LAT. VEST MOVEMENT VARIABLE	POSITION	VEST		
		BS	OS1	OS2
LP (counts/sec)	S	143.45±9.34	138.98±8.42	138.34±8.68
	P	138.57±8.62	132.75±8.18	134.20±7.70
L3sP (counts/sec)	S	140.61±9.58	137.41±8.67	137.70±8.80
	P	120.95±10.70	111.00±9.21	111.91±8.75
LS (counts)	S	469.39±25.20	465.86±21.98	461.30±22.46
	P	471.57±22.81	458.89±22.35	454.50±19.46
L3sS (counts)	S	297.93±23.36	296.41±21.19	306.70±22.34
	P	197.73±20.97	172.07±13.53	171.11±17.12
L5sS (counts)	S	454.64±24.96	451.75±22.92	449.39±22.97
	P	409.48±25.28	396.18±23.13	388.57±22.16

Note: BS=best-sized vest; OS1=vest one size too large; OS2=vest two sizes too large; S=standing starting position; P=prone starting position; LP=lateral peak; L3sP=lateral 3-second peak; LS=lateral sum total; L3sS=lateral 3-second sum total; L5sS=lateral 5-second sum total

Table 3.6. Summary of vertical vest movement in counts for each movement variable (VP, V3sP, VS, V3sS, V5sS) for standing (S) and prone (P) starting positions. Values given as Mean±SE.

VERT. VEST MOVEMENT VARIABLE	POSITION	VEST		
		BS	OS1	OS2
VP (counts/sec)	S	233.89±8.51	227.36±7.64	225.57±7.56
	P	231.30±6.66	228.52±7.27	227.73±6.67
V3sP (counts/sec)	S	224.41±8.45	220.82±7.67	215.91±7.19
	P	205.11±8.75	198.14±7.93	198.20±9.10
VS (counts)	S	1006.20±48.89	972.59±44.64	982.45±43.61
	P	1040.60±41.84	1012.30±41.68	1023.20±41.15
V3sS (counts)	S	479.30±23.15	483.25±22.08	491.18±24.08
	P	339.66±19.19	317.43±17.17	314.09±22.29
V5sS (counts)	S	860.66±32.45	857.52±33.94	853.23±31.09
	P	758.59±22.05	739.09±23.50	717.98±24.87

Note: BS=best-sized vest; OS1=vest one size too large; OS2=vest two sizes too large; S=standing starting position; P=prone starting position; VP=vertical peak; V3sP=vertical 3-second peak; VS=vertical sum total; V3sS=vertical 3-second sum total; V5sS=vertical 5-second sum total

With each sprint lasting between three and five seconds, only 3-second peak and 3-second sum variables were completely contained within every sprint for every subject. All other movement variables included data collected outside of the total sprint time (T_{TOT}). A summary of the 3-second peak and 3-second sum variables (L3sP, V3sP, L3sS, and V3sS) is shown in Table 3.7. Though all differences between vest conditions were insignificant for all vest movement variables, the data appeared to show less vest movement with oversized vests.

Table 3.7. Summary of lateral and vertical vest movement in counts for each movement variable wholly contained within every sprint for every subject (L3sP, V3sP, L3sS, V3sS) for standing (S) and prone (P) starting positions. Values given as Mean±SE.

VEST MOVEMENT VARIABLE	POSITION	VEST		
		BS	OS1	OS2
L3sP (counts/sec)	S	140.61±9.58	137.41±8.67	137.70±8.80
	P	120.95±10.70	111.00±9.21	111.91±8.75
V3sP (counts/sec)	S	224.41±8.45	220.82±7.67	215.91±7.19
	P	205.11±8.75	198.14±7.93	198.20±9.10
L3sS (counts)	S	297.93±23.36	296.41±21.19	306.70±22.34
	P	197.73±20.97	172.07±13.53	171.11±17.12
V3sS (counts)	S	479.30±23.15	483.25±22.08	491.18±24.08
	P	339.66±19.19	317.43±17.17	314.09±22.29

Note: BS=best-sized vest; OS1=vest one size too large; OS2=vest two sizes too large; S=standing starting position; P=prone starting position; L3sP=lateral 3-second peak; V3sP=vertical 3-second peak; L3sS=lateral 3-second sum total; V3sS=vertical 3-second sum total

Position Conditions: Most lateral vest movement variables (LP, L3sP, L3sS, and L5sS) were higher from the standing position than the prone position ($P<0.01$), though LS did not change with starting position ($P=0.60$). Three vertical vest movement variables (V3sP, V3sS, and V5sS) were higher from the standing position than the prone position ($P<0.01$). Conversely, VS was higher from the prone position than the standing position ($P<0.01$). Vertical peak movement (VP) did not change with starting position ($P=0.92$).

