THE EFFECT OF ARMY RESERVE OFFICER TRAINING CORPS PHYSICAL TRAINING ON AEROBIC FITNESS, MUSCULAR ENDURANCE AND BODY COMPOSITION

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE UNIVERSITY OF HAWAI’I AT MĀNOA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Mahalo and much love, until we meet again!
ABSTRACT

A Comparison of Three Techniques for Calculation of Body Fat Percentage in a Cohort of Army ROTC Cadets

Genevro JK, Oba Y, Tamura K, Romine RK, Kunkle RG, Stickley CD: University of Hawai`i, Mānoa, (Honolulu, HI)

**Context:** Soldiers actively participating in the Army must meet and maintain the Army’s body composition standards. Soldiers exceeding the weight standards require further assessment of body composition through gender specific body circumference measurements and must enroll in the Army body composition program if standards are not met. It is not clear the extent to which the Army’s current method for determining body composition compares with more widely accepted methods. **Objective:** To compare the Army’s current body circumference based method of assessing body composition to validated clinical assessments of body composition including skinfold thickness measurements and body circumferences and breadths. **Design:** Test-retest **Setting:** Human Performance Lab. **Patients or Other Participants:** 28 male (24.57±4.39 years) and 12 female (24.17±4.95 years) Army ROTC cadets from the University’s Warrior Battalion. **Interventions:** Body fat percentage (%BF) was calculated utilizing three separate techniques: 1) from body density as obtained using the Army’s current circumference measurement protocol (ARMY) for males (neck and umbilicus) and females (neck, waist and hip), 2) indirectly from lean body weight as determined via breadth, limb, and body circumference measurements (LBC) for males (waist circumference, knee circumference, and biiliac breadth) and females (umbilicus circumference), and 3) from body density calculated from skinfold thickness (SKF), measured with Lange calipers (Cambridge Scientific Industries, Inc., Cambridge, Maryland, USA) at three sites on the right side of the body, (triceps, supra-ilium, and thigh for females; chest, abdomen, and thigh for males). Percent body fat was calculated from body density using the Brozek 2-Compartment model equation. **Main Outcome Measurements:** A repeated measures ANOVA with an alpha level of p<0.05 was used to assess differences in %BF as calculated by LBC, SKF, and ARMY. **Results:** Body fat percentage in males as calculated via ARMY (16.79±4.00%) was significantly higher than LBC (11.86±3.19%, p<0.001) and SKF (12.25±3.14%, p<0.001). In females, ARMY (27.17±4.04%) was significantly lower than LBC (28.42±3.40%, p=0.001) and significantly higher than SKF (24.62±2.68%, p=0.026). **Conclusions:** Results from the current study indicate %BF determined using the Army’s current body circumference based measurements is inconsistent with more commonly accepted, validated methods such as skinfold thickness measurements. The overestimation of %BF for both genders brings into question the reliability of the Army’s current protocol. Future research should validate the existing Army protocol with a current “gold standard” of body composition such as the 4-Compartment model. **Word Count:** 383
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INTRODUCTION

A physical training (PT) program is a mandatory component of United States Army training [1] to ensure that soldiers exhibit physical fitness and have the ability to meet the physical demands of any combat or duty position. The Army Physical Readiness Training (PRT) manual (FM 7-22) outlines the importance of physical readiness, while striving to decrease injury rate. Strength, endurance, and mobility are critical components of physical readiness, and are integrated into an Army PT program to strengthen and improve factors related to physical fitness [1]. Select factors, including cardiorespiratory endurance, body composition, muscular strength and muscular endurance have been shown to affect soldiers’ physical readiness and aid in the ability to perform duty assignments and combat roles [1-7]. Assessment of physical fitness and body composition are essential to ensure cadets and soldiers meet the general requirements for enlistment and continued participation in the Army [1, 3].

The Army’s established weight and body composition standards are based on age, gender and height. Soldiers falling above the maximum weight requirement are further evaluated through an assessment of body fat percentage (%BF) via body circumference measurements [3]. The accuracy of the Army’s current method for determining body composition remains unclear, and few studies have compared the Army’s current body composition assessments with more widely used methods. Despite the limited data assessing the validity of the current Army body composition assessments, soldiers must enroll in a body composition management program if they exceed %BF standards based on their age and gender. Studies have investigated the impact of %BF on performance and higher levels of aerobic fitness (via maximal oxygen consumption [V\text{O}_2\text{max}] values) have been reported in soldiers with less than 18 %BF [6]. In recent decades,
however, increases in body mass index (BMI), body mass and %BF in military personnel have been reported, necessitating additional investigations to evaluate the impact of %BF, body mass and BMI on factors such as physical readiness and performance. [3, 8-11]

Physical fitness of Army Soldiers is currently assessed via the Army Physical Fitness Test (APFT) [5, 12, 13]. The APFT consists of a 2-minute push-up event, a 2-minute sit-up event and a 2-mile timed run. Cardiorespiratory endurance, aerobic fitness and muscular endurance can be evaluated via field tests, like the APFT, or clinical tests within a lab, which possess a greater degree of validity and reliability compared to field assessments [4, 9, 10, 12-21]. Clinical assessments of cardiorespiratory endurance and %BF in soldiers have been conducted via direct and indirect measurements of V̇O₂max and commonly used calculations of %BF [4, 22]. Many studies have examined the effects of Army basic combat training (BCT) and found increases in V̇O₂max values and decreases in %BF based on gender and age specific norms following a 5-week [18, 23], 10-weeks [19], and 12-weeks of Army BCT [24]. However, few studies have clinically assessed components related to physical fitness and the effect of physical training programs in Army ROTC cadets [5]. Therefore, the purpose of this study is three-fold: (1) to determine the training effect of an Army ROTC PT program on aerobic fitness, muscular endurance, body mass, BMI and %BF; 2) to determine if cadet rank plays a role in physical fitness outcomes of an Army ROTC PT program and 3) to compare previously validated techniques for calculating %BF to the current Army technique.
METHODS

Research Design

A repeated measures design was conducted, consisting of two one-hour data collection sessions, pre-Army Reserve Officer Training Corps (ROTC) Physical Training evaluation (pre-ROTC PT) and post-Army ROTC Physical Training evaluation (post-ROTC PT). The pre-ROTC PT data collection session was held prior to the start of the Army led ROTC PT cycle and the post-ROTC PT data collection session was conducted after 3-months of Army led ROTC PT. Independent variables included time (pre-ROTC PT and post-ROTC PT data collection sessions), military science (MS) rank and gender. Dependent variables included body fat percentage (%BF), body mass, body mass index (BMI), maximal oxygen consumption (V̇O₂max) values, max heart rate (HR) values, Army Physical Fitness Test (APFT) scores (2-minute push-up, 2-minute sit-up, 2-mile run times, overall score), and APFT event outcomes (reps of push-ups, reps of sit-ups and 2-mile run times).

Subjects

Sixty-two (male: n=47, 24.57±4.39 years) (female: n=15, 24.17±4.95 years) cadets were recruited from the University of Hawai`i, Mānoa’s Army ROTC Warrior Battalion. Demographic and anthropometric data for subjects used for study analysis are presented in Table 1. Inclusionary criteria included classification as low-risk according to the American College of Sports Medicine (ACSM) guidelines for exercise testing [4]. Exclusionary criteria included previous Army Ranger training or completion of the ROTC Army Ranger Challenge, actual or
suspected pregnancy, lower extremity (LE) surgery in the past six months, or current LE injury that prohibited subjects from study participation.

| Table 1 Demographic and anthropometric data for current study participation |
|------------------------------------------|----------|------------------------------------------|
|                                         | Males (n=36) | Females (n=12) |
|                                         | Mean ± SD   | Mean ± SD   |
| Age (years)                             | 24.60 ± 4.39 | 24.17 ± 4.95 |
| Height (cm)                             | 174.4 ± 8.1  | 162.3 ± 9.6  |
| Rank                                    |            |              |
| MS-2                                    | 5          | 2            |
| MS-3                                    | 12         | 4            |
| MS-4                                    | 18         | 6            |

*SD: standard deviation; cm: centimeters; MS: military science/rank*

**Instruments**

The APFT was conducted in accordance to military protocol to determine aerobic fitness (2-mile timed run event) and muscular endurance (2-minute push up and 2-minute sit-up event). A wall-mounted stadiometer (Model 67032, Seca Telescopic Stadiometer, Country Technology, Inc., Gays Mills, WI, USA) was used to record height. A Detecto Certifier Scale model 442 (Detecto, Webb City, MO) was used to measure weight. Lange Skinfold Calipers (Cambridge Scientific Industries, Inc., Cambridge, Maryland, USA) were utilized to obtain skinfold thickness (SKF) measurements. A Gulick standardized tape measure was utilized for measuring body circumferences and determination of SKF measurements anatomical location. A GPM anthropometer (Siber & Hegner, Zurich, Switzerland) was utilized to measure male bi-iliac breadths. A Sprague stethoscope (model number 641, Diagnostix, Hauppauge, NY) and an aneroid sphygmanometer (model number 700, Diagnostix, Hauppauge, NY) blood pressure cuff were utilized to measure blood pressure. The Modified-Astrand protocol was conducted on Star Trac Treadmill (Unisen Inc., Irvine, CA), which was calibrated per the manufacturer’s instructions prior to the start of the study. A Polar Pacer T31 heart rate monitor (Polar Electro,
Oy, Finland) was used to obtain heart rate (HR) values at each stage of the treadmill protocol. During the Modified-Astrand treadmill protocol, perceived exertion was measured via Borg’s 15-point Ratings of Perceived Exertion (RPE) scale.[25] A Lactate Plus Analyzer (Nova Biomedical Corporation, Waltham, Massachusetts, USA), calibrated per the manufacturer’s instructions, was used to obtain blood lactate concentrations pre- and post- \( \text{V}O_2\text{max} \) testing.

**Procedures**

The APFT was administered at the beginning and end of the academic semester under the supervision of the Army ROTC Battalions’ commanding officers and in accordance to Army Standards [1]. Data from the pre- and post- APFT scores were used for statistical analysis purposes. The pre-ROTC PT data collection was conducted before the diagnostic APFT and prior to start of Army ROTC PT and the post-ROTC PT data collection was conducted at the end of the academic semester. Subjects reported to the University of Hawai`i, Mānoa’s Human Performance Laboratory and were given standardized written and verbal instructions prior to initiation of all testing sessions (Appendix A). All subjects completed informed consent, health history questionnaires (Appendix B), lower extremity orthopedic injury (LEOI) questionnaires (Appendix C), and the physical activity readiness questionnaires (PAR-Q) (Appendix B) [4]. All forms were reviewed and approved by a member of the research team before beginning the study. At the beginning of each data collection session, anthropometric measurements including height, body mass, blood pressure and resting HR were obtained.

Jackson and Pollock’s male [26] and female [27] three skinfold site protocols were utilized to measure skinfold thickness for determination of body density (SKF). All skinfold thickness measurements were assessed on the right side of the body [28] at three skinfold
thickness sites which consisted of the triceps, supra-ilium, and thigh for female subjects and the chest, abdomen, and thigh for male subjects. Skinfold thickness measurements were assessed in an alternating pattern to allow restoration of tissue elasticity [4, 28]. An average of two skinfold thickness measurements for each site were used for analysis. A third measurement was obtained and averaged if the previous two duplicate site’s skinfold thickness measurement values differed by 2 or more millimeters [26, 27].

Body circumference measurements were assessed in accordance to the Army Body Composition Program’s measurement guidelines (ARMY) [3]. Male circumference measurements included the neck and umbilicus. Female circumference measurements included the neck, waist and hip. Additional circumference and breadth measurements were collected for comparison to the ARMY technique for assessing body composition. These measures consisted of waist circumference, knee circumference, and bi-iliac breadth to determine lean body weight for males (LBC) [29], abdomen and body mass to determine lean body weight for males (LBM), and abdomen circumference, hip circumference, and umbilicus circumference to calculate body density for females (CIRC) [29, 30]. Three measurements were taken at each site, in an alternating pattern. An additional measurement was necessary and averaged if the two duplicate site measurements differed by more than one centimeter for the larger circumference sites (umbilicus, abdomen, and hip), and more than 0.3 cm for the smaller circumference sites (neck and knee) [3]. Percent body fat for the SKF and CIRC technique was calculated according to the Brozek 2-Compartment model equation [22], %BF for the LBM and LBC technique was calculated according to Wilmore and Behnke’s lean body weight to %BF equation [29].

Following anthropometric measurements, a HR monitor was tightly fitted to the bare skin over the xiphoid process and blood was taken via the finger-prick method (on the non-dominant
hand) to determine pre-test blood lactate concentrations. Each subject was given verbal explanation of the Borg’s RPE scale (Appendix D) [31] and the multi-staged Modified-Astrand treadmill protocol (Appendix E). Subjects completed a voluntary warm up including self-directed stretching and a five-minute brisk walk (off treadmill) prior to starting the treadmill protocol. Subjects were instructed to select a treadmill speed (5-8 mile per hour range) that they could run quickly but comfortably for thirty minutes and were blinded to the actual treadmill speed.

