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<b>13. ABSTRACT (Maximum 200)</b>  <p>Military recruit training is physically demanding and results in a high rate of musculoskeletal injuries. Identification of back injury risk factors and the successful development of preventive measures could significantly decrease recruiting expenses, lost time due to injury, and training costs for female military recruits.</p> <p>The aims of this prospective, non-experimental study of female military recruits are to: (1) Describe the incidence and prevalence of back injury. (2) Describe the distribution of types of back injuries in basic training. (3) Identify basic training tasks which are leading causes of back injury. (4) Identify physical performance, trunk performance, functional lifting ability, back knowledge, behavioral, psychosocial, and demographic factors that correlate with development of back injury. (5) Identify a model which can predict the likelihood of back injury during basic training.</p> <p>A convenience sample of at least 700 female recruits attending basic training at Fort Jackson, Columbia, SC will be examined. Explanatory variables will be collected prior to beginning training activities. Back injury, the response variable, will be obtained from medical records and a self-reported questionnaire prior to graduation.</p> <p>Rates, frequencies, and percentages will be used to accomplish aims 1, 2, and 3. Point-biserial correlation coefficients will be calculated between the dichotomous response variable and the predictor variables (aim number 4). An all subsets logistic regression method will be employed to address aim number 5.</p>			
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FOREWORD

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None For the protection of human subjects, the investigator(s) adhered to policies of applicable Federal Law 45 CFR 46.

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Michael S. Weaver 10/22/97  
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## **Introduction**

The overall goal of this study is to gain a better understanding of development of back injury in female military recruits during basic training. Just as any vigorous exercise or sports program may increase injury rates, basic training for new recruits results in a high risk for musculoskeletal injuries. Musculoskeletal injuries among recruits contributes to lost time, pain, medical costs, and even attrition. Although women recruits have been found to be at higher risk than men for some training-related injuries<sup>1,2</sup>, no studies have been reported on the risks of women recruits for back injury. Therefore, an expected result of the study will be the identification of predictors of back injury which will be beneficial to the armed forces in preventing back injuries and lowering costs among women recruits. Five specific aims will be addressed toward achieving the study's overall goal:

1. To describe the incidence and prevalence of back injury in women military recruits participating in basic training.
2. To describe the distribution of types of back injuries in women military recruits participating in basic training.
3. To identify basic training tasks which are leading causes of back injury.
4. To identify physical fitness, trunk performance, functional lifting ability, behavioral, back knowledge, psychosocial, and demographic factors which correlate with development of back injury in women military recruits participating in basic training.
5. To identify a model which can predict the likelihood of back injury in women military recruits participating in basic training.

These aims are addressed within the following research questions (aims 1, 2, 3, and 5) and hypotheses (aim 4):

### ***Research Questions***

1. What is the incidence of back injury in women military recruits participating in basic training?
2. What is the prevalence of back injury in women military recruits participating in basic training?
3. What is the distribution of types of back injuries in women military recruits participating in basic training?
4. What basic training tasks are most frequently associated with back injury?
5. Which of the selected physical fitness, trunk performance, functional lifting ability, back knowledge, behavioral, psychosocial, and demographic variables are required in a logistic regression model to predict development of back injury in women military recruits participating in basic training?

### ***Hypotheses***

1. There will be significant associations between development of back injury in women military recruits participating in basic training and: (a) aerobic capacity (two mile run time), (b) upper body strength (number of push-ups and sit-ups in a two minute period), (c) lower body strength (number of squats in a one minute period), (d) trunk performance (Isostation B200

trunk performance measures), (e) functional lifting ability (floor-to-waist lift task), (f) hamstring flexibility (sit-and-reach), (g) body composition (body mass index; percent body fat), (h) smoking, (i) previous back injury, (j) back knowledge, (k) life satisfaction, (l) anxiety (Spielberger State-Trait Anxiety Questionnaire), (m) age, and (n) race.

### **Technical Objectives**

Four technical objectives will be addressed within this study:

1. Measure and describe back injuries in a cohort of female military recruits undergoing basic training. This objective involves describing incidence and prevalence of back injuries and the distribution of type of back injury.
2. Describe the types of basic training activities associated with back injury.
3. Identify risk factors for back injury by testing for significant associations between development of back injury in women military recruits participating in basic training and: (a) aerobic capacity, (b) upper body strength, (c) lower body strength, (d) trunk performance, (e) functional lifting ability, (f) hamstring flexibility, (g) body composition, (h) smoking, (i) previous back injury, (j) back knowledge, (k) life satisfaction, (l) anxiety, (m) age, and (n) race.
4. Develop a model to predict likelihood of developing back injury in female military recruits during basic training.

The identification of risk factors and a predictive model for back injury are the first steps required in order to develop screening and training interventions to prevent back injury. Development of successful preventive strategies could significantly decrease recruiting expenses, turn-over rates, lost time due to injury, and training costs for female military recruits.

### **Background**

This study is guided by an injury control perspective. Within this perspective, health problems, such as back injury, are viewed as preventable if interventions are adopted which protect the individual from stressors that threaten to disrupt system stability. Requirements of basic training are considered occupational stressors which may result in back injury. The objective of this study is to identify factors which are associated with development of back injury. Once those factors are identified, preventive screening and training interventions designed to reduce risk of back injury could be incorporated into the basic training routine.