Discussion

While there is a considerable amount of research available on the performance effects of load carriage in the form of an armored vest, an exhaustive search of relevant literature did not uncover any prior research on the specific effects of vest sizing. Common sense suggests, and research confirms, that performing the same task with increasingly heavier loads usually results in a decline in performance. This was shown by Pandorf et al. (2002) for women performing the same 3.2 km march wearing 14 kg, 27 kg, and 41 kg. Additionally, carrying increasingly heavier loads also results in changes in biomechanical markers, as shown by Ling et al. (2004) for women performing the same 60-min treadmill march wearing 20 lbs, 30 lbs, 40 lbs, and 50 lbs. These results clarify the effects of carrying significantly heavier loads (in each case, the increase in weight was at least 10 lbs per condition), which may be seen as a proxy for using different styles of armor or adding equipment to an existing vest or kit. They do not, however, accurately represent the small changes in mass (for the present study: 1.2 kg, 0.5 kg, and 0.8 kg changes between the small and medium, medium and large, and large and extra-large vests, respectively) that result when the vest style and kit are kept the same and only the vest size is changed. With this in mind, the purpose of this study was to examine the effects associated with wearing two sizes of oversized armored vests on time and movement markers of sprint performance.

The initial hypotheses of the present study were that both sprint time and vest movement would increase when sprinting in oversized vests. Additionally, the data were analyzed by gender to see if gender was associated with any differences in performance. For all subjects, sprint time was found to increase when performing sprints in an oversized vest. When the data were reanalyzed by gender, however, it was discovered that there was no main effect for vest sizing for men. Women, however, did experience a detriment to sprint performance when sprinting in an oversized vest. Vest movement variables were not significantly affected by vest sizing, though the data did appear to show less vest movement with oversized vests. Thus, the sprint time hypothesis was shown to be true for women, but not for men, and the vest movement hypothesis was not supported for men or women.

Subject Selection - Gender

Researchers testing the effects of load carriage on performance, metabolic factors, and biomechanics have tested both a single gender (Attwells et al. 2012; Larsen et al. 2012; Majumdar, Pal, & Majumdar 2010; Pandorf et al. 2002) and both genders (DeMaio et al. ND; Ricciardi et al. 2007; Treloar & Billing 2011; Swain et al. 2010). Those testing men and women were able to assess the effects of gender on performance, as was the case with Ricciardi et al. (2007) and Treloar and Billing (2011). Different rationales have been given for testing a single gender. Ling et al. (2004) were interested specifically in how women were affected by load carriage. Larsen et al. (2012), however, reasoned that men were more likely to wear body armor and they wanted their results to be as relevant as possible to that population.

The present study was exploratory in nature with a secondary interest in assessing possible gender differences on the effect of vest sizing. As such, we chose to test both men and women. Though the differences were small, the trend shown by the present study was that as vest size increased, so too did the split and total times for the sprints. When the data were analyzed by gender, however, it was revealed that all of the significant time differences between vest conditions were the result of significant effects for women, while there were no significant effects between vest conditions for men.

Time Variables

Effects of Vest Sizing: No significant differences between vest conditions were observed for any of the time variables for men. In contrast, the results for women showed significant increases in elapsed time for all time variables when wearing an oversized armored vest. For women, there was a 3.7% increase in T_{S2} time when wearing the OS2 vest over the BS vest and a 4.7% increase in T_{S2} time when wearing the OS2 vest over the OS1 vest. Likewise, there was a 1.6% increase in T_{S15} time when wearing the OS2 vest over the BS vest. Lastly, there was a 2.5% increase in T_{TOT} time when wearing the OS2 vest over the BS vest and a 2.6% increase in T_{TOT} time when wearing the OS2 vest over the OS1 vest. These results are similar to results by Martin and Nelson (1985), who found that increasing load carriage (0.77 kg, 9.41 kg, 17.59 kg, 29.93 kg, and 36.73 kg) during 25-yard sprints caused women to significantly increase time to complete the sprint. Though the difference in mass and the associated difference in sprint times between the lightest and heaviest conditions for Martin and Nelson's (1985) study was much greater than the present study, when scaled for added mass, the increases in sprint time for the two studies were more similar than they initially seemed. In the present study, sprint times increased 1.5% and 1.9% per kg when moving from the small to large and medium to extra-large vests, respectively. Likewise, for Martin and Nelson (1985), when moving from the lightest condition to the heaviest condition, sprint time increased by 1.1% per kg. The results of the present study suggest that some interaction between the small amount of added mass (0.05 kg and 0.08 kg for those starting with a small and medium vest, respectively) and the difference in bulk or fit of the vest associated with sizing up from an OS1 to an OS2 vest was enough to negatively affect both T_{S2} and T_{TOT} time variables for the women tested. With the design of the present study, however, it was impossible to separate the potential effects of the added mass from the potential effects of the added bulk and changed fit associated with the larger size.