Determination of self-selected speed was followed by a 2-3 minute warm-up for familiarization [32]. Speed remained constant throughout the treadmill protocol. The first 3-minute stage of the treadmill protocol was conducted at a 0% grade. Incremental increases in grade by 2.5% occurred every two minutes for the duration of the treadmill protocol [32, 33]. At the end of each stage, RPE and HR were recorded. Verbal encouragement was provided to each subject for the duration of the treadmill protocol. The test was terminated at the point of subject volitional exhaustion.

Immediately following termination of the treadmill protocol, subjects completed a five-minute active cool-down at a 0% grade and speed between 1.5-2.0 mph. Seven minutes after completion of the treadmill protocol, post-test blood lactate concentrations were measured. [32] Maximal oxygen consumption was estimated utilizing treadmill grade at test termination and self-selected speed [33-35]. Determination of maximal effort was based on ACSM guidelines for maximal exertion, including RPE >17, greater than 8mmol of blood lactate concentrations, and a failure of HR to increase with increased exercise intensity [4, 32].

Health and injury status of each Army ROTC subject was monitored for the duration of ROTC conducted PT. A lower extremity injury was defined as 1) any injury to the lower
extremity that reduced the level and/or amount of physical activity, or 2) required subjects to seek medical advice/treatment [36]. Subjects who suffered acute or chronic injuries to the lower extremity that removed them from ROTC PT participation for three or more weeks during the observation period were excluded from analysis. All potential overuse and acute injuries sustained to the lower extremity were evaluated, recorded, and treated by the same certified Athletic Trainer (AT). Subjects also completed the LEOI questionnaires in the pre-ROTC and post-ROTC PT data collections to identify possible development of an overuse or acute lower extremity injury. Questionnaire responses indicating potential injuries were assessed clinically by the same AT and referred for further medical diagnosis and care as needed.

**Statistical Analysis**

All statistical analyses were completed using the Statistical Package for the Social Services (SPSS) version 23 with an alpha level set at p<0.05. Multiple one-way repeated measures analysis of variance (ANOVA) were used for comparisons of APFT scores, \( \text{\textit{V}}{\text{\textit{O}}}_2\text{\textit{max}} \) values, and body composition variables over time, separated by gender. The following variables were used during analysis: Body mass, BMI, \( \text{\textit{V}}{\text{\textit{O}}}_2\text{\textit{max}} \), APFT scores, and %BF. A one-way ANOVA was utilized to determine changes in physical fitness levels over time (delta ROTC-PT) between male and female ranks (MS-3 and MS-4). Independent t-tests were conducted to compare means of pre-ROTC physical fitness variables between male and female ranks (MS-3 and MS-4). A repeated measures ANOVA was used to calculate differences in %BF as calculated by LBC, LBM, SKF, and ARMY techniques for males, and CIRC, SKF, and ARMY techniques for females.
RESULTS

A total of 62 subjects participated in the study. Fifty-two of the 62 subjects completed the pre-ROTC PT and post-ROTC PT data collections; 10 subjects completed the post-ROTC PT data collection only. Sixteen were excluded from the study due to: 1) non-ROTC PT related injuries (n=4), 2) failure to follow up (n=6), 3) failure to follow subject guidelines specified by the research staff prior to data collection (n=1) and 4) participation in Ranger training (n=5). Subjects who only participated in the post-ROTC data collection session (n=10) were included in the statistical analysis that compared %BF techniques. Pre- and post-ROTC PT data from 36 subjects (males: n=27, 24.74±4.13 years, females: n=9, 25.22±5.07 years) were used for analysis to determine the effect of Army ROTC PT program on aerobic fitness, muscular endurance, body mass, BMI and %BF.

Means and standard deviations for male and female pre- and post-ROTC PT assessments are listed in Table 2. Prior to the start of ARMY led ROTC PT, males had significantly higher \( VO_2\text{\textsubscript{max}} \) (p=0.048), time on treadmill (p=0.030), push up reps (p=0.001), and significantly lower %BF (p=0.01) when compared to females. A comparison of pre-ROTC PT and post-ROTC PT variables revealed a significant increase in the male APFT push up score (p=0.036) and total APFT score (p=0.009). A one-way ANOVA revealed significant differences between ranks for males (MS-3: n=11, MS-4: n=14) when examining ROTC PT assessments over time (delta) for 2-mile run times and body mass. Means and standard deviations for ROTC PT and mean delta assessments by rank are displayed in table 3, table 4, table 5 and table 6.
Independent t-tests revealed significantly different pre-ROTC sit-up scores and push-up scores in the MS-3 female cadets compared to the MS-4 female cadets. Means and standard deviations are displayed in table 7.
### Table 2 Pre and Post ROTC PT Assessments

<table>
<thead>
<tr>
<th></th>
<th>Pre ROTC PT</th>
<th>Post ROTC PT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td><strong>Mean ± SD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Body Mass</strong></td>
<td>80.74 ± 12.32</td>
<td>65.94 ± 15.86</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>25.77 ± 3.06</td>
<td>24.92 ± 2.87</td>
</tr>
<tr>
<td><strong>%BF</strong></td>
<td>12.12 ± 3.48*</td>
<td>28.99 ± 3.84*</td>
</tr>
<tr>
<td><strong>V\textsubscript{0}\textsuperscript{2}max</strong></td>
<td>50.69 ± 2.80*</td>
<td>44.95 ± 1.30*</td>
</tr>
<tr>
<td><strong>Treadmill Time</strong></td>
<td>11:50 ± 1:52*</td>
<td>9:48 ± 1:10*</td>
</tr>
<tr>
<td><strong>APFT Overall</strong></td>
<td>254.43 ± 24.09</td>
<td>276.75 ± 22.02</td>
</tr>
<tr>
<td><strong>APFT 2MRS</strong></td>
<td>81.24 ± 10.63</td>
<td>92.00 ± 7.17</td>
</tr>
<tr>
<td><strong>APFT 2PUS</strong></td>
<td>82.62 ± 15.39</td>
<td>94.50 ± 5.20</td>
</tr>
<tr>
<td><strong>APFT 2SUS</strong></td>
<td>91.43 ± 9.65</td>
<td>90.25 ± 13.23</td>
</tr>
<tr>
<td><strong>APFT 2MRT</strong></td>
<td>14:39 ± 0:53</td>
<td>16:05 ± 0:56</td>
</tr>
<tr>
<td><strong>APFT 2PUR</strong></td>
<td>60.81 ± 15.01*</td>
<td>43.00 ± 5.48*</td>
</tr>
<tr>
<td><strong>APFT 2SUR</strong></td>
<td>74.00 ± 8.45</td>
<td>77.50 ± 15.50</td>
</tr>
</tbody>
</table>

SD: Standard deviation; BMI: Body Mass Index (kilograms/meters\(^2\)); %BF: percent body fat $V_0^{max}$: Maximal oxygen consumption; APFT: Army physical fitness test

* Significantly different between gender (p=0.05)
** Significantly different between pre-and post-ROTC PT (p=0.05)
### Table 3 Male Pre- and Post- ROTC Physical Fitness Assessments by Rank

<table>
<thead>
<tr>
<th>Rank</th>
<th>Time</th>
<th>Body Mass</th>
<th><strong>Pre</strong></th>
<th><strong>Post</strong></th>
<th><strong>Pre</strong></th>
<th><strong>Post</strong></th>
<th><strong>Pre</strong></th>
<th><strong>Post</strong></th>
<th><strong>Pre</strong></th>
<th><strong>Post</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>82.91±13.27</td>
<td>74.96±11.47*</td>
<td>74.96±11.47*</td>
<td>76.54±11.88</td>
<td>75.38±12.97</td>
<td>75.38±12.97</td>
<td>11:00±2:12</td>
<td>12:17±1:46</td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>26.39±4.23</td>
<td><strong>Pre</strong></td>
<td>24.82±2.99</td>
<td>25.16±3.46</td>
<td>25.16±2.94</td>
<td>13.95±4.23</td>
<td>11.68±2.82</td>
<td>12:00±1:38</td>
<td>12:07±1:48</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>13.95±4.23</td>
<td>11.87±2.94</td>
<td>11.68±2.82</td>
<td>12.24±3.32</td>
<td>12.24±3.32</td>
<td>49.81±3.56</td>
<td>50.29±3.92</td>
<td>51.07±3.22</td>
<td>50.61±3.59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>51.07±3.22</td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12:17±1:46</td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
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<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11:00±2:12</td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
</tr>
</tbody>
</table>

MS: Military science; N: Subjects; BMI: Body mass index (kilograms/meter²), %BF: body fat percentage
VO₂max: Maximal oxygen consumption
*Significantly larger decrease by MS-3 cadets in delta (body mass) from Pre- to Post-ROTC PT compared to MS-4 cadets p=0.05

### Table 4 Male Pre- and Post- ROTC APFT Assessments by Rank

<table>
<thead>
<tr>
<th>Rank</th>
<th>Time</th>
<th>APFT Overall</th>
<th>APFT 2MRS</th>
<th>APFT 2PUS</th>
<th>APFT 2SUS</th>
<th>APFT 2MRT</th>
<th>APFT 2PUR</th>
<th>APFT 2SUR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
<td><strong>MS-3</strong></td>
<td><strong>MS-4</strong></td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>253.73±27.24</td>
<td>78.64±82.64</td>
<td>83.73±16.32</td>
<td>93.00±10.32</td>
<td>15:00±0:39</td>
<td>61.00±15.05</td>
<td>75.91±9.16</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>273.40±12.19</td>
<td>87.05±10.73</td>
<td>90.2±10.11</td>
<td>96.3±5.80</td>
<td>14:09±0:58*</td>
<td>67.50±11.21</td>
<td>78.5±6.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14:30±1:02</td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
<td><strong>Pre</strong></td>
<td><strong>Post</strong></td>
</tr>
<tr>
<td></td>
<td>Pre</td>
<td>258.57±20.17</td>
<td>82.64±12.80</td>
<td>85.93±8.34</td>
<td>90.00±10.58</td>
<td>14:30±1:02</td>
<td>63.64±10.62</td>
<td>72.79±8.65</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>272.00±11.27</td>
<td>85.57±10.97</td>
<td>89.62±9.91</td>
<td>95.95±5.88</td>
<td>14:11±0:56</td>
<td>66.32±11.63</td>
<td>77.84±6.56</td>
</tr>
</tbody>
</table>

MS: Military science; APFT: Army Physical Fitness Test; APFT Overall: 3-APFT event scores combined; APFT 2MRS: 2-mile timed run score
APFT 2PUS: 2-minute push-up score; APFT 2SUS: 2-minute sit-up score; APFT 2MRT: 2-mile timed run; 2PUR: 2-minute push-up reps
APFT 2SUR: 2-minute sit-up reps
*Significantly larger decrease by MS-3 cadets in delta (run-times) from Pre- to Post-ROTC PT compared to MS-4 cadets p=0.05
Table 5 Male Mean Deltas (Physical Fitness Assessments)

<table>
<thead>
<tr>
<th></th>
<th>MS-3 Mean Delta</th>
<th>MS-4 Mean Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Body Mass</td>
<td>-3.16 ± 4.35*</td>
<td>-0.38 ± 1.85</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.59 ± 0.95</td>
<td>-0.01 ± 0.63</td>
</tr>
<tr>
<td>%BF</td>
<td>-0.39 ± 1.47</td>
<td>0.51 ± 1.30</td>
</tr>
<tr>
<td>V\text{O}_2\text{max}</td>
<td>0.97 ± 1.96</td>
<td>-1.40 ± 1.72</td>
</tr>
<tr>
<td>Treadmill Time</td>
<td>0:36 ± 0:44</td>
<td>0:07 ± 0:51</td>
</tr>
</tbody>
</table>

PT: physical training; (Mean Delta=Post-ROTC PT-Pre-ROTC PT)  
MS: military science; SD: standard deviation  
BMI: body mass index (kg/meters²)  
V\text{O}_2\text{max}: maximal oxygen consumption  
*Significantly larger decrease in MS-3 compared to MS-4 cadets  
p=0.04

Table 6 Male Mean Deltas (APFT Assessments)

<table>
<thead>
<tr>
<th></th>
<th>MS-3 Mean Delta</th>
<th>MS-4 Mean Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>APFT Overall</td>
<td>22.50 ± 18.51</td>
<td>12.85 ± 14.22</td>
</tr>
<tr>
<td>APFT 2MRS</td>
<td>12.13 ± 12.07</td>
<td>2.69 ± 9.29</td>
</tr>
<tr>
<td>APFT 2PUS</td>
<td>2.63 ± 13.45</td>
<td>6.23 ± 7.44</td>
</tr>
<tr>
<td>APFT 2SUS</td>
<td>5.50 ± 9.01</td>
<td>4.15 ± 6.05</td>
</tr>
<tr>
<td>APFT 2MRT</td>
<td>1:02 ± 0:57*</td>
<td>0:12 ± 0:47</td>
</tr>
<tr>
<td>APFT 2PUR</td>
<td>2.88 ± 13.14</td>
<td>5.77 ± 6.15</td>
</tr>
<tr>
<td>APFT 2SUR</td>
<td>3.88 ± 6.13</td>
<td>4.31 ± 6.87</td>
</tr>
</tbody>
</table>