Military recruit training is physically demanding and results in excessive musculoskeletal injuries<sup>3</sup>. Vigorous exercise requirements during basic training pose risks for musculoskeletal injury among recruits, many of whom are not physically fit upon entry into military service. Despite publicity given to the hazards of deployment, recruit training and routine military work present greater continuing hazards because of the mandatory fitness testing, marching, field exercises, and frequent lifting of heavy materials<sup>4</sup>. Musculoskeletal injuries among recruits result in pain, lost training time, medical costs, and inability to complete training<sup>5</sup>. The Army reported that 9 percent of the discharges within the first six months of service were attributed to low back problems<sup>6</sup>. From 1990 to 1991, two-thirds (67%) of the medical discharges in the Air Force were for new recruits in basic training and resulted in cost of \$2.7 million<sup>7</sup>. Women recruit trainees have been

found to have more lost time injuries than males in the same recruit training regimens<sup>1,2</sup>. Prevention clearly is indicated to reduce musculoskeletal injuries among women recruits.

Statistics about occupational musculoskeletal injuries and back injuries are alarming. Low back injury is the leading cause of compensable injury and only the common cold results in more absenteeism in the workplace<sup>8</sup>. Expenditures for medical care, workers' compensation and lost work time resulting from back injury are estimated at 56 billion dollars per year<sup>9</sup>. Because industry is experiencing increased rates of back disabilities and is seeking ways to control these costs, the American Association of Occupational Health Nurses has identified back injury prevention research as one of its twelve priority areas<sup>10</sup>. Simultaneously the Department of Health and Human Services in Healthy People Year 2000<sup>11</sup> proposes a national health objective to increase to at least 50 percent the number of worksites which offer back injury prevention programs.

Uncertainty about the causes and pathophysiology of back injury continue to complicate efforts to control occupational back problems<sup>12</sup>. Hypotheses about the causes of low back injury include: (a) muscle incoordination during rapid motion, (b) muscle fatigue with repetitive movements, and (c) disc degeneration from compression forces during repeated lifting<sup>13,14</sup>. Risk factors which have been associated with back injury include weak lumbar and abdominal muscles, obesity, poor posture, physical stressors of heavy or frequent lifting, excessive bending, twisting or reaching, prolonged sitting or standing, vibration, smoking, age, time of day, and anxiety<sup>15,16,17,18,19,20,21</sup>.

Attempts to control occupational back injury have traditionally focused on pre-employment x-rays, safety training, and strength testing<sup>22</sup>. While employers have held to the notion that x-rays may detect applicants with pre-existing back problems, empirical evidence does not support the use of x-rays for predicting the incidence of back injuries<sup>23,24</sup>. In addition, pathology detected from imaging has not been found to correlate with reports of back symptoms<sup>25</sup>. More recently, ergonomic task redesign to improve manual materials handling, minimize excessive loads, and alter work stations have demonstrated some success in control of back problems<sup>26</sup>. Pre-placement medical screening of subjects for minimum job strength requirements has been found to be superior to a traditional medical examination in reducing the incidence of musculoskeletal problems<sup>27,28</sup>. The latest innovation in back assessment is the use of computerized back testing equipment such as Cybex and the Isostation B-200 (Isotechnologies, Inc.). No published empirical evidence is available on the use of this equipment for assessing trunk performance of women and for predicting back injury among military women.

### Physical Performance and Injury

Mechanical trauma is the major prevailing notion for the etiology of work-related back injury. Muscles strained by repetitive or sudden motion undergo an inflammatory response producing symptoms of pain and restricted motion. Even slight trauma limits the extent to which muscle fibers will stretch. When joints are not properly exercised and conditioned, connective tissue in tendons, ligaments, muscles, and joint capsules become dense and shortened; any attempt to regain the lost range of motion in the joint is resisted. This accounts for much of the limitation in range of motion of most joints in the body<sup>29</sup>. This natural chain of events can perhaps be accelerated by repeated microtrauma which occurs when recruits are required to participate in new physical requirements and field exercises throughout basic training.

The use of exercise for prevention of injury is based on experience in military and sports medicine. A review of military, medical, physical therapy, and sports medicine literature supports the notion that flexibility and strength training may ultimately reduce injury rates<sup>30,31,32,33</sup>. Gracovetsky and Farfan<sup>34</sup> suggest that stronger trunk musculature can stabilize the spine to protect it from injurious forces. Empirical evidence indicates that sports injuries can be avoided with flexibility and strength training<sup>35,36</sup>. However, participation in exercise, conditioning, and military training is known to result in injuries<sup>3</sup>. Limited data are available on the incidence of back injuries resulting from military basic training.

Trunk performance is a function of muscular strength and flexibility. Muscular strength and flexibility maintain the spine in an erect posture and maintain equilibrium when the center of gravity shifts due to an outstretched arm or carrying a load, etc. Flexibility refers to the suppleness of a joint. With limited flexibility muscles are tight and restrict movement of the joint through the full range of motion. Lack of flexibility has been correlated with an increase in muscular injuries<sup>37,38</sup>. Flexibility is accomplished with a stretching routine which serves to lengthen muscle fibers, muscle sheathing, ligamentous joint capsule, and tendons and to make them more pliable. More pliable muscles, tendons, and ligaments are less likely to be injured. Because high demand muscular activity results in microscopic muscle tears that cause the muscle to heal shorter, stretching is recommended to overcome the effects of vigorous muscular activity. Investigators attribute the back inflexibility and pain found in runners, tennis players and other athletes to this healing mechanism. Therefore, back exercises including knee to chest, trunk rotation, hamstring stretch, and press-up exercises are routinely included in exercise training to improve trunk flexibility<sup>39</sup>.

Strength refers to the ability of a muscle to contract and exert power. Strength is not simply explained by the size of the muscle but is dependent on motor neuron involvement in activating the muscle fiber<sup>40</sup>. Strength improvement requires 6-12 weeks of repetitive contractions and has been found to be due to enhanced neural activation through increase in electrical stimulation of motor units, i.e. increase in firing frequency or synchronization of firing between motor units<sup>41</sup>. Specificity of muscle groups is an essential concept in muscle training therefore to strengthen the muscles which support the back (the abdominal muscles and lumbar extensors), sit-ups and exercises such as prone isometrics are usually recommended<sup>39</sup>.