One possible factor contributing to the sprint time differences between men and women in the present study was that each vest condition was characterized by a fixed mass. The mass of each vest was higher as a percent of mean body mass for women than for men (as shown in Table 3.2). Thus, it is possible that the greater relative mass being carried during each sprint by women contributed to their slower times. Rundell and Szmedra (1998) came to a similar conclusion about the effects of a fixed rifle mass carried by male and female biathlon athletes. Though at 3.65 kg, the rifle the biathletes carried was lighter than the armored vests in the present study, Rundell and Szmedra (1998) determined that the fixed mass of the rifle contributed to a greater relative energy cost for women than for men because the rifle was heavier for women as a percentage of their body mass. Additionally, for the present study, total sprint time for women was slower than men even in their BS vest (as shown in Table 3.4). This is in agreement with Martin and Nelson (1985), who showed that even when loads were expressed relative to lean body mass, women were significantly slower under load carriage than men during a 25-yard sprint. Furthermore, Miller et al. (1992) found that for a group of men and women with similar numbers of muscle fibers, numbers of motor units and strength per cross sectional area of muscle, men were still stronger, especially in the upper body. This was attributed primarily to the size of the muscle fibers, with men having larger fibers than women (Miller et al. 1992). The slower BS sprint times for women in the present study (as shown in Table 3.4) may have been the result of a reduced capacity for muscular force generation. Moreover, reduced muscular force generation for women may have contributed to a reduced ability to accelerate the mass of the oversized vests when compared to men, thus resulting in slower sprint times for the OS1 and OS2 conditions.

For the present study, though significant differences were found among the vest conditions for women, the actual differences in the means were very small (mean differences between the largest and smallest vest condition mean were 0.088 sec, 0.040 sec, and 0.114 sec for T_{S2}, T_{S15}, and T_{TOT} variables, respectively). It is fair to wonder if these differences, while statistically significant, are also practically significant. The fact that active duty military personnel are the intended beneficiaries of the results of this study gives the issue added dimension. When one is sprinting away from a place where they are actively being fired upon, perhaps the better questions is: Does “impractical significance” even exist?

Effects of Starting Position: Subjects performed sprints not only in a series of vests, but also starting in both standing and prone positions. We were interested to discover if there were any interactions between the vests and starting position. Though there were no vest by starting position interactions found, a significant starting position main effect was found for all subjects for the T_{S2} and T_{TOT} variables. For these variables, starting in a prone position always resulted in a slower sprint time than starting in a standing position. Since there was no starting position effect for T_{S15}, and since $T_{S2}+T_{S15}=T_{TOT}$, it can be assumed that the T_{TOT} starting position effect was the result of the starting position effect for T_{S2}, the initial two meters of the sprint. Essentially, the prone position required more time to get up and moving through the first two meters (T_{S2}). Once subjects were moving, however, starting position did not affect their ability to complete the sprint (T_{S15}). Similarly, in 2006, Duthie et al. showed that starting position significantly affected 20-meter sprint time by testing three different starting positions; Standing, standing with footpad activated start, and a conventional three-point start with thumbpad activation. Like the present study, Duthie et al. (2006) found a standing, footpad activated start to be faster than a starting position in which the body was more parallel with and closer to the ground, which in Duthie et al.'s case was the conventional three-point start.

Vest Movement Variables

Vest condition did not significantly affect vest movement for any of the vest movement variables. The data did appear, however, to reveal insignificant decreases in vest movement when subjects sprinted in an oversized vest (as shown in Table 3.5 and

Table 3.6). Unlike vest condition, starting position did significantly affect four out of the five lateral vest movement variables (LP, L3sP, L3sS, and L5sS) and four of the five vertical movement variables (V3sP, VS, V3sS, and V5sS). Care should be taken when interpreting significance of the vest movement variables, however, since only the lateral and vertical 3sP and lateral and vertical 3sS variables were wholly contained in every sprint for every subject. Though it was the original goal of the study protocol to have each subject run exactly 20 meters (15 meters through the final timing gate and stop on a line exactly five meters beyond the final gate), not all subjects were able to stop within five meters, so the distance represented by the LP, VP, LS, VS, L5sS, and V5sS variables was not completely consistent between subjects.