PT: physical training; (Mean Delta= Post-ROTC PT- Pre-ROTC PT)  
MS: military science; SD: standard deviation  
APFT: Army physical fitness test; 2MRS: 2-mile run score  
2PUS: 2-minute push-up score, 2SUS: 2-minute sit-up score 2MRT: 2-mile run time; 2PUR: 2-minute push-up rep; 2SUR: 2-minute sit-up reps  
*Significantly larger decrease in MS-3 compared to MS-4 cadets  
p=0.04
<table>
<thead>
<tr>
<th></th>
<th>MS-3</th>
<th>Mean ± SD</th>
<th>MS-4</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Mass</td>
<td>65.39 ± 3.64</td>
<td>57.36 ± 13.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>23.24 ± 1.80</td>
<td>23.09 ± 1.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%BF</td>
<td>28.09 ± 1.86</td>
<td>26.81 ± 2.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V(\text{O}_2)\text{max}</td>
<td>43.86 ± 1.40</td>
<td>45.26 ± 1.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treadmill Time</td>
<td>8:50 ± 0:31</td>
<td>9:59 ± 1:32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT Overall</td>
<td>223.33 ± 60.04</td>
<td>289.67 ± 11.06</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2MRS</td>
<td>77.33 ± 18.04</td>
<td>95.00 ± 8.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2PUS</td>
<td>84.00 ± 20.81*</td>
<td>94.67 ± 4.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2SUS</td>
<td>76.33 ± 30.07*</td>
<td>100.00 ± 0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2MRT</td>
<td>5:28 ± 1:27</td>
<td>3:55 ± 1:05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2PUR</td>
<td>34.00 ± 13.23</td>
<td>43.00 ± 6.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APFT 2SUR</td>
<td>63.67 ± 18.93</td>
<td>86.33 ± 1.77</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PT: Physical training; MS: Military Science Rank
SD: Standard deviation
BMI: Body Mass Index kilograms/meters\(^2\); %BF: percent body fat;
V\(\text{O}_2\)\text{max}: Maximal oxygen consumption; APFT: Army physical fitness test; APFT Overall: Total combined score
APFT 2MRS: two mile timed run score
APFT 2PUS: two minute push-up score
APFT 2SUS: two minute sit-up score
APFT 2MRT: two-mile timed run
2PUR: two minute push-up reps
2SUR: two minute sit-up reps
*Significantly lower in MS-3 compared to MS-4
p=0.05
Additional analyses were completed on 39 subjects (males: n=27, 24.60±4.49 years, females: n=12, 24.17±4.95 years) to determine differences between %BF measurement techniques (LBC, LBM, CIRC, SKF and ARMY). Means and standard deviations of the %BF measurement techniques are shown in table 6 (male) and table 7 (female).

Male %BF via the ARMY technique was significantly higher than %BF calculated from the SKF technique, LBC technique, and the LBM technique (p=0.001). Female %BF via the ARMY technique was significantly lower than CIRC (p=0.001) and significantly higher than SKF (p=0.026).

**Table 8 Comparison of Male %BF Techniques**

<table>
<thead>
<tr>
<th>%BF Techniques</th>
<th>Mean  ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBC</td>
<td>11.86 ± 0.60α</td>
</tr>
<tr>
<td>LBM</td>
<td>13.43 ± 0.68δ</td>
</tr>
<tr>
<td>SKF</td>
<td>12.25 ± 0.59δ</td>
</tr>
<tr>
<td>ARMY</td>
<td>16.79 ± 0.77α*</td>
</tr>
</tbody>
</table>

* %BF: Body fat percentage; SD: standard deviation; CIRC: %BF via circumference technique; SKF: %BF via skinfold thickness technique; ARMY: %BF via Army technique
*α Significantly different than LBC p=0.001
*δ Significantly different than ARM Y p=0.001
*β Significantly different from SK F p=0.001

**Table 9 Comparison of Female %BF Techniques**

<table>
<thead>
<tr>
<th>%BF Techniques</th>
<th>Mean  ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRC</td>
<td>28.42 ± 3.42αβ</td>
</tr>
<tr>
<td>SKF</td>
<td>24.62 ± 2.68*β</td>
</tr>
<tr>
<td>ARMY</td>
<td>27.17 ± 4.04*α</td>
</tr>
</tbody>
</table>

* %BF: Body fat percentage; SD: standard deviation; CIRC: %BF via circumference technique; SKF: %BF via skinfold thickness technique; ARMY: %BF via the Army technique
*α Significantly different from CIRC p=0.03
*β Significantly different from ARMY p=0.03
*α Significantly different from SKF p=0.03
DISCUSSION

The main findings of the current study were that males significantly increased push up repetitions and APFT scores from pre- to post-ROTC PT. Additionally, when examining the changes (delta) in assessments from pre- to post- ROTC PT, male MS-3 cadets displayed greater decreases in body mass and 2- mile run times compared to their MS-4 male counterparts. As expected, male ROTC cadets showed significantly higher $\text{V}_\text{O}_2$ max values, time to exhaustion on the $\text{V}_\text{O}_2$ max treadmill test, and repetitions completed on the two-minute push-up event compared to females. Males also displayed significantly lower %BF compared to female cadets. An assessment of techniques for calculating %BF revealed the ARMY technique resulted in significantly higher values in both males and females than widely used validated assessments of %BF utilized in this study (LBM, LBC, and SKF).

Previously published data have reported ROTC cadets to be above average (at or above the 80th percentile) for $\text{V}_\text{O}_2$ max values, %BF, and APFT assessments when compared to gender and age specific normative data [5]. Similarly, prior to Army led ROTC PT, evaluation of the current study’s cohort of ROTC cadets $\text{V}_\text{O}_2$ max and APFT scores categorized both males and females as average to above average (above the 70th percentile). Males were also considered healthy in terms of %BF [4]. Females, however, were classified as “below” to “well below average” for %BF [4]. Actual assessment of $\text{V}_\text{O}_2$ max and the use of underwater weighing [5] in previous research likely provided better accuracy than our study’s techniques for determining cadets’ aerobic fitness, as these values were only estimated in the current study as opposed to measured via open circuit spirometry [5]. Similarly, in the present study %BF was estimated via
body circumference measurements as opposed to underwater weighing [5] to represent military standards which utilize body circumference measurements [1, 3].

The limitations associated with assessment of body composition based of basic anthropometric measurements such as height and weight has been well documented in recent research as such measurements disregard the influence of lean body mass [32]. Similarly, %BF as calculated from current circumference measurements utilized by ARMY also may not accurately reflect an individual soldiers body composition. The current study’s SKF technique used for determination of %BF is a validated and commonly used method [4, 5, 28, 32]. The LBC and LBM techniques, though not as widely used as SKF, produced similar results. As an example from the current study of the potential limitations of using the ARMY technique when assessing body composition, a male cadet who fell into the 10 percentile (poor category) %BF [4] according to the current study’s ARMY technique was categorized into the 40th percentile (average category) based on the SKF technique [4]. Utilization of SKF, LBC, and LBM techniques rather than ARMY technique would have removed the requirement for this cadet to enroll in a body composition management program.

Previous literature has investigated the effects of an Army basic combat training program on body composition and V\textsubscript{O}\textsubscript{2}max values, and reported significant increases in V\textsubscript{O}\textsubscript{2}max and significant decreases in %BF [18, 19, 23, 24]. In contrast, the current study did not reveal any significance differences between pre- and post- ROTC PT assessments of aerobic fitness (V\textsubscript{O}\textsubscript{2}max values, 2-mile run times), and %BF [18, 19, 23, 24] in males and females. However, results from the current study demonstrated significant increases in 2-minute push-up repetitions and overall APFT scores from pre- to post- ROTC PT in males. It is important to note that the current study is one of the few studies to investigate the effects of an Army ROTC PT program
[5], and previously published literature has only investigated the effects of Army basic combat training. Differences in frequency and hours of training exist between the current Army ROTC PT program and previously published Army basic combat training programs [18, 19, 23, 24]. These differences in volume may explain the variation in response to the physical training programs seen in the present study. Cadets in the current study exhibited slight, but not significant, increases in VO$_2$max and APFT scores and decreases in 2-mile run times over time. Although results were not significant, both males and females in the current study demonstrated increases similar to those previously reported [18, 19, 23, 24]. The post-ROTC PT assessments revealed slight improvement from the pre-ROTC PT, with both male and female cadets remaining in the average to above average categories based on gender and age specific norms for all assessments of physical fitness except for %BF in females [4]. These findings suggest that the current study’s Warrior Battalion’s ROTC PT program was effective in at least maintaining aerobic fitness and muscular endurance in the Army ROTC cadets.

A recent study by Crawford et al. [6] examined the impact of %BF on performance in males, and reported a significant decrease in performance outcomes in cadets exceeding Department of Defense’s accepted %BF maximum (>18%). Cadets with less than 18% body fat had significantly higher VO$_2$max values (p<0.01), and significantly higher completed push-up repetitions on the 2-minute push up event (p<0.002). Of the male cadets in the current study, 88% (24 out of 27) had less than 18%BF. Male cadets with %BF < 18% had a higher mean pre-ROTC PT VO$_2$max (50.66 ml/kg/min) compared to cadets with a %BF higher than 18 (49.93 ml/kg/min, p=0.07). Data on female %BF in relation to VO$_2$max performance is limited. In the current study, female mean %BF and mean VO$_2$max were 28.99% and 44.95 kg/ml/min, respectively. Based on age and gender norms, females were classified as below average in %BF
but, interestingly, as excellent for \( \text{V} \dot{\text{O}}_2 \text{max} \), suggesting that the relationship between %BF and \( \text{V} \dot{\text{O}}_2 \text{max} \) may not be as clearly defined in female soldiers. The conflict between expected results in aerobic fitness as it relates to body composition necessitates additional research on female ROTC cadets and soldiers.

In summary, this study found that the University of Hawaii’s Army ROTC Warrior Battalion Physical Training Program was effective in maintaining and improving assessments of physical fitness, with the exception of female and male %BF. Since previous studies have indicated males soldiers with ideal body composition display higher levels of aerobic fitness and muscular endurance [6], future studies should aim to clarify the relationship between %BF and performance, specifically in female soldiers and ROTC cadets. When calculating Army soldiers %BF, this study’s findings bring into question the accuracy of the Army’s current method for calculating %BF. This study found that the Army’s current body circumference based measurements are inconsistent with more commonly accepted, validated methods such as skinfold thickness measurements. A comparison of commonly used, validated techniques for determination of %BF and the ARMY protocol revealed that the ARMY protocol for calculation of %BF overestimated %BF for both male and female cadets. Future research should assess validity of the existing ARMY protocol with a current “gold standard” of body composition such as the 4-Compartment model.
LITERATURE REVIEW

Military leaders recognize the importance of physical conditioning for duty assignments and combat roles. A physical training program (PT) aims to develop soldiers’ strength, endurance, and mobility [1, 18-20]. A soldier must possess physical capabilities that include marching long distances, running long distances, and jumping in and out of craters. Soldiers’ lives and victories in battle depend on physical readiness for combat. The primary goal of a military PT program is to develop and maintain a high level of individual readiness that contributes to the overall readiness of a military unit [1].

The Army Physical Readiness Training program (PRT) adheres to specific exercise principles including precision, progression, and integration that aid in injury prevention [1]. Physiological assessments of muscular endurance, cardiorespiratory endurance, and aerobic fitness are utilized to examine the effectiveness of a PT program. Current literature has focused on assessing physical fitness outcomes prior to and following implementation of basic combat training programs [18-20, 23, 24].

An important component of physical fitness is cardiorespiratory endurance. The gold standard for assessing cardiorespiratory endurance is via a maximal oxygen consumption (VO$_2$max) test [4, 32]. An assessment of VO$_2$max reflects the ability of vital organs to transport oxygen to the muscles throughout vigorous exercise, and closely resembles the heart’s functional capacity of undergoing an exercise bout [4, 32]. Physiological and body composition assessments conducted in a laboratory setting are not always suitable for Army soldiers due to the environment a Soldier is placed in. When direct measurements of VO$_2$max are not feasible
for a testing environment, studies validate estimation of VÔ₂max via submaximal and maximal exercise tests [4, 5, 33-35, 37].