Muscular demands in military work may be greater than the muscular stress of sports. Trunk mobility is essential for workplace activities such as lifting and bending<sup>42</sup>. Although studies demonstrated that vigorous exercise can improve trunk performance<sup>43,44</sup>, numerous controversies are found in the literature regarding the value of improving mobility vs. strengthening abdominal and lumbar extensor muscles. The merits of static flexibility training, active flexibility training with or without resistance, aerobics training, or extension training are also topics of debate<sup>44,45,46,47</sup>. Further research is needed to correlate trunk performance, fitness levels, and subsequent back injury rates.

Because empirical evidence has demonstrated that low back pain patients have weak abdominal and lumbar muscles and tight hip flexor, hamstring, and lower back muscles, a combination of isometric flexion, extension, and active flexion exercises are currently utilized in exercise training and exercise prescriptions<sup>39</sup>. An emphasis on extension is based on observations that 1) prolonged flexion postures often result in low back pain, and 2) trunk extensor performance exceeds trunk flexor performance in subjects without back pain.

Evidence has been accumulating that workers who have insufficient strength and fitness for their jobs are likely to experience injury<sup>12,48,49,50</sup>. Men and women recruits who were less physically fit on entry into military service were found to have greater lost time musculoskeletal injuries than new recruits who were physically fit<sup>1</sup>. In a classic prospective study of 1652 firefighters Cady et al. demonstrated that exercise may have a protective effect in the prevention of back injuries<sup>48</sup>. Increased levels of physical performance (flexibility, strength, and endurance) were associated with decreased incidence of back injury and decreased duration of back injury symptoms. In a more recent report, Cady and associates demonstrated that firefighters with better than average physical fitness as evidenced by increased flexibility or strength or work capacity had fewer back injuries than those firefighters who were less physically fit<sup>49</sup>.

Although Cady's initial 1979 findings have been held in high regard, recent conflicting evidence has been reported and indicates the need for further research regarding trunk performance measures as predictors for back injury<sup>16,51</sup>. In Mostardi's study, strength measured by an isokinetic lifting device was not predictive of injury in the one hundred seventy one women followed prospectively. Women in the military may be at high risk for back injury due to insufficient strength for jobs which have been traditionally performed by men. Studies are needed which use state-of-the art physiologic back testing methods on women recruits in order to study optimally the influence of trunk performance as a predictor of back injury.

#### Behavioral and Psychosocial Correlates of Back Injury

Cigarette smoking has been identified in a number of studies as a correlate of low back pain<sup>52,53,54,55</sup>. In one recent study the relationship between smoking status and low back pain was investigated among subjects representing 13 occupations<sup>56</sup>. Smoking was significantly correlated with back pain in those occupations that required physical exertion. Upon further examination, the researchers determined that smoking was more clearly related to pain in the extremities than to neck or back pain.

Only one study of military recruits has been reported which investigated the relationship between low back pain and smoking<sup>6</sup>. Male recruits ( $n = 160$ ) from a single basic training group were studied. After excluding subjects with a previous history of back pain, self-report of back pain during basic training resulted in an incidence rate of 17.0% (95% confidence interval: 11.6% - 24.1%). Two trainees were discharged from the military because of low back pain. Smoking status was significantly related to low back pain. Alcohol use, fitness level before enlistment, age, race, educational level, and work satisfaction were not significant. The investigators considered the study to be initial research on an apparently high risk population, that of military recruits. The study was limited in that no women recruits were included. Further research is indicated to ascertain if smoking is a predictor of back injury among women recruits.

Conflicting results on the relationship between obesity and low back pain have been reported. Manninen and colleagues found no correlation between body mass index and low back pain<sup>53</sup>. The one study of military trainees which examined obesity and injury, including low back injury, tendonitis, sprains, strains, and stress fractures, found no relationship between obesity and injury for women but did find this relationship among men<sup>1</sup>. Other investigators report positive findings. A survey of over 34,000 subjects in England reported that obesity was related to back pain at all ages<sup>55</sup>. In a study of nursing personnel, severity of back injury was found to be related to weight of the nurse<sup>57</sup>. In summary, the limited number of investigations on this association reveal only a

possible relationship between low back pain and obesity at the upper quintile and fail to examine other psychosocial factors which might be confounding<sup>58</sup>.

Educational level, age, income, marital status, history of previous back injury, and parenthood have also been found to be related to low back pain<sup>54,59,60,61</sup>. A study of 1,149 Finnish men, followed prospectively for 3 years, revealed a fourfold risk for back injury among those with a history of low back pain<sup>62</sup>. Croft and Rigby (1994) found that back pain was reported more often among women in lower income and educational levels<sup>59</sup>. However, in O'Connor and Marlowe's study (1993), age, race, educational level, and work satisfaction were not significant predictors of low back pain<sup>6</sup>. Similarly, a population-based study of 4,000 Belgian adults did not find an association between work satisfaction and initial report of low back pain<sup>12</sup>. Additional studies are needed to investigate the relationship between psychosocial and demographic variables and low back pain in women. No studies of military women recruits have described the relationships between these variables and the development of back injury. For these reasons, the investigators propose to investigate multiple correlates of back injury among military women. Thus, results of this study will lead to scientific information about military women's risks for back injury.