Three-Second Peak and Sum Variables: Three-second peak and sum vest movement variables (L3sP, L3sS, V3sP, Vs3P), while not statistically significant, appeared to show less movement in an oversized vest. Additionally, these variables significantly increased when sprints started from a standing position rather than a prone position. Though it was originally hypothesized that sprinting in an oversized vest would increase vest movement, thereby negatively influencing sprinting speed, the data did not confirm this. For women, sprinting speed was negatively influenced when an oversized vest was worn, but it was not the result of increased vest movement. Moreover, it was hypothesized that the “get up” movement required to start a sprint from a prone position would result in greater overall vest movement when starting in a prone position than a standing position. Again, this was found not to be the case. For each 3-second peak and sum variable, vest movement was significantly less for sprints from a prone position than sprints from a standing position.

Previous studies have shown that when measures are taken to improve the fit (Hollins et al. 2012) or alter the load-bearing mechanism (Hoover & Meguid 2011) of a backpack during load carriage, positive changes can result. Hollins et al. (2012) determined that the addition of a chest strap to a heavy pack improved both physiological and performance variables. Likewise, Hoover and Meguid (2011) found that use of a suspended-load backpack improved energy efficiency of walking for high pack loads and fast walking speeds. Neither research team, however, measured the motion of the pack directly. The lack of any directly related available research makes it difficult to provide concrete context for our results.

One possible explanation for the results of the present study may be that our original hypothesis had the wrong order of causality for speed and vest movement. It was initially assumed that increased vest size would cause increased vest movement, ultimately resulting in decreased sprint speed. It may instead be the case that vest movement is dependent upon sprinting speed, such that simply decreasing speed resulted in decreased vest movement. If this is the case, then the decreased speed resulting from sprinting in oversized vests would be the cause of the decrease in vest movement recorded in the oversized vests. If it is true that speed determines vest movement, it would also explain the fact that for the 3-second peak and sum variables, starting in a prone position always resulted in less vest movement than starting in a standing position. Sprints from prone were significantly slower for all subjects than sprints from standing, so it may be that the initial burst of speed when starting in a standing position caused higher vest movement variables than the slower start and initial acceleration (T_{S2} time variable) of the prone sprints. Future studies are needed to clarify the causal effects of speed and vest movement.

Conclusions

In the present study, wearing an oversized armored vest was shown to increase 15-meter sprint time for women, but not for men. Additionally, starting a sprint from a prone position instead of a standing position resulted in a slower 15-meter sprint time as well as decreased markers of vest movement for all subjects. Ideally, all active-duty military personnel will always have access to their best-sized armor, but it is especially important for women in ground combat. While the present study showed that for the women tested, sprint times increased in oversized armored vests, further research is needed to separate the potential effects of the added mass from the potential effects of the added bulk and changed fit associated with the larger size.

CHAPTER FOUR

CONCLUSIONS

Load carriage in the form of an armored vest is an unavoidable part of functioning in a ground combat team. While the physiological, kinematic and performance effects of load carriage in general have been the focus of a large body of research, the idea of armored vest sizing as an independent variable has been overlooked. Ideally, all military ground troops will have access to their best-sized armor whenever they need it, but anecdotal reports suggest that this may not always be the case. Therefore, the purpose of the present study was to examine the effects of armored vest sizing on time and vest movement markers of 15-meter sprint performance.

Fifteen meter sprint speed while wearing an oversized vest was found to be adversely affected for women, but not for men. Though all differences between vest conditions were insignificant for all vest movement variables, the data appeared to show less vest movement with oversized vests. Starting position for the 15-meter sprints, however, did significantly affect both sprint speed and vest movement. For both men and women, starting from a standing position resulted in significantly faster sprint time and greater vest movement than starting the sprint from a prone position.

While the present exploratory study yielded interesting results, further research is necessary to clarify some of these findings. The subjects recruited for this study were a heterogeneous group. Both genders were represented, ages ranged from 19 – 46 years, and with about half of the subjects coming from MSU’s Air Force ROTC, experience wearing armored vests was wide ranging as well. Though all subjects were healthy and free from contraindications to sprint exercise, their average weekly physical activity ranged from "one game of racketball per week" to "16 hours per week of road biking and running." A more homogenous group of subjects (single gender and tighter age range with more similar weekly physical activity) might reveal differences between vest conditions that were hidden in the present study by the wide range of subject characteristics and experiences. Additionally, testing a single gender with subjects in two distinct size groups would be a good way to determine if the results of the present study were truly gender-based or if subject size was a confounding factor.

Changes to the study protocol and instrumentation may also contribute to the clarity of the results. Further research is needed to separate the potential effects of the added mass from the potential effects of the added bulk and changed fit associated with the larger sizes. This could be tested by running a similar protocol to the present study, but keeping the mass of all vests constant. To address the issue of fixed armor mass representing a larger percentage of body mass for women than men, sprints could be run wearing a vest that is tailored to weigh a fixed percentage of each subject's body mass. A protocol with multiple fixed running speeds per vest could help determine whether vest movement is determined by speed. Additionally, recording more timing splits within each sprint could help determine the effects of vest sizing on acceleration and deceleration during a sprint. Summarizing the vest movement data for each half-second or quarter-second rather than each one-second may show more clearly what is happening to the vest movement variables over the course of a three to five second sprint. Finally, the addition of 3D kinematic analysis may be able to show potential changes in gait or torso motion with each condition, thus helping to separate the effects of added mass from the effects of the changed bulk and fit of oversized vests.