The Army Physical Fitness Test (APFT) is the current Army field assessment utilized to determine a soldiers’ physical fitness level. The APFT consists of a 2-minute push-up event, a 2-minute sit up event, and a 2-mile timed run. Studies have found the APFT to serve as a means of assessment for aerobic fitness via the two mile timed run, and as an assessment of upper and lower body muscular endurance via the 2-minute sit-up and push-up event [1, 5, 7, 14, 20, 21]. Additionally, research has indicated that a relationship exists between injury and the performance outcomes on each APFT event [7, 9, 14, 16, 21]. A clear relationship exists between training related injuries and soldiers’ with slow 2-mile run performances [7, 9, 10, 12, 14, 16, 21, 38], however, a less clear relationship between injury risk and low repetitions on the 2-minute push-up and sit-up event [7, 9, 14, 16, 21, 38].

Various techniques have been utilized in literature to assess Army soldiers body fat percentage (%BF), these include: skinfold thickness measurements, the bod pod, hydrostatic weighing, circumference measurements, dual energy x-ray absorptiometry, and bioelectrical impedance [5, 6, 8, 13, 14, 17, 39]. Investigations are limited in regards to the relationship between soldiers body fat percentage (%BF) and PT related injuries [3, 8-11]. The studies over the past few decades are reporting an 10% increase in %BF in male Army soldiers, and a 5% increase in body mass for male and female soldiers [8, 12]. This increase warrants concern, and researchers are suggesting that the increases in both %BF and body mass index (BMI) could poise a problem to soldiers’ physiological and physical performance in the future [6]. A study looking at the effects of %BF on performance found that soldiers with less than 18 %BF performed better aerobically and anaerobically on physical fitness tests [6]. Additionally,
another study found Army soldiers with a higher %BF via bioelectrical impedance to suffer a greater risk for acute and overuse injury throughout a 7-week basic combat training period [39]. Therefore, continuous assessments of physical fitness and body composition can have various benefits.

**The Effects of Army Physical Training Programs on Components of Physical Fitness**

Investigations have been conducted on Army soldiers to assess select components of physical fitness prior to and following a military physical training program [18-20, 23, 24]. Current literature has examined basic combat training (BCT) programs lasting 5-weeks, 10-weeks, and 12-weeks in duration. These studies pre- and post- BCT data collection sessions include assessments of aerobic fitness, anthropometrics, and body composition. [18-20, 23, 24].

Three studies have examined changes in soldiers aerobic fitness levels via pre- and post-basic Army training, and utilized a submaximal or maximal cycle ergometer workload test for estimating $\text{VO}_2\text{max}$ values [18, 20, 23]. Additional studies have estimated $\text{VO}_2\text{max}$ values via a 20-minute multi-staged shuttle test [19, 24]. Body composition is also an important component of physical fitness, and has been studied prior to and following a training program. These previously reported studies have utilized skinfold thickness or bioelectrical impedance for estimating %BF [18-20, 23, 24]. The current studies have reported favorable outcomes of aerobic fitness and body composition following 5-weeks, 10-weeks, and 12-weeks Army BCT programs. These studies have reported these findings in both genders of soldiers. [18-20, 23, 24]
Vogel et al. [23] conducted a repeated measures study design on 254 male Army recruits (mean age 19.4 ± 2.4 years) to compare pre- and post- physical fitness values of a 10-week Army BCT program. A four site skinfold thickness technique (subscapular, triceps, bicep, and suprailiac) was utilized to estimate %BF, and a single work load submaximal bicycle ergometer test utilizing heart rate responses and the Astrand-Rhyming nomogram were utilized to predict VO\textsubscript{2}max. Predicted VO\textsubscript{2}max values were corrected for age, and also normalized to body mass (kilograms). Estimated VO\textsubscript{2}max values (mililiter/kilogram/minute), body weight (kilograms), and %BF (%) from pre- to post- BCT went from 42.0 ± 8.3 mililiters/kilogram/minute to 45.3 ± 7.2 mililiters/kilogram/minute, 67.9 ± 9.5 kilograms to 68.2 ± 8.7 kilograms, and 14.2 ± 4.7 % to 12.9 ± 3.8 % respectively. Results indicated an increase from pre-to post- training in aerobic fitness as determined by predicted VO\textsubscript{2}max values (p< 0.001), and a decrease in pre- to post-training %BF values (p<0.001). Overall, the male subjects VO\textsubscript{2}max values revealed an 8% increase following the 10-weeks of training, and an 8.6% reduction in %BF following the 10-weeks of training. [23]

Williams et al. [19] conducted a repeated measures study design on 47 male (mean age 19.40 ± 3.21 years) and 10 female (mean age 21.50 ± 3.50 years) British Army recruits to compare pre- and post- physical fitness values of a 10-week British Army BCT program. Pre- and post- British Army PT data collections included assessments of body mass, %BF and estimated VO\textsubscript{2}max. Soldiers %BF were estimated via bioelectrical impedance, and VO\textsubscript{2}max values were estimated to determine aerobic fitness via a progressive 20-minute multi-staged shuttle run. Means and standard deviations of female and male pre- to post- assessments of %BF expressed in percentage were 24.4 ± 4.63 to 20.29 ± 3.55 and 10.9 ± 3.63 to 8.5 ± 3.16 respectively. Mean and standard deviation of female and male pre- to post- assessments of
estimated \( \text{VO}_2\text{max} \) expressed in liters/minute were 2.50 ± 0.23 and 2.64 ± 0.25, and 3.58 ± 0.48 to 3.72 ± 0.40 respectively. Mean and standard deviation of female and male pre- to post-assessments of estimated \( \text{VO}_2\text{max} \) values expressed in mililiters/kilogram/minute were 39.6 ± 3.51 to 42.9 ± 3.14, and 50.3 ± 5.02 to 53.2 ± 4.14 respectively. Mean and standard deviation of female and male pre- to post-assessments of %BF expressed in percentage were 24.4 ± 4.63 to 20.29 ± 3.55, and 10.9 ± 3.63 to 8.5 ± 3.16 respectively. Results indicated a significant reduction in %BF and body mass for female and male soldiers from pre- to post training (\( p<0.001 \), \( p<0.05 \)). Aerobic fitness as determined via the 20 meter shuttle run improved time to exhaustion by 9.0\%, and both genders of soldiers \( \text{VO}_2\text{max} \) values expressed in liters/minute and mililiters/kilogram/minute displayed significant improvement from pre- to post- physical training (\( p<0.05 \)).

Brock and Legg [18] conducted a repeated measures design study on 73 female soldiers (mean age 19.2 ± 1.4 years) to evaluate physical fitness assessments of aerobic fitness and %BF prior to and following a 5-week Army recruit basic training program. Body fat percentage was determined according to Durnin and Womersely 4-site SKF thickness measurements (biceps, triceps, subscapular, and suprailiac). Assessments of aerobic endurance were conducted via an estimation of \( \text{VO}_2\text{max} \). An estimation of \( \text{VO}_2\text{max} \) was determined utilizing a NATO test on a cycle ergometer. The cycle ergometer was programmed to produce one minute incremental increases in workload throughout the cycling period, and volitional exhaustion was determined when soldiers were unable to continue. Pre- to post- Army basic training mean and standard deviation of body mass increased from 60.0 ± 7.9 kilograms to 60.6 ± 7.4 kilograms. Pre- to post- \( \text{VO}_2\text{max} \) mean and standard deviation increased from 45.66 ± 5.16 mililiters/kilogram/minute to 46.66 ± 4.40 mililiters/kilogram/minute. Pre- to post- %BF mean
and standard deviation decreased from 27.6 ± 4.1 to 26.7 ± 3.8. Results indicated from pre- to post- basic training, a decrease in %BF (p<0.001), and an increase in estimated \( \text{VO}_2\text{max} \) values (p<0.05) and body mass (p<0.05). Overall, this study found a 3.5 % decrease in %BF, a 1% increase in body mass, and a 2.2 % increase in aerobic fitness following 5-weeks of training.

Legg and Duggan [20] conducted a repeated measures design on 62 adult artillery recruits (mean age 18.79 ± 1.68 years) to compare body mass, estimated \( \text{VO}_2\text{max} \), and cycle time from pre- to post- following a three month basic training program. The mean maximal oxygen uptake was predicted via completed cycle times as determined by a cycle ergometer graded workload test. Body mass from pre- to post- basic training significantly increased from 67.09 kilograms to 68.37 kilograms (p< 0.01). Predicted \( \text{VO}_2\text{max} \) values from pre- to post- basic training significantly increased from 51.63 ± 5.22 mililiters/kilogram/minute to 53.48 ± 5.53 mililiters/kilogram/minute (p<0.01). Cycle time of the graded workload test from pre- to post- significantly increased from 7.27 ± 1.23 minutes to 7.96 ± 1.21 minutes (p<0.05). Body mass, estimated \( \text{VO}_2\text{max} \) values, and cycle time displayed an average increase of 1.38 kilograms, 1.85 mililiters/kilogram/minute and 0.69 minutes respectively. This current study produced a significant increase in body weight and aerobic fitness in Adult artillery recruits who started their initial training at a moderate level of aerobic fitness.

Williams [24] conducted a repeated measures design on: 1) 11 British Army regular soldiers, 2) 14 Territorial Army reserve soldiers and 3) 20 control subjects. This current study aimed to compare aerobic fitness, and estimated \( \text{VO}_2\text{max} \) values on regular soldiers, reserve soldiers, and control subjects from pre- to post- of a 12-week basic training program. Training for the regular Army soldiers consisted of 90 training periods lasting 40 minutes (3,600 minutes), training for the reserve Army soldiers consisted of 10 training periods lasting 45 minutes (450
minutes), and the control group training consisted of subjects following their normal habitual physical activity patterns throughout the 12-week period. Mean maximal oxygen uptake for each group was estimated via a progressive 20 minute shuttle run test. Body fat percentage was determined via bioelectrical impedance.

Following 12 weeks of training results indicated that %BF decreased, but not significantly between the regular (p<0.034) and reserve Army (p<0.046) relative to the control group. Estimated V\(\text{O}_2\)\(_{\text{max}}\) values expressed in liters/minute significantly increased from pre- to post- in both the regular and reserve Army soldiers relative to the control group (p<0.05). The regular soldiers V\(\text{O}_2\)\(_{\text{max}}\) values from pre- to post- training expressed in liters/minute and mililiters/kilogram/minute went from 3.03 ± 0.37 to 3.46 ± 0.39, and 44.8 ± 4.9 to 50.6 ± 4.5 respectively. The reserve soldiers estimated V\(\text{O}_2\)\(_{\text{max}}\) values expressed in liters/minute and mililiters/kilogram/minute from pre- to post- training went from 3.05 ± 0.62 to 3.35 ± 0.57, and 40.9 ± 6.1 to 43.5 ± 4.1 respectively. [24]

Pre- to post- estimated V\(\text{O}_2\)\(_{\text{max}}\) values expressed in liters/minute and mililiters/kilogram/minute were significantly different between the reserve and the regular Army soldiers, indicating the regular Army soldiers displayed a significantly greater increase in estimated values from pre- to post- physical training. The greater increase in estimated V\(\text{O}_2\)\(_{\text{max}}\) displayed by the regular soldiers was expected by the investigator due to the higher frequency of training in the regular soldiers compared to the reserve soldiers. Overall, both reserve and regular Army soldiers from pre- to post- physical training displayed a non-significant decrease in %BF and a significant increase in V\(\text{O}_2\)\(_{\text{max}}\), indicating favorable improvements in V\(\text{O}_2\)\(_{\text{max}}\) values and %BF. [24]
The current literature presented displays positive outcomes from Army BCT programs. Vogel et al examined male soldiers and found a decrease in %BF and an increase in aerobic fitness following an Army physical training program [23]. Brock and Legg expanded on Vogel et al’s study and examined changes in aerobic fitness and %BF in female soldiers [18]. The results reported by Brock and Legg were similar to previous studies, %BF decreased and aerobic fitness increased. Interestingly, William et al. conducted a study to compare the effects of an Army PT program on two different military populations, Army reserve recruits and Army regular recruits [24]. The results indicated increases in aerobic fitness, and decreases in %BF for both regular and reserve recruits. However, the changes displayed by the regular Army recruits were much more significant. The researchers discussed this higher change being a result of a higher frequency in training for the Army regular recruits [24]. Regardless of the duration and frequency of the training, studies have shown consistent findings that military physical training programs are effective at improving factors related to physical fitness [18-20, 23, 24].

The Clinical and Non-Clinical Importance of the Army Physical Fitness Test

The Army Physical Fitness Test (APFT) is a field test that assesses physical fitness levels of Army soldiers via a 2-minute push-up event, a 2-minute sit-up event, and a 2-mile timed run. All soldiers must complete the APFT prior to military entrance, and soldiers must fall into the gender and age specific normative APFT scores. Army physical fitness tests can be administered several times throughout a BCT period to ensure soldiers’ have maintained or developed a base level of physical conditioning [1]. Currently, military studies have reported the 2-mile timed run APFT event to serve as a means of assessment of soldiers aerobic fitness levels. Additionally the
2-minute sit-up and 2-minute push up APFT events have been reported in military studies as an assessment of soldiers muscular endurance [5, 9, 13].