### Low Back Injury in Military Recruits

Only a few prospective studies on low back injury in military recruits have been conducted. Hellsing investigated lumbar mobility and tightness of hamstring and psoas major muscles in 999 male recruits upon enlistment in compulsory military service in Sweden and followed these recruits over four years<sup>63,64</sup>. No correlations were found between tight hamstring or psoas muscles and current back pain or the incidence of low back pain. Decreased lumbar mobility was related to current back pain at the second and third follow-up periods but was not a predictor of back injury. Clinical assessments utilizing a goniometer were the only methods of measuring mobility therefore subjectivity may have influenced the results. In addition, no women recruits were included in this study.

A recent study of male U. S. marine recruits examined the incidence of soft tissue and musculoskeletal injuries during basic training<sup>5</sup>. Findings revealed a rate of 19.9 injuries per 100 recruit months. The most frequently occurring injuries were iliotibial band syndrome (22.4%), patellar tendonitis (15.1%), and low back pain (11.4%). Although the study provided important data on the occurrence of low back injury in recruits, it failed to investigate an essential question: What are the predictors of low back injury?

Two other prospective studies on injuries in military recruits have been reported. O'Connor and Marlowe (1993) reported a low back pain incidence of 17% in their study of 160 male army basic trainees<sup>6</sup>. Associations between low back pain and smoking, alcohol use, fitness level, exercise frequency, emotional state, age, education, and race were examined. Smoking was the only statistically significant correlate of low back pain. A major limitation of the study was that all variables were measured by self-report. In addition, women were excluded from the study. Jones and colleagues (1993) included both males ( $n = 124$ ) and females ( $n = 186$ ) in their study of army recruits<sup>1</sup>. Objective physiological measures of height, weight, body mass index, and physical performance measures of 1 mile run, number of sit-ups, and number of push-ups were investigated as possible correlates of lost time injuries. Female gender, high BMI, low running performance, and short stature for women were predictors of injury. No measures of trunk performance were examined as possible predictors of back injury. The investigators' finding that

women recruits are at greater risk for exercise-related injury than men recruits provides support for our proposed study.

## **Body**

### **Methods**

This section consists of five parts: (1) a description of the design, sample and research setting, (2) a discussion of the measurement of trunk performance, (3) procedures for data collection, (4) data management and analysis, and (5) strengths and weaknesses of the proposed study. Data will be collected via physical performance measures, questionnaires, and use of existing medical records.

#### **Design, Sample, and Research Setting**

The proposed investigation is a prospective, non-experimental study, to examine associations between back injury and selected physical performance, back knowledge, behavioral, and psychosocial factors. The sample will involve a minimum of 700 female military recruits, of all races, who are entering basic training. The population to be studied is a normal, non-clinical population. All recruits meeting inclusion criteria will be given the opportunity to participate in the study. Subject recruitment will continue until a sample size of 725 has been realized, to allow for subject drop-out.

Subject exclusion criteria are designed to exclude risk factors and medical conditions causing low back pain which are not related to the conditions of interest and/or which might be a contraindication to trunk performance testing. Subjects with the following conditions or symptoms will be excluded from participation in the study:

1. Serious underlying spinal pathology (infection, tumor, spinal stenosis, cauda equina syndrome, or other)
2. Pregnancy
3. Evidence of current urinary tract infection (by history, physical, or laboratory examination)
4. Ankylosing spondylitis, rheumatoid arthritis or other rheumatoid or connective tissue disorders

A minimum of 700 subjects with complete data are required for this study. The sample size was estimated based on a power analysis extrapolated from results of a previous study. This sample size will provide a power of .95 at a two-tailed .05 significance level for  $Rho = .15$ . While a sample size of 654 was estimated as being required to address the logistic prediction model research question (Predicated on a model which included 10 predictors, 9 predictors partialled,  $R^2 = .39$ ,  $R^2_{red.} = .38$ , power = .90,  $\alpha = .05$ ), the exploratory nature of the study and desire to identify all potentially relevant risk factors necessitates using the larger sample size estimate. To allow for dropouts and incomplete data, 725 subjects will be recruited.

In order to foster efficiency of data collection and minimize interference with recruit training, data routinely collected by the military as part of basic training (e.g.: PFT testing and medical records) will be used. In order to minimize interference with recruit training, all initial study-specific testing

will be conducted during the first two days after the recruit's arrival on base. This testing includes (a) demographic, back knowledge, and anxiety questionnaires, (b) B200 testing of trunk performance, (c) functional lifting ability, (d) hamstring flexibility, (e) lower body strength, and (f) skinfolds for body composition estimation. It is estimated that not more than 1.5 hours of a subject's time would be taken up by this testing. Since the questionnaires, which require approximately 30 minutes, can be completed at any time, the 1.5 hour time period does not have to be one contiguous period. Measures of upper body strength, aerobic capacity, height, and weight will be obtained from the routine preliminary medical exam and fitness testing conducted on all recruits.

Data on numbers and types of back injury will be collected from base medical records as well as via a Back Injury Self-Report questionnaire filled out prior to graduation. The Back Injury Self-Report questionnaire, requiring approximately 15 minutes to complete, will help to capture back injuries which were not medically treated or were otherwise not recorded in the subject's medical record.

Copies of all questionnaires and data collection forms appear under Appendix A.

### ***Response Variables***

Back injury. Occurrence of back injury during basic training is defined as an indication on either the recruit's medical record or self-report questionnaire of an episode of lower back pain which occurred after enlistment. This data will be collected prior to basic training graduation, before medical records are pulled for future assignments.