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APPENDICES

APPENDIX A

SUBJECT CONSENT FORM

SUBJECT CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH AT
MONTANA STATE UNIVERSITY – BOZEMAN

PROJECT TITLE: Influence of Armored Vest Sizing on Markers of Sprint Performance

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Dept. of Health and Human Performance, MSU
Phone: 406-994-6324, Email: dheil@montana.edu

FUNDING: Equipment support provided by Mystery Ranch, LTD, Bozeman, MT.

PURPOSE:
You are being asked to participate in a research project to measure the effects of wearing an oversized US Marine Corps issue Scalable Plate Carrier (hereafter referred to as “armored vest” or “vest”) on markers of sprint performance. It is a well-known fact that for members of the US military, ballistic protection in the form of armored vests is necessary. As load carriage requirements for military personnel continue to rise, however, it is becoming increasingly important to keep additional weight and bulk down to the bare minimum. While a considerable amount of research has clarified the effects of load carriage in general, there is still much to be discovered about the importance of sizing of armored vests with respect to military-specific task performance. A 15-meter sprint was chosen for this study because it represents a task commonly undertaken by people in a wide range of military roles, including ground-combat, and in all branches of the US military.

Each participant is presented with this Informed Consent Document, which explains the purpose of the testing, as well as risks and benefits associated with participation in the study. As a study participant, you should be between the ages of 18 – 45, healthy, with no contraindications to sprinting exercise, and have a torso length no greater than 42.5 cm (16.7 in). Each participant will fill out a Health History Questionnaire to identify any potential health risks that may prevent you from participating in this research project. If a concern is identified by the Project Director, it is your responsibility to acquire written medical clearance from your physician and provide a copy of this written clearance to the Project Director prior to participation in the project. This procedure is in compliance with policies formulated by the American College of Sports Medicine.[1]

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[1] American College of Sports Medicine (2010). *ACSM’s Guidelines for Exercise Testing and Prescription* (8Th Edition). Williams & Wilkins, Philadelphia, PA.

GENERAL PROJECT OUTLINE:
There is no cost to you (the participant) and participation in this research project is voluntary. If you agree to participate, you will be asked to make three separate visits to the MSU-Bozeman campus. The first visit, in the Romney Gymnasium (RG), is to practice sprinting in an armored vest and will take approximately 45 minutes. During the second visit, also in the RG, you will sprint wearing three different sizes of armored vests and data will be collected for analysis. This visit will take approximately 60 minutes. The third visit, in the Movement Science Lab (MSL) is for a procedure called hydrostatic (underwater) weighing, which is a way to estimate percent body fat. This visit should take no longer than 30 minutes.

Before arriving to RG for the sprint tests, you should refrain from high intensity or long duration exercise for at least 24 hours. Additionally, you should refrain from ingesting alcohol for at least 24 hours and caffeine for at least 3 hours. While there is no specific required food intake prior to testing, we suggest that you fuel (nutrition and hydration) for both visits as though you were preparing for a strenuous bout of high intensity exercise. Water will be provided to you as desired over the course of the two visits. Please dress in athletic shoes and lightweight clothing suitable for sprinting.

This study is designed to test the effects of wearing oversized armored vests on markers of vest movement and sprint performance. You will be asked to complete a series of 15-meter sprints, from standing (one foot forward, hands at sides) and prone (lying on your stomach in a push-up position) positions, for each of three conditions. These conditions include wearing your best-sized armored vest (BS), an oversized vest one size too large (OS1), or an oversized vest two sizes too large (OS2). A BS vest is defined as the armored vest that most closely complies with the torso-length based sizing requirements developed by trained personnel from a local backpack company specializing in military contracts (Mystery Ranch, LTD, Bozeman, MT). The vests available for testing include a small (14.7 kg; 32.3 lbs), medium (15.9 kg; 35.0 lbs), large (16.4 kg; 36.1 lbs), and extra-large (9.3 kg; 37.8 lbs). It is hypothesized that wearing either the OS1 or OS2 vests will negatively influence measures of vest movement or sprint performance.