Studies have been conducted on large populations of Army soldiers to develop gender and age specific normative data specific to each APFT event [40]. Additionally, research has investigated male and female Army soldiers APFT event outcomes over the past few decades to see the trends in physical fitness levels over time [12]. Lastly, research has investigated the performance outcomes on the APFT events prior to BCT, and how the pre- BCT performance outcomes associate to PT related injuries [13, 14, 16, 17, 21]. Research has consistently reported slow run times on the 2-minute timed run event of the APFT to serve as a risk factor for training related injury. The other APFT events (2-minute push-up and 2-minute sit-up) yield inconclusive results [13, 14, 16, 17, 21], some studies have identified the 2-minute push-up and the 2-minute sit-up to be a risk factor for Army training related injury, while others identify the 2-mile timed run as the only risk factor for training related injury. [13, 14, 16, 17, 21].

Knapik et al. [40] developed normative values for the Army Physical Fitness Test events via conduction of the APFT on 5246 male soldiers and 676 female soldiers from 14 Army installations in the United States. Subjects were instructed to complete as many push-ups as they could in 2-minutes, as many sit-ups as they could in 2-minutes, and perform a 2-mile run for time. There were 609 subjects that were excluded for not providing maximal effort. Data was separated into gender and age specific categories, and percentile distributions were calculated for each event. Normative scores were derived for each individual APFT event, and included age groups of: 1) 17-21, 2) 22-25, 3) 27-31, 4) 32-36, 5) 37-41, 6) 42-46, 7) 47-51 and 8) greater than 52 years old. This database’s main purpose for APFT normative data generation was to
give soldiers, commanders, and medical professionals an idea on how individuals should perform on each APFT event based off of the norms the current study’s subjects generated [40].

Knapik et al. [12] completed a meta-analysis on male and female United States Army recruits to investigate trends in male and female APFT outcomes over time. Temporal trends were assessed on the 2-minute push-up event, the 2-minute sit-up event, and the 2-mile timed run event. Ten studies reported subjects with completed 2-minute push-up and 2-minute sit-up event outcomes from 1984 to 2003. The 2-minute push-up event and sit-up event showed small regression slopes and low correlation coefficients for both male and female subjects, suggesting little change in reps of sit-ups and push-ups from 1984-2003. However, the 2-mile timed run showed favorably different results. Nine studies from 1987 to 2003 reported male and female 2-mile run times, and results indicated a significant decrease in running performance for both male and female recruits. Male recruits ran 10% slower in 2003 compared to 1987, and female subjects ran 6% slower in 2003 compared to 1988. [12]

Interestingly, Thomas et al. [5] collected APFT scores from a cadre of 43 male and female Army ROTC cadets. The APFT was utilized as an assessment aerobic fitness via the 2-mile timed run, and an assessment of muscular endurance via the 2-minute push-ups, and 2-minute sit-up event. The cadets under investigation participated in the ROTC cadre’s physical training three times per week, which prepared the cadets for the physical rigors of military service. The 2-mile timed run results for males and females in minutes were 13.97 ± 1.4 and 17.0 ± 1.6 respectively. The total numbers of push-ups in two minutes for males and females were 60.2 ± 13.2 and 33.3 ± 11.2 respectively. The total number of sit-ups in two minutes for males and females were 70.5 ± 12.8 and 65.0 ± 12.9. Results indicated all events of the APFT to be at or above the 83rd percentile when compared with peer-age and sex-corrected norms. [5]
Knapik et al. [14] investigated the relationship between training related-injuries and poor performance on the APFT events. Subjects included 756 male and 452 female soldiers who performed the APFT prior to BCT. Injury was defined as an event that resulted in damage to the body and for which the subject visited a medical care provider. Injuries were classified as acute or chronic, and were placed into the three injury categories. The injury categories were: 1) all injuries, 2) time-loss injuries and 3) lower extremity injuries. Heat injuries, cold injuries, or animal bites were not utilized for statistical analysis. Fewer push-ups and slower 2-mile run times were associated with higher injury risk in both male (sit-ups, p<0.01, 2-mile timed run, p<0.04) and female (sit-ups, p<0.02, 2-mile timed run, p<0.01) subjects. However, lower completion reps of sit-ups were only associated with higher injury risk in male soldiers (p<0.03). [14]

Another study by Knapik et al. [21] examined the associations between musculoskeletal injuries and physical fitness levels via the APFT. Subjects included a cohort of 298 male soldiers assigned to an infantry battalion in Alaska. Injuries were retrospectively reviewed six months prior to the APFT conduction. Each medical incident, the injury diagnosis, body part injured, disposition, and days of limited duty were recorded. soldiers who performed in the lowest quartile on the 2-mile timed run were 1.6 times more likely to suffer an injury compared to the fastest quartile of runners. soldiers with the lowest number of reps on the 1-minute sit-up event were 1.9 times more likely to suffer an injury compared to the quartile performing the most sit-up repetitions. Push-ups did not show a significant linear trend in injury incidence between the lowest rep quartile and highest rep quartile. This study concluded a higher incidence of injury in the subjects with lower levels of anaerobic endurance via the 2-mile timed run and muscular endurance via the 2-minute sit-up event [21].
Bell et al. [13] investigated the relationship between injury and performance on the APFT in 352 female and 861 male Army soldiers during BCT. Prior to the start of BCT, muscular endurance was assessed via the 2-minute push-up and 2-minute sit-up event, and aerobic fitness was assessed via the 2-mile timed run. Soldiers withheld from one or more days of duty were classified as injured for statistical analysis purposes. Male and female subjects with slow 2-mile run times had a significantly higher risk for sustaining a BCT related injury (p<0.04). There was not a relationship between injury and poor repetitions on the 2-minute push-up and sit-up event. Compared to the fastest runners, the slowest male and female runners were 3.5 times more likely to suffer an injury. Although the female soldiers injured two times the amount of male soldiers, the multivariate regression model determined that the gender-injury relationship is due to low levels of aerobic fitness. [13]

Jones et al. [38] investigated injuries associated with 303 soldiers undergoing a 12-week Army infantry BCT program. Risk factors of the training program included slow two-mile run times, thus connecting low aerobic fitness to increased injury risk. Additionally, low frequency of exercise prior to training was also associated with higher injury risk. The lowest quartile of soldiers completing the 2-minute push up event had a significantly greater risk of injury compared to the quartile of most fit peers (p<0.05). [38]

A clear association exists between injury and low aerobic fitness via the 2-mile timed run [13, 14, 16, 17, 21]. The relationship between injury and low muscular endurance via the APFT 2-minute sit-up and 2-minute push-up events has inconclusive results [13, 14, 16, 17, 21]. Knapik et al. reported both males and females were at an increased injury risk when they displayed lower levels of muscular endurance via the 2-minute sit-up event and 2-mile timed run. However, only males were at increased injury risk when they had poor performance on the push-
up event [14]. Interestingly out of all the APFT events examined, Bell et al. only found the 2-mile timed run to be a significant risk factor for injury in male and female soldiers. Literature has reported a decrease in male and female 2-mile run times over the past few decades [12]. These findings can raise concern due to studies linking injury in the Army soldiers with slower 2-mile run times [13, 14, 16, 17, 21]. Continuous investigation is needed to ensure soldiers PT programs are effective, and to incorporate additional training to prevent PT related injuries in soldiers displaying lower levels of aerobic fitness and muscular endurance prior to military entrance.

**Impact of Anthropometrics on Injury Incidence in Army Soldiers**

A weight table based on age, height, and gender is currently utilized prior to and throughout Army training to ensure a soldier falls into the proper weight category [3]. Soldiers classified as overweight via the Army height and weight table must enroll in a weight management program, or they cannot continue future participation in the Army [1, 3]. A calculation of body mass index (BMI) is easily attainable and defined by taking the weight in kilograms and dividing by the square of the height in meters [4]. Gender and age specific BMI calculations classify individuals as underweight, normal, overweight, and obese as determined by American College of Sports Medicine (ACSM) guidelines [4]. Existing research has calculated BMI on multiple Army populations to determine whether or not soldiers are meeting the specified Army BMI guidelines. A longitudinal study by Knapik et al. collected BMI and body mass values from 1978-2003 on male and female Army soldiers’ prior to BCT participation [12]. Results indicated that the most recently published military studies are displaying significantly higher BMI and body mass values than literature previously reported throughout earlier decades.
Additionally, literature has identified an association between BMI and Army training related injury. The relationship between BMI and injury is inconsistent; investigations have found that both high and low BMI are risk factors for Army training related injuries [9, 10, 14, 17, 39].

Heir and Eide [10] assessed the relationship between anthropometric variables, (height, body mass and BMI) and musculoskeletal injury in a population of 480 Army male Norwegian soldiers (18-28 years of age). Anthropometrics were assessed prior to soldiers participation in a 10-week BCT program. The Army soldiers’ were placed into high (23.59-33.88 kg/m²), middle (21.37-23.58 kg/m²), and low (17.41-21.35 kg/m²) categories based off the age and gender BMI calculations. Throughout the 10-week study observation period, doctors attached to the training camp registered injuries. This study defined injury as pain or functional limitations of the musculoskeletal or soft tissues of the body. Most of the injuries sustained were due to marching and infantry running. Approximately 60% of the injuries sustained were to the lower extremity (LE). Although height and body mass alone were not a significant risk factor for injury, Soldiers classified into the low category for BMI were 1.6 percent more likely to suffer an injury (p<0.05). [10]

Jones et al. [17] assessed the relationship between anthropometrics (BMI, height, and body mass) and injury occurrence in 124 male (mean age 20.2), and 186 female (mean age 21.1) Army Soldiers entering an 8-week BCT program. Injury data included three categories of injuries: musculoskeletal, lower extremity, and Soldiers placed on limited duty for one or more days. Physical training for all subjects was identical and included calisthenics, running, road marching, and other vigorous activities. Results found females had higher time loss injuries, lower extremity injuries, and stress fractures in comparison to male Soldiers participating in the
BCT program. Females were 2-times more likely to suffer LE injuries and time loss injuries. Additionally, stress fractures were 5-times more likely in females. The highest percent of injuries for both genders occurred to the LE (females 44.6%, males 20.9%). Time loss injuries occurred in 44.6% of female Soldiers compared to the 29.0% of male Soldiers. Throughout the observation period, male Soldiers with high BMI (p<0.02) and a history of inactivity (p<0.02) were identified as risk factors for injury (p<0.02), but no trends of injury related to BMI and previous activity were seen in female Soldiers. [17]

Havenetidis and Paxinos [39] investigated BMI as a risk factor for injury in 290 Greek Army Cadets undergoing a 7-week BCT program. The mean BMI for the 233 male cadets were 24.4±2.3 kg/m² and 22.6 ± 2.2 kg/m² for the 20 females Soldiers. A total of 81 subjects experienced injuries (74 males and 7 females), and 53% of the injuries were classified as overuse. During the 7-week BCT program, calculations of BMI prior to the training program were not identified as significant risk factors for injury in either gender. However, %BF was the greatest predictor for training related injury. Subjects classified as over-fat were 1.2 times more likely to suffer an injury compared to the normal fat subjects (p<0.01). [39]

Knapik et al. [14] recorded body mass and BMI in 756 male and 452 female Army Soldiers prior to participation in an 8-week BCT program. The mean BMI for males and females were 24.2 ± 3.8 kg/m² and 23.0 ± 3.2 kg/m². Body mass for males and females were 75.3 ± 13.3 kg and 62.2 ± 10.6 kg. Body mass and BMI were not found to be a significant risk factor for training related injury. However, the authors concluded that additional research is necessary to clarify associations with body composition, BMI and injury [9, 10, 14, 17, 39].

Knapik et al [12] conducted a meta-analysis on 13- male and female Army studies to compare body mass, height, and BMI from 1978 to 2003. The 13 studies collected male and
female height, body mass, and BMI prior to participation in their BCT programs. Linear regression indicated that the male and female Army Soldiers’ height, body mass and BMI increased in 2003 compared to 1978 by 1%, 8%, and 6% respectively [12].

Knapik et al. [15] assessed injury rates and injury risk factors in 1838 male (mean ages 20.6 ± 3.0 ) and 553 female (mean ages 20.5 ± 2.8) soldiers in military police training (MP) at Fort Leonard Wood Missouri. Military police training consisted of a 19 week program designed to teach soldiers the essential basic combat skills, military specific duties, Army values, and Army lifestyles in the first 10 weeks, followed by more occupational specific duties in the last 9 weeks. This type of training is known as One-Station-Unit-Training (OSUT). A questionnaire obtained variables including soldiers’ age, height, weight, prior physical activity, and prior injury history. The comprehensive injury index (CII) was the primary outcome measurement for this investigation, and included injuries due to energy exchange. Male OSUT training soldiers’ risk factors included age (>30, p<0.01), prior LE injury (p<0.04), only jogging/running one month prior to OSUT (p<0.01), engaging in physical activity less than one time a week in the two months prior to OSUT (p<0.01), injury that prevented soldiers from engaging in physical activity for more than one week (p<0.05), low levels of self-reported physical activity compared to peers (p<0.01), and soldiers that didn’t recover from a previous injury (p<0.01). For female soldiers, the risk factors included age (>30, p<0.01), engaging in activity less than one time a week in the two months prior to training (p<0.04), only jogging 1-6 months prior to OSUT (p<0.01).