Type of back injury. To provide consistency, Co-Investigator Dr. Brian Forrester will evaluate medical records information. Back injuries will be classified into one of three categories, based on the information obtained from the medical record and/or Back Injury Self-Report Questionnaire:

1. **Nonspecific acute low back pain.** Acute or subacute low back pain beginning after enlistment localized to the lumbosacral region, with or without radiation to the thigh, but without radiation below the knee.
2. **Acute low back pain with sciatica.** Acute low back pain beginning after enlistment localized to the lumbosacral region with radiation of pain below the level of the knee on straight leg raising.
3. **Low back pain due to major trauma.** Low back pain due to major trauma resulting in fracture or dislocation, occurring after the date of enlistment.

### ***Predictor Variables***

Aerobic capacity is defined as time to complete a two-mile run, as administered for the Army PFT evaluation. The aerobic capacity score will be the subject's VO<sub>2</sub> value in ml/kg/min obtained from a nomogram using time elapsed in minutes for the subject to complete a 2-mile run on a track in basic training<sup>39</sup>. Running tests have been found to be a practical and valid means of measuring physical fitness in large groups<sup>65</sup>. The running test, a dynamic exercise involving large muscle groups, can reveal the individual's maximal aerobic capacity<sup>66</sup>. High correlations between running velocity and measured VO<sub>2</sub> provide the empirical physiologic basis for this test<sup>39,67,68,69,70</sup>.

Upper body strength is comprised of two measures, (a) number of sit-ups completed in two minutes and (b) number of push-ups completed in two minutes, as administered for the Army PFT evaluation. In our pilot study with fire fighters, number of curl-ups in one minute was predictive of trunk performance. Additionally, number of sit-ups in one minute was found to be associated with back pain in our study of fire fighters and police.

Lower body strength is defined as number of squats completed in a one minute time period. Subjects will be asked to stand with arms at sides and instructed to squat, bending at the hips and knees while keeping the trunk vertical. With each squat they will be asked to touch the fingertips of both hands to the floor.

Hamstring flexibility is defined as score on the Acuflex I Sit-and-Reach test. The Acuflex I Sit-and-Reach test, a commonly used flexibility test, is indicative of everyday body movements such as reaching and bending<sup>71</sup>. The subject sits on the floor with legs fully extended, bottom of feet against the Acuflex I and toes pointed up (no shoes), and with one hand on top of the other reaches forward as far as possible to push a sliding device forward with the fingertips. Knees should remain flat against the floor. The flexibility score is the number of inches reached on the best of three attempts.

Trunk performance is defined as scores obtained on the Isostation B200 back testing equipment. Overall trunk performance is the score obtained from the 21 Isostation B200 trunk performance measures using the method of principal components analysis. The printout produced by the B200 will serve as the data form for trunk performance information.

Functional lifting ability. The floor-to waist lift task is one of 36 work-related functional tasks tested in the Physical Work Performance Evaluation<sup>72</sup>. This task measures a person's ability to lift progressively heavier weights from the floor to waist height. Each subject will be assessed with an empty weight receptacle to determine that she is using the best possible lifting technique. Weights are then added in five pound increments until a safe maximum is reached. Specific objective observational criteria are used to determine when a maximum level has been reached. The kappa for inter-rater reliability is .78 for this task.

Body mass index is defined as the ratio of weight in kilograms to squared height in meters<sup>73</sup>. Height and weight measures will be obtained from subjects' medical records.

Percent body fat. Percent body fat will be estimated using measures of thigh (midline of anterior aspect of thigh, midway between inguinal crease and proximal border of patella), suprailiac (midaxillary line immediately superior to the iliac crest), and tricep (midline of posterior aspect of arm over triceps muscle, midway between lateral projection of acromion process of the ulna) skinfold thickness, as described by<sup>74</sup>. Three measurements of skinfold thickness will be obtained at each anatomical site, using Lange calipers, and recorded. The average of the three values will be used to estimate percent body fat.

Back knowledge is defined as the number of correct subject responses to 13 items on spine anatomy and physiology, proper lifting, and ergonomics on the Back Knowledge Questionnaire. Six items were modifications of White's back evaluation questionnaire<sup>75</sup>. Remaining items were investigator-developed and adapted from those used in our previous research. Content validity was assessed by a panel of three experts in the fields of ergonomics, occupational health nursing, and physical therapy. Initially our test-retest reliability was .67. Subsequent to receiving reviewers'

comments, we conducted a second test-retest reliability assessment in January 1992. Test-retest reliability with a two week interval between tests was .79 on 33 maintenance workers.

Smoking is measured by self-report regarding cigarette and other tobacco use on the Demographic Questionnaire. These items are adapted from the "Good Health Program" Health Risk Appraisal Questionnaire.

Anxiety. Anxiety will be measured using the State-Trait Anxiety Inventory (STAI, Form Y) which measures both state and trait anxiety<sup>76</sup>. The STAI is a 40 item, self-administered test that requires about 10 minutes to complete and is written below the sixth-grade reading level. Two scores will be obtained on the STAI. One score will reflect the person's current level of state anxiety and can range from 20 to 80 with higher scores reflecting more anxiety. The other score indicates the person's general level of trait anxiety and also can range from 20 to 80 with higher scores indicative of more anxiety. The internal consistency of the Trait-anxiety scale, as indexed by coefficient alpha, ranges from .89 to .91 across male and female samples of working adults, military recruits, and college and high school students. For the State-anxiety scale, this range is from .86 to .95.

Life satisfaction. Self-report regarding life satisfaction on the Demographic Questionnaire. This item is adapted from the "Good Health Program" Health Risk Appraisal Questionnaire.

Parental status. Self-report regarding whether the subject is primary caregiver for a child of six years or younger on the Demographic Questionnaire.

Education. Self-report of highest grade level completed on the Demographic Questionnaire.

Age. Calculated from self-reported date of birth, representing age at time of entry into the study.