Procedures for the first visit to RG will be as follows:

1. Ten-minute period for filling out required paperwork and asking investigators any questions you may have.
2. Measurement of body height and weight. A trained personnel from a local backpack company specializing in military contracts (Mystery Ranch, LTD, Bozeman, MT) will size you for your best-sized armored vest.
3. STANDARDIZED WARM UP
    a. Two minutes of walking and three minutes of jogging at your own pace around the periphery of RG.
    b. Four 15-meter submaximal (self-determined 70% - 85% effort) sprints wearing no armored vest. Two of these sprints will be from a standing

position and two will be from a prone position. Two minutes of rest will be given after each sprint.

4. PRACTICE SPRINTS
   The goals of performing the practice sprints are to allow you to get used to sprint testing wearing an armored vest, establish standardized standing and prone starting positions, and make sure you are comfortable with the testing protocol in general.
   a. Two 15-meter practice sprints, one from a standing position and one from a prone position, will be performed at 85% effort and wearing your best-sized vest. Two minutes of rest will be given after each sprint.

   b. Four 15-meter practice sprints, two from a standing position and two from a prone position, will be performed maximally (self-determined 100% effort) and wearing your best-sized vest. Two minutes of rest will be given after each sprint.

Procedures for the second visit to RG will be as follows:

1. Measurement of body height and weight.
2. STANDARDIZED WARM UP
   a. Two minutes of walking and three minutes of jogging at your own pace around the periphery of RG.
   b. Four 15-meter submaximal (self-determined 70% - 85% effort) sprints wearing the armored vest assigned to your first testing condition. Two of these sprints will be from a standing position and two will be from a prone position. Two minutes of rest will be given after each sprint.
3. SPRINTS
   a. Four 15-meter sprints for each of the three conditions (BS, OS1, OS2), two from a standing position and two from a prone position, for a total of 12 maximal sprints. Two minutes of rest will be given after each sprint.

During each sprint, vest movement variables will be collected using small accelerometers mounted to the front of the armored vest.

While the visits to RG will occur in sequential order (practice, then testing), the visit to the MSL for hydrostatic weighing may occur at any time before, between, or after the two visits to RG. There are no pre-testing exercise or fueling requirements for the underwater weighing test. Ideally, you should wear tight-fitting swimwear for the underwater weighing, but if you are more comfortable wearing different swimwear, you may do so. When you arrive to the MSL, your body height and weight (wearing only shorts or swimwear) will be measured by a lab technician. The procedure for the test involves sitting in a chair in a specially designed water tank that is chemically treated with bromine and maintained at a comfortable temperature (90 – 96° F). The tank is only 4.5 ft deep and you are unrestrained in the chair so you will always be able to get your head above the water by standing upright. When instructed, you will submerge yourself completely while sitting in the chair (which is suspended from a digital scale) and maximally exhale all air possible out of your lungs. You will remain underwater for 5-10 seconds while your underwater weight is read from the scale and recorded. You may need to practice this procedure several times to feel completely comfortable underwater. A total of 3-10 underwater weighing tests will be performed, which includes those trials needed for practice. Being submerged like this can make some people uncomfortable, so please inform the lab technician if you are feeling uncomfortable or if you want to stop testing for any reason. There are both male and female lab technicians available for testing. If you prefer one over the other, please let us know as much in advance as possible and we will accommodate the request.

No photographs will be taken during the underwater weighing test, but you do have the option of allowing photographs to be taken during the sprint testing. If photographs are allowed, they may be displayed during professional presentations of this research.

POTENTIAL RISKS:

The risks associated with the sprint task are minimal and similar to risks associated with other high intensity exercise, such as sprinting, interval running or weight lifting. You may experience a small amount of discomfort associated with wearing a weighted vest (ranging in mass from 6.8 – 9.3 kg; 15.0 – 20.5 lbs) during the sprint. Additionally, you may experience some muscle soreness later in the day or the next day associated with the performance of a series of 15-meter sprints.

It is possible that you will feel uncomfortable with the procedures required for underwater weighing. Anyone who experiences claustrophobia or gets very uncomfortable with putting their head underwater for 5-10 seconds should NOT participate in this testing. The weighing tank is only 4.5 feet deep so it is possible to stand upright at any time to get your head out of the water. In addition, the tank itself is fairly large (6 ft wide x 10 ft long x 4.5 deep) so being within the tank usually does not feel confining.

SUBJECT COMPENSATION:

All participants who take part in the hydrostatic (underwater) weighing visit will receive a free copy of their body composition analysis. Body composition analysis via hydrostatic weighing is a service that is available to the public and normally costs $30.

BENEFITS:

There are no direct benefits to you a volunteer for this project. However, the Project Director, Lisa Whalen, will make a summary of study findings available to you upon request after the completion of the study. Lisa Whalen can be reached by phone at 907-545-1557 or by email at lisamwhalen@gmail.com.