Knapnik et al was the first to identify specific risk factors in MP training, concluding that one injury was sustained in 34.2% of men, and 66.7% of women. [15]

The existing literature indicates over the past few decades male and females body mass and BMI continue to rise [12]. Investigators examining BMI as a risk factor for injury during a
BCT program yield inconclusive results. Heir and Eide found male Norwegian Soldiers participating in an Army BCT program to be at an increased risk for injury when they were classified in the low BMI category. However, the study did not examine the relationship of BMI and increased injury risk in females, and the Army provides enlistment for both genders [10]. Jones et al examined the association between injury and BMI in 310 male and female Army soldiers undergoing an 8-week BCT program. Male Soldiers classified in the high BMI category had a significantly higher risk for training related injury; female counterparts did not find an association between BMI and training related injury. However, female Soldiers who were shorter were at a higher risk for training related injury [17]. Further studies should be conducted to clarify the relationship between training related injuries and anthropometric measurements. [9, 10, 14, 17, 39].

The Impact of Body Fat Percentage on Injury and Performance in Army Soldiers

Body composition can be beneficial or detrimental to Soldiers’ individual readiness. Standardized norms for body composition have been generated based upon gender and age. Falling into the age and gender specific norms for the various body composition variables can help soldiers achieve an optimal performance level. Higher levels of performance not only benefits each Soldier, it benefits an entire unit and all Army populations [1, 3, 7]. Maximum allowable gender and age specified body fat percentages have been standardized via the Army Body Composition Manual [3]. Crawford et al assessed body fat percentage via the bod-pod and found that male Soldiers with less than 18 %BF had greater performance outcomes on tests involving anaerobic and aerobic capacity, push-ups, and strength [6]. However, little research exists in regards to examining %BF on female Army performance outcomes [6]. Excess %BF
has shown to inhibit performance [6], but the relationship between %BF and injury risk is inconclusive [8, 9, 13, 16, 39]. Current literature has focused on determining: 1) the change in %BF from pre-Army training to post-Army training, 2) the effects of %BF on performance and 3) to determine if excessive %BF has a relationship with increased injury risk in Soldiers undergoing a BCT program. [8, 9, 13, 16, 39]

Havenetidis and Paxinos [39] investigated the relationship between %BF and relative risks of injury during a 7-week BCT program on 290 male and female Greek Army Soldiers. Body fat percentage was assessed via bioelectrical impedance (BIA). Physicians identified and recorded injuries, and classified the injury as acute or chronic based on the severity, type, and anatomical site. Additionally injury records included the number of lost training days because of the specific injury, and what week during BCT the injury was sustained. During the investigation period, 81 Army Soldiers experienced an injury, 47% were classified as acute, and 53% were classified as chronic. Over-fat cadets were 1.2 times more likely to suffer an injury compared to the normal fat Soldiers (p<0.01). Additionally, the over-fat cadets were more likely to present with overuse injuries, when normal fat cadets had a combination of overuse and acute injuries. In conclusion, body composition has an association with injury rates. Authors suggest further clarification of the associations via different %BF techniques. [39]

Crawford et al [6] examined the relationship between %BF and physiological performance in 99 male Army Soldiers. Body composition was assessed via the bod-pod, anaerobic power was assessed via the Windgate Protocol on the cycling ergometer, maximal oxygen consumption (V\(\text{O}_2\)\text{max}) was assessed via an incremental treadmill test, and aerobic capacity was assessed via the APFT. Subjects were classified into two categories based on %BF for statistical analysis purposes. The first group consisted of subjects who were less than 18
%BF, the second group consisted of subjects who were greater than 18 %BF. The %BF categorization was according to the department of defense’s body fat goal. Subjects in the group with less %BF had higher anaerobic capacity VO₂max values, the push-up performance (p<0.002). Authors concluded that %BF can impact military preparation for training and combat. Future research should be conducted to examine the direct relationship between body composition and physical readiness. [6]

Similarly, Sharp et al. [8] assessed body composition measurements, and anthropometrics of 168 female (20.7± 3.2 years of age) and 182 male (19.9± 2.7 years of age) Army recruits prior to Basic Combat Training (BCT) at Fort Jackson South Carolina’s BCT site. The data collected was compared to the historical data obtained from the same BCT site in previous years (1978-1993). Skin-fold thickness measurements were measured via Womersley’s four-site skinfold technique. Results indicated male recruit body mass was 12% greater compared to the 1978 recruits and 8% greater compared to the 1983 male recruits. Female recruits BW increased 6% and 7% compared to 1978 and 1983 females, respectively. Male recruits %BF was 15% greater compared to 1983 and 1978 (p>0.05). Female recruits %BF was 5% and 15% greater than the 1978 and 1983 recruits (p<0.05). The %BF and body mass of male and females have shown a significant increase.[8]

Jespersen et al. [41] conducted a 2.5-year longitudinal study to examine the association between lower leg injuries, %BF, and calculations of BMI. The subjects in this investigation included 632 children from the age of 7.7-12 years. Subjects included male and female children from 10 public schools, and from pre-school to fourth grade. Injuries were recorded weekly via phone text, and were diagnosed by the international classification of diseases (ICD-10). Physical activity of each subject on average was 4.5 hours of physical education a week for sport schools,
and 1.5 hours a week for normal schools. Leisure time was also recorded via a text message from parents. Measurements in this investigation included BMI, which was done via collecting each subject’s height and body mass, and %BF via dual-energy x-ray absorptiometry. The BMI classified subjects into normal, overweight, and obese categories. Total Body Fat percentage classified subjects into normal weight and overweight categories. Fitness measurements of each subject included a 10-minute intermittent run test to determine maximal oxygen uptake ($\text{VO}_{2}\text{max}$). Both %BF and BMI were risk factors for injuries, and increased participation in PE and in leisure time sports a risk factor for lower extremity injury. In conclusion both %BF and BMI were classified as risk factors of injury in overweight subjects, but this study found that %BF was a higher risk factor than BMI, suggesting adiposity is more predictive of lower extremity injuries. [41]

Weak associations exist between training related injury and %BF in Soldiers undergoing BCT programs. The outcomes reported in Crawford et al’s study raise a concern; as %BF continues to rise, excess %BF may not only decrease overall performance outcomes, but it can also contribute to a higher occurrence of musculoskeletal injuries [6, 12, 39]. A civilian study conducted by Jesperson found %BF was more efficient than BMI at predicting lower extremity injury [41]. Continuous investigations should be conducted to determine risk factors related to Army PT overuse lower extremity injuries [14, 17, 39]. Results by current studies necessitate additional research between performance, %BF, and injury.
Direct and Indirect Assessments of V̇O₂max

The gold standard for assessing cardiorespiratory endurance is via an assessment of V̇O₂max. Clinical assessments of V̇O₂max can be conducted via cycle ergometer protocols or via treadmill protocols [4, 18, 23]. Various treadmill protocols are reliable and accurate for determining actual or estimated V̇O₂max values, and preferred by individuals who are not highly trained in cycling. Commonly used validated treadmill protocols include the Modified Astrand [4], Bruce [33], and Balke graded treadmill exercise tests.[4]. Although indirect methods for estimating V̇O₂max are not as accurate and reliable as the direct measurement of V̇O₂max [32], direct measurement of V̇O₂max requires expensive equipment and highly trained staff. One of the first generalized equations for estimating V̇O₂max was developed by Bruce et al. [33]. The Bruce treadmill protocol found high correlation between V̇O₂max and the maximum time on treadmill in male and female populations [33, 35, 37]. Additional estimation techniques for V̇O₂max can be calculated via maximal or submaximal treadmill tests utilizing percent incline and treadmill speed; ACSM’s running equation indirectly estimates V̇O₂max, and is commonly used in various settings [4]. Military settings rarely undergo clinical assessments of V̇O₂max, and use the APFT as an alternative field assessment to determine muscular endurance (2-minute push-up and 2-minute sit-up) and aerobic fitness (2-mile timed run) [1]. Field-tests, like the APFT, or estimation of V̇O₂max are usually preferred over clinical assessments. However, studies have been conducted that clinically assess V̇O₂max values in Army Soldiers [5, 6, 8, 12, 14]. Overall, current literature is indicating Army soldiers with low peak V̇O₂max values to have higher risk for PT related injuries. [39] Additionally, soldiers with greater than 18% body fat are showing lower levels of aerobic fitness via V̇O₂max values compared to soldiers with less than 18% body fat [6]. Current research that has examined direct and indirect assessments of
V\(\text{O}_2\)\text{max} in the military population can be beneficial to practicing clinicians, doctors, athletic trainers, and future/current commanders in the military.

Knapnik, et al. assessed the association between male and female V\(\text{O}_2\)\text{max} values and PT related injury among 756 male soldiers (mean age 21.5), and 452 female soldiers (mean age 21.3) participating in a BCT program. A graded treadmill protocol was utilized to measure V\(\text{O}_2\)\text{max} (via open oxygen uptake system), which increased in grade 2% every three minutes. Test termination occurred when soldiers had less than a two-milliliters/kilogram/minute increase with grade, or when they reached voluntary exhaustion. Injuries were recorded based on each medical visit, diagnosis, anatomical location, the final outcome, and the number of days each soldier spent on limited duty. The results indicated significant gender differences in mean V\(\text{O}_2\)max values (50.6 males, and 39.4 females, p<0.01), and mean %BF (16.7% males, and 28.8% females, p<0.01). Female soldiers were 2-times more likely to suffer from any type of injury, a time loss injury, and a LE injury (p<0.05). Approximately 83% of injuries sustained were to the LE for male soldiers, and 75% of the injuries were categorized as overuse injuries. The female soldiers suffered 87% of their injuries to the LE, and 78% of the injuries were categorized as overuse injuries. Peak V\(\text{O}_2\)\text{max} values of 20.9-37.0 mL/kg/min and 40.0-46.6 for males and females put cadets at a significantly higher relative risk for time-loss injury (p=0.05). The study concluded that women have a higher injury rate than men, but both genders will be more likely to injure if they enter BCT with low measurements of peak V\(\text{O}_2\)\text{max}. [14].

Crawford et al examined the impact of %BF on aerobic fitness and muscular endurance in 79 male Army 101st Airborne Division Soldiers. Independent variables included Soldiers who 1) exceeded the Department of Defense’s %BF standards (>18%BF), and 2) Soldiers who did not exceed the Department of Defense’s %BF standards (<18%BF). Dependent variables
included assessments of aerobic fitness (via a VO2max treadmill test and 2-mile timed run), and assessments of muscular endurance (via a 2-minute push-up and 2-minute sit-up event). Means and standard deviations for the assessments of VO2max for the <18%BF and >18%BF groups were 52.2±5.4 ml/kg/min and 44.1±6.8 respectively. Means and standard deviations for the assessments of 2-minute push-up events for the <18%BF and >18%BF groups were 78.2±18.5 and 65.7±13.9 respectively. Soldiers in the <18% BF group displayed higher levels of aerobic fitness (via the VO2max test, p=0.001) and higher levels of muscular endurance (via the 2-minute push-up event, p=0.003).

Bruce et al [33] established the Bruce treadmill protocol, a multi-staged graded treadmill protocol utilizing an open circuit technique. Subjects were categorized according to age (29-73 years old), activity status (active or sedentary), and gender (98 cardiac males, 168 healthy males, and 157 healthy females). The study’s reproducibility and compatibility of male and female VO2max values determined via the Bruce treadmill protocol showed excellent reproducibility (n=67, SEE=1.9 mL/Kg/min, and r=0.990), and excellent comparability (n=16, SEE=1.9 ml/Kg/min, and r=0.962). Results indicated lower VO2max values in sedentary men (p<0.001) and women (p<0.01). Comparison of gender revealed higher VO2max values during the last two minutes of exercise termination in healthy male subjects compared to the healthy female subjects (p<0.0001). An Estimation of VO2max was also found reliable based on regression equations utilizing sex, activity status, and age (r=0.920). High correlation was seen in duration of exercise based on the Bruce treadmill protocol.

Froelicher et al. [37] estimated maximal oxygen consumption on 79 active and sedentary Army Aircrew men (mean age=38.2 ± 7.4, 34.2 ± 8.6) utilizing the Bruce treadmill protocol, and on a another group of 77 active and sedentary Army Aircrew men (mean age= 32.0 ±9.7, 36.9 ±
8.0) utilizing the Balke treadmill protocol. Both treadmill protocols were regressed by plotting $\dot{V}O_2_{max}$ against maximal treadmill time, the Bruce ($r=0.87$, SEE=4.71) and Balke treadmill protocols ($r=0.80$, SEE=3.95) showed comparable correlation coefficients and standard errors when estimating $\dot{V}O_2_{max}$. Both protocols were then regressed based on age and activity status (sedentary, moderate exercisers, and heavy exercisers). The Bruce ($r=-0.40$, SEE=6.72 ml) and Balke ($r=-0.31$, SEE=5.3 ml) protocols regression equations based on age and activity status were not significantly better than the regression equations based on maximal treadmill time. Froelicher et al. concluded that both treadmill protocols can be used respectively in a clinical setting.[37].