Race. Self-report response to two items on the Demographic Questionnaire. These items are adapted from the "Good Health Program" Health Risk Appraisal Questionnaire.

Previous back injury. Demographic Questionnaire self-report of back injury prior to enlistment.

### ***Data Collection Procedures***

To reduce measurement error, data collectors will include local physical therapists and graduate research assistants. Physical Therapist data collectors will be trained in the use of the Isostation B200 by Isotechnologies at their Hillsboro, NC site. Physical therapist training for measuring functional lifting ability will be accomplished on-site by Deborah Lechner, MS, PT (physical therapist). Research assistants will be trained in administration of the hamstring flexibility and lower body strength measures, as well as use of the data collection forms. All physiologic measurements will be done under similar circumstances, with at least 15 minutes rest period between trunk performance and lower body strength testing. Collecting the trunk performance measures before the fitness training component of basic training begins will eliminate the potential for trunk performance degradation due to training-induced muscle soreness. A pilot study of 10 subjects is planned to verify subject recruitment, scheduling, testing, data retrieval, and follow-up procedures. To minimize attrition, we will work closely with training personnel and subjects to schedule testing times that do not interfere with processing activities.

**Results: No results are available at this time.**

## **Recommendations**

### ***Site Acquisition***

For this first year, **site acquisition and data collection were the principal tasks outlined in the Plan of Work. Site acquisition and revision of protocols** have been the primary activities of the research team during the first year of this study. **The major difficulty with meeting the data collection targets stated in the Plan of Work has been securing permission to access basic trainees at a military site.** The following listing details our efforts steps to secure a site for data collection at a military installation:

### **U.S. Army**

Of the three armed services, initial contact was made with the U.S. Army. The Army was selected as first choice based on significance of this study for Army basic training and suggestions by military-affiliated contacts at the University of Alabama at Birmingham.

#### **I. Brig. General Nancy Adams: November 1995.**

While waiting on funding notification, **Gen. Marilyn Musaccio** referred us to **Brigadier Gen. Nancy Adams, Commander of Health Promotion**, to identify contacts to secure a site for data collection. General Adams' office referred us to **Col. Mike Smutok**, in Occupational Health at Natick. He provided the name of the chief of physical therapy at **Fort Jackson** (Maj. Kathy Zurawel at that time).

#### **II. Fort Jackson: December 1995-May 1996.**

Physical therapy at Fort Jackson was interested in the project, and materials about the study were sent to **Maj. Kathy Zurawel, Col. William Tucker** (Moncrief Army Hospital), and **Col. Greene** (DPTM) to seek permission to access recruits. I received a call from the commanding general's office stating that they were not interested in allowing the study. No reason for the refusal or suggestions regarding feasibility problems were identified.

#### **III. Fort Leonard Wood: July 1996-September 1996**

I next contacted **Lt. Col. Jim Heeter**, chief of physical therapy at Fort Leonard Wood (contact provided by Col. Smutok), who expressed an interest. Based on his advice, I submitted materials directly to **Major General Clair F. Gill**, Commanding General, with a request for accessing recruits. A note from General Gill indicated that Fort Leonard Wood would not be able to support the study. Reasons provided were (a) insufficient recruit time, (b) belief that most injuries are result of previous injury, and (c) that only 1 injury in the past year resulted in necessity for discharge.

#### **IV. Brig. General Betty Simmons: November 1996**

Based on a suggestion from **Captain-Promotable Joyce Giger**, I next contacted Brig. Gen. Betty Simmons, Deputy Commander and Chief, Army Nurse Corps, at AMEDD. **Col. Carol Reineck**, of the General's office, suggested that recruits might have more time for measurement at the MEPS stations, and referred me to **Maj. Marscheen** of the **Fort Knox Recruiting Command**.

#### **V. MEPCOM: December 1996-April 1997**

Maj. Marscheen provided me with the name of **Mr. Bill McLarty**, the **Pentagon MEPCOM Liason**. Based on Mr. McLarty's recommendation, I submitted materials re: the grant to **Dr. Steve Sellman** ( OUSD (P&R) OASD (FMP) (MPP) /AP ). Access to recruits at the MEPS sites was turned down due to the time required for the measurements.

#### **VI. Dr. Patricia Modrow: October 1997**

I have also been in contact with Dr. Modrow at Ft. Detrick for additional U.S. Army contacts. **Col. Holly**, Deputy Commander for the hospital at FT. Bragg and consultant for The Surgeon General on OBGYN, recommended contacting **Maj. Ronald Stevens** at **Ft. Bragg** to see about working together. This contact developed October 24, 1997, and will be followed up October 28, 1997.

### **U.S. Air Force**

After exhausting our Army contact list, the Air Force was approached to determine if one of their bases might be interested in providing access to basic trainees. The Air Force was suggested by Deborah Lechner, the physical therapist on this grant, who had been working with personnel at Kelley Air Force Base on back injuries.

#### **I. Kelley Air Force Base: May 1997**

Deborah Lechner provided me with a contact at Kelley AFB, **Col. Schiller**. He suggested that Lackland AFB may be a better site, since no basic training is done at Kelley.

#### **II. Lackland Air Force Base: June 1997-Present**

Col. Schiller provided me with the name of **Maj. Katrina Newhauser**, who was part of Preventive Medicine at Lackland AFB (replaced by **Maj. David Chen**). Lackland AFB is interested in the study, as they have noticed an increase in injuries to female recruits since changing their training course. In the first round, the biggest objection was, again, the testing time involved. The training people wanted to be able to take a "flight" (unit of basic trainees) of 50 female cadets out of training for a maximum of 90 minutes, and test them all in that time period. In consultation with Deborah Lechner, we decided to eliminate the B200 testing, since we could accomplish testing 50 recruits in under 90 minutes using the Functional Lift Test alone. I submitted the revised protocol to Dr. Chen, and the revision was scheduled to be discussed at the Tuesday, October 14, 1997 Primary Care Quality Improvement Committee meeting. Unfortunately, time did not permit discussion of the revision, and it was rescheduled for the November 18, 1997 meeting. If approved then (Dr. Chen was optimistic, since time was the major problem.), it would be presented to the Chief of Training for his approval.