CONFIDENTIALITY:
The data and personal information obtained from this project will be regarded as privileged and confidential. Your height, weight, body composition, and sprint times will not be released to anyone else except upon your written request/consent. Your right to privacy will be maintained in any ensuing analysis and/or presentation of the data by using coded identifications of each person's data.

FREEDOM OF CONSENT:
You may withdraw consent for participation in writing, by telephone, or in person without prejudice or loss of benefits (as described above). Participation in this project is completely voluntary.

In the UNLIKELY event that your participation in the project results in physical injury to you, the Project Director will advise and assist you in receiving medical treatment. No compensation is available from Montana State University for injury, accidents, or expenses that may occur as a result of your participation in the project. Further information regarding medical treatment may be obtained by calling the Project Director, Lisa Whalen, at 907-545-1557 or the Lab Director, Dan Heil, at 406-994-6324. You are encouraged to express any questions, doubts, or concerns regarding this project. The Project Director will attempt to answer all questions to the best of her ability prior to any testing. The Project Director fully intends to conduct the study with your best interest, safety, and comfort in mind. If you have additional questions about the rights of human subjects you can contact the Chair of the Institutional Review Board, Mark Quinn, at 406-994-4707 or mquinn@montana.edu

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STATEMENT OF AUTHORIZATION

I have read the above and understand the discomforts, inconvenience, and risk of this study. I, ______________________________ *(print your name)*, agree to participate in this research. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

_____________________________________ _______________

Signature of Participant Date

_____________________________________ _______________

Investigator Date

Please initial one of the following:

☐ I give permission for photographs to be taken of me during this project with the understanding that these photographs may be used in professional presentations. No photographs will be taken of the hydrostatic weighing test.

☐ I DO NOT give permission for photographs to be taken of me during this project.

APPENDIX B

HEALTH HISTORY QUESTIONNAIRE

Health Status Questionnaire - Montana State University
Movement Science/Human Performance Laboratory

INSTRUCTIONS

Complete each of the following questions as accurately as possible by filling in the blanks or checking the most appropriate box. All information provided is confidential and no information will be released without your written consent.

Today's Date ________________

GENERAL INFORMATION

Mr. □ *Ms.* □ *Miss* □ *Mrs.* □ *Dr.* □

Last Name _______________________________ *First Name* ____________________

Mailing Address ____

____

Home Phone ___________________________ *Office Phone* ______________________

Occupation ____

Employer ____

Person to Contact in Emergency: Name _____________________________________

Relationship _____________________________________

Phone _____________________________________

- *Descriptive information:*

Gender: Male □ *Female* □ *Body Weight* __________________

Age ________ *Date of Birth* ____________ *Body Height* __________________

- *Why are you filling out this questionnaire?*

□ *You have volunteered for a research study or project.*

□ *You are being screened for fitness testing in the Movement Science Lab.*

□ *Other reason...*____

MEDICAL HISTORY

Name of your physician ____
(Address/phone?)____

- *Family History:*

Did your father, or other first degree male relative (like a brother) die before the age of 55?
No ☐ Yes ☐ If Yes, cause? _____________________
Age at death? _____________________
Which relative? _____________________
Did your mother, or other first degree female relative (like a sister) die before the age of 65?
No ☐ Yes ☐ If Yes, cause? _____________________
Age at death? _____________________
Which relative? _____________________

- *List any food or drug allergies:*

____
____
____
____

- *List any medication you are currently taking (non-prescription and prescription, including oral contraceptives). Please comment on the reason for each medication.*

____
____
____
____
____
____

- *Please describe any recent illnesses, hospitalizations, or surgical procedures:*

____
____
____
____
____

· *Any of these health symptoms that occurs frequently (ranked as either a 4 or 5 below), either at rest or during physical exertion, is the basis for a prompt medical evaluation. Circle the number indicating how often you have each of the following:*

0 *= Never*	***1*** *= Practically never*	***2*** *= Infrequently*
3 *= Sometimes*	***4*** *= Fairly often*	***5*** *= Very often*

a. Coughing up blood.	*0*	*1*	*2*	*3*	*4*	*5*
b. Abdominal pain.	*0*	*1*	*2*	*3*	*4*	*5*
c. Low-back pain.	*0*	*1*	*2*	*3*	*4*	*5*
d. Chest pain.	*0*	*1*	*2*	*3*	*4*	*5*
e. Neck, jaw, arm, or shoulder pain.	*0*	*1*	*2*	*3*	*4*	*5*
f. Leg pain.	*0*	*1*	*2*	*3*	*4*	*5*
g. Swollen joints, especially the ankles.	*0*	*1*	*2*	*3*	*4*	*5*
h. Feel faint.	*0*	*1*	*2*	*3*	*4*	*5*
i. Feeling of dizziness.	*0*	*1*	*2*	*3*	*4*	*5*
j. Breathless with slight exertion.	*0*	*1*	*2*	*3*	*4*	*5*
k. Palpitation or fast heart rate.	*0*	*1*	*2*	*3*	*4*	*5*
l. Unusual fatigue with normal activity.	*0*	*1*	*2*	*3*	*4*	*5*
m. Abnormal/labored breathing at night.	*0*	*1*	*2*	*3*	*4*	*5*

For any score of "4" or higher, use the space below to explain the frequency and the conditions under which you experience that particular symptom:

____

____

____

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____

____

____

____

____

· *Please indicate which of the following for which* ***you have been diagnosed or treated*** *by a physician or health professional. Please be as complete as possible.*

Check if "Yes" If AYes@, please comment further...