Pollock et al. [35] compared $\dot{V}O_2_{max}$ values between Bruce and Balke treadmill protocols on 49 female subjects 20-42 years of age. Results indicated a significant difference between the Balke and Bruce treadmill protocol’s mean $\dot{V}O_2_{max}$ values (Balke=38.4 ml/kg/min and Bruce=40.3 ml/kg/min, $p<0.01$). A regression equation was then developed on both treadmill protocols based on subjects $\dot{V}O_2_{max}$ values and maximal treadmill time. Both the Bruce ($r=0.91$, SEE=2.2 ml) and Balke ($r=0.94$, SEE= 2.7 ml) generalized equations had similar SEE and $r$ values. Pollock et al. concluded that prediction equations should be based on the group, age, and activity status of the subjects being evaluated. If the subject does not fit the prediction equation being used, significant underestimating can occur [35].

Foster et al. [34] developed a multifactorial regression equation utilizing the Bruce Treadmill Protocol on 230 male subjects to predict $\dot{V}O_2_{max}$. Subjects had a broad age range, and were classified according to health status (having or not having cardiovascular disease) and self-reported physical activity levels (active or sedentary). A validation sample consisting of 200 subjects (mean ages 48.1±16.3) were used to develop regression equations based on maximum
treadmill performance and clinical characteristics of $\dot{V}O_2$max. A cross-validation sample was utilized (n=30, mean ages 43.4±16.3) to compare the study’s developed regression equations to the already existing population-specific equations. The validation sample was analyzed by means of multiple regressions with a backwards ordering of the probable predictors of $\dot{V}O_2$max. Treadmill performance data was first tested for nonlinearity by adding linear, quadratic, and cubic expressions of treadmill time.

The possible predictors for Foster et al’s multi-factorial regression equation included health status, activity status, and interaction of health and activity status. These variables were entered into the multivariate prediction model to determine if the what variables increased the accuracy of the prediction models. Age was included as the last predictor variable, and also examined to determine if it had an independent effect on V̇O₂max and performance. When comparing the cubic generalized regression equations to the linear, multiple correlation and standard error of estimate showed the cubic equation (r=0.977, SEE=3.5 ml/min/kg) accounted for variance beyond linear explanation (r=0.96, SEE= 4.0). Accuracy of the current study’s prediction equations and previous studies population specific equations were then examined by calculation of measured and predicted VO₂max, showing high correlations for both equations respectively (r=0.96). A single regression equation dependent on only treadmill performance can be accurate in predicting VO₂max during the Bruce treadmill protocol. Foster et al. concluded that V̇O₂max based on maximal treadmill time should be estimated utilizing a cubic regression equation, and other factors such as activity levels, health status, and age did not improve the predictive accuracy. [34]

Koutlianos et al [42] compared the direct measurement of V̇O₂max with indirect measurement of V̇O₂max via ACSM’s running equation (V̇O₂max
=0.2*speed+0.9*speed*%grade+3.5). Subjects included 55 male athletes (mean age 28.3±5.6). Male subjects completed the Bruce treadmill protocol maximally for both the direct and indirect (via ACSM’s running equation) measurement of $V\dot{O}_2$max. Subjects had to meet the following criteria for achievement of $V\dot{O}_2$max: 1) a leveling off or “plateau” of oxygen uptake with an increase in workload, 2) a respiratory exchange ratio >1.10, and 3) achievement of 90% of age-adjusted estimate of maximal heart rate. The direct measurement of $V\dot{O}_2$max and indirect measurement of $V\dot{O}_2$max (via ACSM’s running equation) for the male subjects were 46.09±7.63ml/kg/min and 52.83±2.81 respectively. The indirect measurement of $V\dot{O}_2$max via ACSM’s running equation was significantly higher than the direct measurement of $V\dot{O}_2$max (p=0.001). These findings suggest that ACSM’s running equation overestimates $V\dot{O}_2$max when utilizing the Bruce treadmill protocol. Future studies should be conducted on other widely used protocols (Modified Astrand and Balke) for determining $V\dot{O}_2$max via the ACSM’s running equation. [42]

The American College of Sports Medicine [4] created guidelines to follow during exercise testing. Criteria has been developed to determine an individual reaches volitional exhaustion, and can be utilized for study purpose; the criteria that outlines an individual has reached $V\dot{O}_2$max includes: an RPE $\geq$17, $\geq$8mmol blood lactate concentrations, a respiratory exchange ratio $\geq$ 1.10, and a failure of HR to increase with increased exercise intensity. All of the criteria and guidelines specific to performing $V\dot{O}_2$max tests on treadmills or cycle ergometers help to ensure that the procedures and techniques for measuring $V\dot{O}_2$max are accurate and reliable. [4]

Direct measurement of $V\dot{O}_2$max is the clinical gold standard for assessing cardiorespiratory endurance, however, due to the environments soldiers are placed in it is not
always feasible to directly measure VO$_2$\textsubscript{max} in the clinical setting. Based on the present literature, indirect measurement of VO$_2$\textsubscript{max} via submaximal or maximal exercise tests can be an accurate alternative. Previous studies have investigated the effects of Army BCT programs, and utilized estimation of VO$_2$\textsubscript{max} via cycle ergometers and 20-minute shuttle run tests [18, 19, 24]. The main concern with using these alternatives is to find a estimated VO$_2$\textsubscript{max} equation that is similar to the previous subject sample that validated the prediction equations. Future research necessitates further validation of the current equations, and for generation of new equations specific to various ethnicities, activity levels, and age.

**Techniques for Estimating Body Fat Percentage**

The current body composition assessments in the Army include a weight for height table, and gender specific body circumference measurements. The weight for height table is based off age, gender, and height. When a soldier exceeds the maximum weight allowed based off gender and age specific norms, further assessment of body composition is required. The further assessments are conducted utilizing body circumference measurements for calculation of %BF. Other cheap, validated, and widely used assessments for calculating %BF include circumferences and breadths, and skinfold thickness measurements. Jackson and Pollock’s three, four, and seven site skinfold thickness measurement protocol has been cross validated in male and female subjects via hydrostatic weighing [26, 27]. Tran and Wellman and Wilmore and Benkhe derived equations for determining female body density based off body circumferences [30], and for determining male lean body weight based off circumference and breadth measurements [29]. Once female and male body density and lean body weight is determined, %BF can be calculated. Studies have found circumferences equations for determining body
composition to be comparable to the skinfold thickness equations for determining body composition [26, 27, 29, 30]

Tran and Weltman [30] developed generalized equations for predicting body density via girth measurements in 482 white, middle-aged female subjects. Subjects body density were assessed by hydrostatic weighing, residual lung volume was measured using the oxygen dilution technique, and girth measurements were assessed by the same tester (intra-tester reliability >0.95) at the abdomen 1 (mid-way between the lowest portion of the rib cage and iliac crest, and anteriorly, midway between the xiphoid process of the sternum and umbilicus), abdomen 2 (at the umbilicus), iliac (anteriorly at the anterior superior iliac spine), hips (maximal protrusion of the gluteal muscles), and maximum thigh. A stepwise multiple regression analysis was utilized to develop a regression equation for body density on a validation sample of the 482 female subjects. The dependent variable was hydrostatic weighing, while the predictor (independent) variables included girth measurements, age, height, and weight. A cross validation sample (n=82) was utilized to validate the body density generalized equation. The regression equation showed significant curvilinear relationship between body density and abdomen measurement. The prediction of body density from the average abdomen 1, average abdomen 2, hip girths, age, and height resulted in a correlation of 0.89 and a standard error of 0.0095. The cross-validation of the regression equation (hydrostatic method) showed a r value of 0.903 and a standard error of 0.0082. The study concluded that predicting body density with a generalized equation utilizing girth, age, height, and body weight is comparable to the current SKF thickness equations [30].

Wilmore and Behnke [29] conducted anthropometric assessments on 133 male students, and derived regression equations based on SKF thickness measurements, diameters, circumferences, height, and weight. Two independent anthropometric measurements were taken
at each of the 54 sites. An additional measurement was taken, averaged, and recorded if the first two measurements differed by 1% or more. During measurement, the subjects maintained a standing position (except for measurements obtained from the upper extremity). Each subjects’ measurements included seven SKF thickness measurements, 20 diameter measurements, and 25 circumference measurements. Equations were developed based on the 54 anthropometric variables measured, a stepwise multiple linear-regression equation was utilized to predict body density and lean body weight. The generalized equations were cross-validated via hydrostatic weighing. The two closest measurements were accepted as the representative value. The bi-iliac diameter was recorded by distance between the most lateral projections of the iliac crest. The abdomen 1 circumference was measured midway between the xiphoid process of the sternum and the umbilicus. The abdomen 2 measurements were taken at the level of the iliac crests, and anteriorly at the umbilicus. The generalized equation for predicting body density utilizing bi-iliac diameter, knee circumference, abdomen 1 circumference, and abdomen 2 circumferences had a correlation of .953 and a standard error of 2.497. The predictive equations attained maximum predictive accuracy in the healthy male subjects [29].

Jackson and Pollock [26] developed generalized equations for predicting body density in 403 male subjects varying in age (18-61 years old), body structure, body composition, and exercise habits. Male subjects were divided into a validation sample that generated the predicted body density regression equations via regression analysis, and a cross validation sample underwent underwater weighing to validate the study’s predicted body density regression equations. The Lange calipers were utilized to measure SKF thickness measurements at the chest, axilla, triceps, subscapular, abdomen, supra-iliac, and thigh. The three site SKF measurements included the chest, abdomen, and thigh. Step-down analysis was utilized to
determine if age, and age in conjunction with circumference measurements accounted for additional body-density variance beyond the sum of the skinfolds. The correlation between the sum of seven and sum of three SKF analyses was 0.98 in active populations. Estimating body density via the quadratic or log form generalized equations was valid for the sum of three and seven site SKF thickness measurements. Compared to the cross validation sample, the sum of three skinfolds based on age, square of the skinfolds, and sum of the skinfolds, the adult men had a correlation of 0.902 and SEE of 0.0078 g/ml, validating the body density predicted equations for men of various age and body stature. [26]

Similarly, Jackson et al. [27] developed generalized equations for estimating body density in the female population. The study consisted of 331 female subjects between the ages of 18-55 years of age. A validation and cross validation sample was divided between the subjects, the validation sample underwent multiple regression analysis to develop the generalized equations, and the cross validation sample validated the regression equations via underwater weighing. During measurement of SKF thickness, the Lange caliper was at constant pressure, and all measurements were taken on the right side. The gluteal circumferences used for the prediction equation were measured to the nearest 0.1 cm. The SKF measurements on the female subjects were taken at the chest, axilla, triceps, subscapular, abdomen, supra-ilium, and thigh. Multiple regression coefficients were tested to determine if the sum of skin-folds, age, and gluteal circumference were accurate variables to utilize in the prediction equations of body density. The sums of the skinfolds were the most highly correlated to the hydrostatically determined body density. The three site skinfold measurements included the triceps, supra-ilium, and thigh; the four site skinfold measurements included the triceps, abdomen, supra-ilium, and thigh. The sum of the three, four, and seven skinfolds was highly correlated (r=0.966). The
largest mean difference between the predicted and hydrostatically determined body density was 0.3 percent fat. Compared to the cross-validation sample, the predicted body density equation utilizing the sum of the three sites, the square of the sum of SKF, and age had a standard error of body fat percentage of 3.9% (r=0.842). The study concluded that the prediction equation utilizing the sum of three SKF with age would be the most feasible for mass testing, and its cross-validation statistics were similar to the values found with the other 17 equations derived to predict body density. [27]

The current Army body composition manual outlines the methodological approach for calculating %BF based off gender specific body circumference measurements. The male circumference measurements include the neck and umbilicus; the female circumference measurements include the neck, waist, and hip. The neck circumference is taken directly underneath the laryngeal prominence, the umbilicus circumference is taken anterior to the umbilicus, and in line with the iliac crests, the waist circumference is taken at the narrowest portion of the abdomen between the iliac crests and xiphoid process, and the hip circumference is taken at the greatest protrusion of the gluteal muscles. The overall mean circumference is determined in male Army Soldiers by subtracting the mean neck circumference from the mean umbilicus circumference, %BF is then determined based on each Soldier's gender, height, and overall mean circumference. The same method applies for the female Soldiers, besides the mean overall circumference is determined by taking the sum of the mean hip and the mean waist, and subtracting the mean neck. The current %BF maximum is dependent upon age group and gender. Whenever a soldier exceeds their height for weight chart, and %BF via the circumference measurements, the Soldier must enroll in a body composition program. [3]
An assessment of body composition prior to Army enrollment is required [1]. The current %BF calculation is via body circumference measurements. Additional body composition assessments that have been clinically validated, and are not of great expense include additional circumference and breadth measurements, bioelectrical impedance, and skinfold thickness measurements. Body mass index fails to take lean body mass into account, decreasing the accuracy in assessing body composition. The same principle applies to the Army’s current height for weight chart, since it fails to take a look at lean body weight [3]. The height for weight chart only takes weight into account based off of gender and age specific norms. Additionally, the extent of accuracy in the Army’s current body circumference measurements for calculating %BF has limited research since it is a field-based assessment. Tran and Wellman and Wilmore and Benkhe’s circumference measurements and breadths have been found to be comparable to skinfold thickness measurements for calculating %BF. [26, 27, 29, 30] Jackson and Pollock’s three site skinfold thickness protocol favors comparably to Jackson and Pollock’s four and seven site protocol. These current methods have only been validated to hydrostatic weighing. Future studies should compare skinfold thickness measurements, bio electrical impedance, the bod pod, the Army technique, and other commonly used measurements to the four-compartment model, since it is now the clinical gold standard for assessing body composition.