## U.S. Navy

During a session with military-affiliated faculty members to identify additional alternatives and contacts for accessing basic training recruits, a suggestion was made to contact Rear Admiral Joan Engel, a former graduate of the University of Alabama School of Nursing, to see if the study might be of interest to the Navy or Marine Corps.

### **I. Rear Admiral Joan Engel: October 1997**

Based on the suggestion of **Col. Joan Turner**, we contacted Rear Admiral Joan Engel, Director, Navy Nurse Corps, and Assistant Chief, Operational Medicine and Fleet Support. Admiral Engel has responsibility for the **Naval Research Institute in San Diego**. **Commander Jennifer Town**, of Admiral Engel's office, has contacted **Capt. Dean, Commanding Officer of the Naval Research Institute, San Diego**. Capt. Dean is currently exploring the feasibility of conducting the study with women Naval Recruits.

### ***Protocol Revision***

After evaluating feedback from Fort Leonard Wood, MEPCOM, and Lackland Air Force Base, the research team discussed possible modifications to the research protocol in an effort to improve the opportunities for acquiring a research site. **The research team identified the time required for Isostation B200 measurements to be a major drawback to securing access to recruits. The team then reviewed the testing protocol to identify ways in which to reduce the testing time while maintaining the scientific integrity of the study.**

Using feedback from Lackland Air Force Base, the measurement protocol was examined to identify a way to test a flight of 50 recruits within the 90 minute maximum time availability. According to the research team's physical therapist, **use of nine functional lift testing stations would provide the capability to test 50 recruits in approximately 60 minutes**. Further, **eliminating the Isostation B200 measurements would not significantly compromise the scientific merits of the study.**

From a budgetary perspective, increasing the number of functional lift testing stations would increase costs. However, cost savings from elimination of B200 leasing should offset costs for additional functional lift testing stations.

While the amount of time required to secure a site for data collection has been a major concern, the research team believes that the **study objectives can still be met. A 1-year no-cost extension** of the project would allow data collection to take place during the next year (Year 2) of the study, with analysis and reporting taking place during the no-cost extension year.

### ***Summary***

**Site acquisition** has been a major emphasis for this research year. We have been diligent in

approaching army, navy, and air force branches of the service to identify a site. In addition, we have utilized formal referral mechanisms as well as professional contacts to gain access to a site. The professional disciplines which have been contacted include physical therapy, nursing and medicine. We have initiated our requests at both the site level, as well as higher levels of the armed services. Thus, we have developed many potential contacts and are confident that a site will be forthcoming. At the current time, we are pursuing three prospects for site acquisition: (a) Lackland AFB, (b) National Navy Research Institute, and (c) Fort Bragg.

**Protocols** have been revised to eliminate Isostation B200 testing. As a result, we have streamlined the data collection process and improved opportunities for securing access to female basic trainees.

**Plans** for the upcoming project year (Year 02) include securing final approval for a data collection site and completing data collection. We will defer data analysis and reporting to a no-cost extension Year 03.

**Conclusions: No conclusions are available at this time.**

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**Appendices**

***Appendix A***

Data Collection Instruments

Predictors of Back Injury Among Women Military Recruits

Demographic Questionnaire

Today's Date: \_\_\_\_\_

Name: \_\_\_\_\_ Birth Date: \_\_\_\_\_ Unit \_\_\_\_\_

The following questions tell us something about yourself, and will let us know if there is any physical reason you should not participate in the study. Please circle the letter that best describes your answer to the question.

- I. What is the highest grade you completed in school?
  - A. Grade school or less
  - B. Some High School
  - C. High School Graduate
  - D. Some College
  - E. College Graduate
  - F. Post Graduate or Professional Degree
  
- II. Are you currently:
  - A. Never Married
  - B. Married
  - C. Divorced
  - D. Separated
  - E. Widowed
  
- III. What is your race?
  - A. Aleutian, Alaska Native, Eskimo, or American Indian
  - B. Asian
  - C. Black
  - D. Pacific Islander
  - E. White
  - F. Other
  
- IV. Are you of Hispanic origin?
  - A. Yes
  - B. No
  
- V. Do you currently have a child or children for which you are the primary care giver?
  - A. No (Go to Number 9)
  - B. Yes, 1 child
  - C. Yes, more 2 children or more

- VI. How old is the youngest child? \_\_\_\_\_ Years, \_\_\_\_\_ Months
- VII. How old is the oldest child? \_\_\_\_\_ Years, \_\_\_\_\_ Months
- VIII. Are you primary caregiver for a child with a disability?  
 A. Yes  
 B. No
- IX. Are you currently pregnant?  
 A. Yes  
 B. No
- X. Do you now have a bladder infection or any symptoms of a bladder infection (for example, burning on urination or frequent urination)?  
 A. Yes  
 B. No
- XI. Do you have now or have you had ankylosing spondylitis, rheumatoid arthritis or other rheumatoid or connective tissue disorder?  
 A. Yes  
 B. No
- XII. Do you have now or have you had a serious problem with your spine (for example: infection, tumor, spinal stenosis)?  
 A. Yes  
 B. No
- XIII. Are you currently having back pain?  
 A. Yes  
 B. No
- XIV. Have you ever had back surgery?  
 A. Yes  
 B. No
- XV. Have you ever had any pain in your lower back?  
 A. Yes  
 B. No ( Go to Question # 21 )
- XVI. Do you still have lower back pain occasionally?  
 A. Yes  
 B. No ( Go to Question # 21 )
- XVII. If you still have back pain occasionally, how long ago did the problems first start?  
 A. Years: \_\_\_\_\_ Months: \_\_\_\_\_