- ☐ *Alcoholism* ____________________
- ☐ *Anemia, sickle cell* ____________________
- ☐ *Anemia, other* ____________________
- ☐ *Asthma* ____________________
- ☐ *Back strain* ____________________
- ☐ *Blood pressure - High?* ____________________
  Low? ____________________
- ☐ *Bronchitis* ____________________
- ☐ *Cancer* ____________________
- ☐ *Cirrhosis, liver* ____________________
- ☐ *Cholesterol - High?* ____________________
- ☐ *Concussion* ____________________
- ☐ *Congenital defect* ____________________
- ☐ *Diabetes Type?* ____________________
- ☐ *Emphysema* ____________________
- ☐ *Epilepsy* ____________________
- ☐ *Eye problems* ____________________
- ☐ *Gout* ____________________
- ☐ *Hearing loss* ____________________
- ☐ *Heart problems* ____________________
- ☐ *Hypoglycemia* ____________________
- ☐ *Hyperlipidemia* ____________________
- ☐ *Infectious mononucleosis* ____________________
- ☐ *Kidney problems* ____________________
- ☐ *Menstrual irregularities* ____________________
- ☐ *Mental illness* ____________________
- ☐ *Neck strain* ____________________
- ☐ *Obesity* ____________________
- ☐ *Phlebitis* ____________________
- ☐ *Rheumatoid arthritis* ____________________
- ☐ *Stroke* ____________________
- ☐ *Thyroid problems* ____________________
- ☐ *Ulcer* ____________________
- ☐ *Other* ____________________
  ____
  ____

BLOOD CHEMISTRY PROFILE

- *Have you ever had a fasting blood sample analyzed for cholesterol?* □ *Yes* □ *No*

If "Yes," *when was last time your blood was analyzed?* ___________________
If "Yes," *please provide as much detail as possible with regard to the specific blood components requested below (most recent test results only). Ideally, we would like both the numerical value of the test result AND the units of the measurement (the units are typically reported along with the numerical value of the test result).*

- *Total serum cholesterol* _________ *units?* __________
- *HDL (high density lipoprotein)* _________ *units?* __________
- *LDL (low density lipoprotein)* _________ *units?* __________
- *VLDL (very low density lipoprotein)* _________ *units?* __________
- *Triglycerides* _________ *units?* __________
- *Blood glucose* _________ *units?* __________
- *Hemoglobin* _________ *units?* __________
- *Hematocrit* _________ *units?* __________
- *Iron* _________ *units?* __________

HEALTH-RELATED BEHAVIORS

- *Do you now smoke?* □ *Yes*□ *Infrequently* □ *No*

If "Yes" *or* "*Infrequently*", *indicate the number smoked per day (on average):*

Cigarettes: 40 or more 20-39 10-19 1-9

*Cigars/pipes - describe:*_______________________________________

- *Have you recently quit smoking?* □ *Yes*□ *No*

If "Yes", *how long ago did you quit?* ______ *years* _______ *months*

- *Do you currently work in an environment where smoking is allowed?*

  □ *Yes* □ *No*

  If "Yes", *where do you work AND how frequently do you work in this environment?*

- *Do you drink alcoholic beverages on a regular basis?* □ *Yes* □ *No*
  (ie. at least once/week)

  If "*Yes*", *please answer the following:*

  1) *How frequently do you drink?*

  2) *What alcoholic beverages do you typically consume?*

- *Have you **exercised** regularly in the past 4 weeks?* □ *Yes* □ *No*

  If "*Yes*", *describe in terms of frequency, duration, intensity, and type of exercise:*

- *Do you consider yourself **physically active** due to work-related demands, home or farm chores, etc.?* □ *Yes* □ *No*

  If "*Yes*", *describe in terms of frequency, duration, intensity, and type of exercise:*

- *Please describe anything not already described on this questionnaire that might cause you problems during exercise (use the space below).*

- *Are there any other health-related problems or concerns NOT addressed on this questionnaire that we should know about?*
  □ *Yes* □ *No*

If "*Yes*", *please describe:*