- XVIII. If you still have back pain occasionally, did the pain start with an injury at work?
- A. Yes
  - B. No
- XIX. If you still have back pain occasionally, have you received any medical treatment for back pain?
- A. Yes
  - B. No
- XX. If you still have back pain occasionally, do you do any exercises now to strengthen your back?
- A. Yes
  - B. No
- XXI. Prior to enlisting, in an average week, how many times did you participate in a sport or activity that required lively physical activity? Lively physical activity is exercise which lasted at least 20 minutes without stopping, and was hard enough to make you breathe heavier and your heart beat faster.
- A. Less than 1 time per week
  - B. 1 or 2 times per week
  - C. At least 3 times per week
- XXII. Thinking back on previous jobs you have had, in general, how satisfied with your jobs were you?
- A. Mostly satisfied
  - B. Partly satisfied
  - C. Not satisfied

Predictors of Back Injury Among Women Military Recruits

Back Knowledge Questionnaire

Today's Date: \_\_\_\_\_

Name: \_\_\_\_\_ Birth Date: \_\_\_\_\_ Unit: \_\_\_\_\_

The following questions are about back health care. On each question, please circle what you believe is the best answer.

- I. Which factor is the least important for prevention of back injury:
  - A. having machines to do your work for you
  - B. exercise, correct lifting techniques, proper nutrition, and good posture
  - C. having an excellent doctor and proper medication
  
- II. The bony spine is supported and kept erect by:
  - A. blood vessels
  - B. muscles and ligaments
  - C. nerves
  
- III. There are nerves coming out above or below each vertebra in the spine. These nerves can lead to pain if:
  - A. they are irritated or inflamed
  - B. they have pressure on them caused by bulging disks
  - C. both of the above
  
- IV. Which of the following is not helpful in reducing back injury:
  - A. when the load is heavy or large, get assistance when possible
  - B. use a step or platform to keep from lifting above shoulder level
  - C. when a load can be pushed or pulled, pull the load with a rounded back
  
- V. Which one of the following is most likely to cause back injury:
  - A. sitting
  - B. lifting with bent knees
  - C. twisting the back while lifting
  
- VI. During lifting a moderately heavy object, the knees should be:
  - A. one knee bent, the other straight
  - B. both bent
  - C. both straight
  
- VII. When pulling a heavy object, which muscles should do the most work:
  - A. arm muscles
  - B. leg muscles
  - C. back muscles

- VIII. When pulling a heavy object, a person should:
- A. arch the back to support the object
  - B. angle the body around the object
  - C. hold the object over one shoulder close to the center of the body
- IX. When lifting you should:
- A. hold the load as close to the body as possible
  - B. not twist the back
  - C. both of the above
- X. When bending over to pick up a heavy object:
- A. squat down, keeping the back straight
  - B. squat down, arching the back
  - C. lock your knees
- XI. For good balance during lifting:
- A. keep your feet close together
  - B. keep your feet apart and hold the load close to your body
  - C. lean backwards and hold your head back
- XII. When carrying a load upstairs you should:
- A. carry the load with a bent back to relieve muscles
  - B. face forward with your head in a neutral position
  - C. look down at your feet and turn to look behind you every few steps
- XIII. When pulling a victim you should:
- A. face the victim and pull as you walk backward, keeping your back as straight as possible
  - B. twist your back to turn in the direction you are going while pulling the victim
  - C. both of the above

Thank you for your willingness to participate in this study.

Predictors of Back Injury Among Women Military Recruits

Physical Performance Information Form

Today's Date: \_\_\_\_\_

Name: \_\_\_\_\_ Birth Date: \_\_\_\_\_ Unit: \_\_\_\_\_

Functional Lifting Ability (Pounds): \_\_\_\_\_

# Squats in 60 Seconds: \_\_\_\_\_

Sit-And-Reach (Inches): \_\_\_\_\_

SKINFOLD Measures (mm):

SITE	# 1	# 2	# 3
Tricep			
Suprailiac			
Thigh			

PFT Testing Date (MMDDYY): \_\_\_\_\_

Two-Mile Run Time (Minutes): \_\_\_\_\_

# Push-Ups In Two Minutes: \_\_\_\_\_

# Sit-Ups In Two Minutes: \_\_\_\_\_

Predictors of Back Injury Among Women Military Recruits

Back Injury Self-Report Questionnaire

Today's Date: \_\_\_\_\_

Name: \_\_\_\_\_ Birth Date: \_\_\_\_\_ Unit: \_\_\_\_\_

Please answer the following questions regarding any back injury you may have had during basic training:

I. Did you injure your back during basic training?

A. Yes ( Go to Question # 2 )

B. No ( STOP: Thank you for participating in this study! )

II. How many times did you injure your back during basic training?

A. \_\_\_\_\_

III. Please indicate how you injured your back each time that you can remember (Example: Lifting field pack off ground.):

A. First time:

\_\_\_\_\_

B. Second time:

\_\_\_\_\_

C. Third time:

\_\_\_\_\_

D. Fourth time:

\_\_\_\_\_

E. Fifth time:

\_\_\_\_\_

F. Sixth time:

\_\_\_\_\_

G. Seventh time:

\_\_\_\_\_

H. Eighth time:

\_\_\_\_\_

Thank you for participating in this study!