Conclusion

Army physical readiness training focuses mainly on improving strength, endurance and mobility [1]. It is of importance that soldiers come physically prepared for any combat or duty position that they are placed into. Currently, field based methods for assessing physical fitness
are utilized, however, they are not as accurate and reliable as clinical assessments [1]. Clinical assessments have been conducted in Army soldiers via military research studies. Currently, various studies exist that examine the effectiveness of Army BCT via pre-BCT and post-BCT physical fitness assessments. The studies have examined indirect and direct measurement of $V\bar{O}_2$max, and clinically validated assessments of %BF. [19, 24] These are more reliable than the estimation of physical fitness via the APFT, and few studies exist that compare the Army’s current technique to other validated techniques for assessing body composition.

Investigators continue to examine the effectiveness and trends in physical fitness of Army soldiers. A study by Knapnik et al [8, 12] found that Army soldiers’ one and two mile run times are taking longer to complete, and %BF has increased in recent decades. A significant increase in %BF by 10% was seen from 1978 to 2003. [8, 12] The same trends have been reported for body mass and BMI. These findings are similar to civilian populations [12], however, a soldiers’ duty is to remain physically fit for any occupational position they are placed into. This necessitates continual research to ensure all military populations are maintaining gender and age specific norms on assessments of physical fitness, and to ensure soldiers are physically ready for combat. Based off the research presented in this review of literature, additional studies should be conducted to investigate the relationship between body fat percentage, aerobic fitness levels, muscular endurance levels, and physical readiness.
APPENDIX A
RESEARCH PARTICIPANT INFORMED CONSENT

Department of Kinesiology and Rehabilitation Science, University of Hawaii at Manoa
1337 Lower Campus Road, PE/A Complex Rm. 231, Honolulu, HI 96822
Phone: 808-956-7606

I. Investigator
Principal Investigators: Christopher Stickley, PhD, MS, ATC, CSCS; Rebecca Romine, MS, ATC; Juliane Genevro, ATC, PES

II. Title
The Effect of an Army ROTC Physical Training Program on Maximal Oxygen Consumption, Body Composition, and Injury Risk in Cadets

III. Informed Consent
You are being asked to participate in a study conducted through the University of Hawai‘i at Manoa. The purpose of this consent form is to provide you with all the information pertaining to this study, and help you decide if you would like to become a subject in research. This study is part of a major project required for a master’s student to obtain his/her master’s degree. This form may contain words that you do not understand. If there are any words that you do not understand or that you want to clarify, please ask the research staff to explain them. Please take your time to review this consent form and do not hesitate to voice any concerns you may have with the research staff. If you agree to take part in this study, it is required you sign this consent form. It is important that you understand that taking part in this study is of your own free will. You may decide not to participate, or you may decide to stop being in the study at any time, and it will not affect your regular medical care now or in the future.

IV. Why is this Study Being Done
You are being asked to take part in this study because you are between 18-35 years of age, and part of the University of Hawaii’s ROTC program. A total of 100 subjects will take part in this study.

The purpose of this study is to determine the effect of the University of Hawaii’s Army ROTC physical training program on physical fitness components including: (1) maximal oxygen consumption, 2) cardiorespiratory and muscular endurance, and 3) body composition. A secondary purpose is to investigate the relationship of these physical fitness assessments to injury risk.
V. Study Procedures

If you take part in this study, you will be asked to report to the Human Performance Lab at the University of Hawaii. You will complete a total of 2-separate test sessions. The first test session will be prior to the start of the Army ROTC physical training program, and the second test session will be following one semester of the Army ROTC physical training program. Each test session will last approximately an hour and a half. You will be asked to bring a comfortable shirt and t-shirt for the testing session; you will be asked to refrain from eating, drinking caffeine, and drinking alcohol three hours prior to testing; you will be asked to refrain from exercise for at least 24-hour prior to each test session; and you will be asked to drink plenty of fluids 24-hours prior to testing. At the beginning of the test session, you will be asked to complete a confidential medical health history questionnaire form, a physical activity readiness questionnaire, and a lower extremity orthopedic injury questionnaire.

If you take part in this study, you will have the following tests and procedures:

**Resting heart rate and resting blood pressure**: After sitting comfortably for five minutes, your resting heart rate and resting blood pressure will be measured. Resting heart rate will be assessed via palpation of the radial artery for 30-seconds. Resting blood pressure will be assessed with a stethoscope and blood pressure cuff. The blood pressure cuff will be wrapped around your dominant arm, and blood pressure will then be assessed two times, with a 2-minute rest in between.

**Anthropometric Measures**: Height and body mass will be measured and recorded with your shoes off.

**Body Composition Measurements**: You will be asked to remove your shirt so that the testers can access certain measurement sites. A researcher will use a tape measure to identify specific anatomical landmarks on the right side your body that will be used for the skinfold thickness measurement site. These spots will be marked with a marker so that researchers use the same exact site for each measurement. The marker will be removed after testing is complete via an alcohol prep pad.

Body composition assessment includes Jackson and Pollock’s 3-site skinfold thickness measurements and body circumference measurements, which differ based on gender. The three skinfold thickness sites will be measured with Lange skinfold calipers on the chest, abdomen, and thigh (males) and on the triceps, supra-iliac, and thigh (females). Body circumference measurements will be assessed be using a standardized tape measure. The circumference measurements for males include the neck, abdomen, and umbilicus; the female circumference measurements include the neck, abdomen, umbilicus and hip.

**Blood Lactate Concentration Test**: Prior to the start of testing, baseline blood lactate concentrations will be obtained via the finger-prick method. Seven minutes after
completion of a graded treadmill test (GXT), a second blood lactate concentration measurement will be obtained.

**Maximal Oxygen Consumption Test:** You will complete a $\text{V} \text{O}_2 \text{max}$ test on a treadmill according to the Astrand Treadmill Protocol; $\text{V} \text{O}_2 \text{max}$ is the clinical gold standard for assessment of cardiorespiratory endurance. The Astrand Treadmill Protocol is a multi-stage treadmill test in which you self-select your speed, and the incline (grade) of the treadmill is increased by 2.5% every two minutes. You will warm up prior to test administration, and be fitted with a HR monitor over your chest to collect HR values for the duration of the GXT. Researchers will ask you how you are feeling at the end of each two-minute stage based on a 6-20 point Borg’s ratings of perceived exertion (RPE) scale. The exercise test will be terminated when you indicate that you cannot go any further by fully grasping onto the handrails of the treadmill.

**The researchers may decide to remove you from the study if you:**
1. Are determined unfit to participate by the American College of Sports Medicine (ACSM) standards
2. Cannot perform or complete the exercise test
3. Become injured during the test

**VI. Risks**

When taking blood lactate concentrations, a small needle will be used to prick your finger to get a droplet of blood. The finger prick will cause slight bleeding, but should be minimally painful. Risks associated with caliper use include a mild pinching sensation and slight pain due to the pinching of the skin, and the clamping of the caliper (onto the skin). While participating in this study, there are exists the possibility of certain changes occurring during the test. These include abnormal blood pressure, fainting, irregular, fast or slow heart rhythm, and in rare instances, heart attack, stroke, or death. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing. Emergency equipment and trained personnel are available to deal with unusual situations that may arise.

**VII. Benefits**

You may not receive direct/immediate benefits. Upon request, you can receive information pertaining to your physical fitness levels and body composition (%BF, height, weight, etc). Results of this study may help doctors, athletic trainers, and other health-care professionals become aware of injury risk factors related to ROTC cadets participating in a physical training program. Being knowledgeable of specific risk factors could help with injury awareness and prevention in future cadets.
VIII. Costs

You will not be held liable for any costs regarding this study. All equipment and testing procedures will be of no cost to you.

IX. Compensation

You will not receive any compensation for participating in this study.

X. Confidentiality

All research information about you will be held confidential to the extent allowed by state and federal law. Your personal information will not be given to anyone without your written permission. A code, which will be known only to research personnel, will be used instead of your name on any records pertaining to this study. Research records which may be identifiable to you will be kept in a secure locked file in the Department of Kinesiology and Rehabilitation Science at the University of Hawaii at Manoa when not being used. These materials will be permanently disposed of (destroyed) in a period no longer than 5 years.

Information gathered in this research study may be published or presented in public forums, however your name and other identifying information will not be used or revealed. However, agencies with research oversight, such as The University of Hawaii Committee on Human Studies, have the right to review research records. Confidentiality does not prevent you from releasing information about yourself and your participation in the study. You will be asked to sign an authorization form to release personal health information.

XI. Voluntary Participation

Your decision to take part in this study is voluntary. You may refuse to participate or you may withdraw from the study at any time. Your decision to participate or to withdraw from the study will not affect your medical care provided by the primary ROTC athletic trainer at morning Physical Training sessions.

XII. Injury Related to the Study

If you are injured as a result of being in this study, immediate treatment is available for your injuries. You will then be told where you may get other treatment. The cost for this treatment will be charged to your insurance company or to you. Your insurance company
may not pay for these costs. If your insurance will not pay for these costs, they will be
your responsibility. The University of Hawaii has no program to pay you or compensate
you in any way for your injuries.

XIII. Questions

You are free to ask questions that you may have about your treatment and your rights as a
research participant at any time. If you have any questions related to this study, please
contact any of the principal investigators: Rebecca Romine, MS, ATC at (808) 349-8193,
or Juliane Genevro, ATC, at (814) 591-8033. If you have questions about your rights as
a research subject, contact the UH Committee on Human Studies at (808) 956-5007.

XIV. Statement of Consent

I have read the above information, or it has been read to me. I have had the opportunity
to discuss this research study with Rebecca Romine and/or her study staff, and I have had
my questions answered by them in language I understand. I take part in this study of my
own free will, and I understand that I may withdraw from participation at any time and
this will not affect my medical care. My consent to participate in this study does not take
away any of my legal rights in the event of negligence or carelessness of anyone working
on this project. A copy of this consent form has been given to me.

I agree to take part in this study.

________________________________________________________
Print Name                 Signature                 Date
APPENDIX B

Medical History Form

The Effect of an Army Reserve Officer Training Corp (ROTC) Physical Training Program on Maximal Oxygen Uptake, Body Composition, and Injury Risk in Cadets

HEALTH/INJURY HISTORY AND PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

Instructions: Please complete each question to the best of your knowledge/ability. Please ask the investigators if you have any questions.

Part 1. Participant Information

Date of Birth: _______________ Age (years) ________ Sex: M / F
Home Address: ________________________________
City/State/Zip: ___________________________ Email: __________________
Home/Cell Phone (__) __________________ Emergency Phone (___) _____________
Emergency Contact Person/Relationship: ________________________________

Part 2. Physical Activity Readiness Questionnaire (© Canadian Society for Exercise Physiology)

Instructions: Please circle one response.

1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor? YES or NO
2. Do you feel pain in your chest when you do physical activity? YES or NO
3. In the past month, have you had chest pain when you were not doing physical activity? YES or NO
4. Do you lose your balance because of dizziness or do you ever lose consciousness? YES or NO
5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity? YES or NO
6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition? YES or NO

7. Have you ever been told that you have peripheral vascular disease? YES or NO

8. Do you know of any other reason why you should not do physical activity? YES or NO

**Part 3. Medical History:** the subsequent sections were obtained following guidelines for exercise testing (American College of Sports Medicine, 2005).

**A. History:** please check the box any condition you currently have or had in the past.

- [ ] Heart Attack
- [ ] Heart Surgery
- [ ] Cardiac Catheterization
- [ ] Coronary Angioplasty (PTCA)
- [ ] Pacemaker/implantable cardiac
- [ ] Defibrillator/rhythm disturbance
- [ ] Heart valve disease
- [ ] Heart failure
- [ ] Heart transplantation
- [ ] Congenital heart disease
- [ ] Diabetes
- [ ] Asthma
- [ ] Lung Disease
- [ ] Heart murmur
- [ ] Seizures
- [ ] Head injury or concussion
- [ ] Loss of consciousness or memory

**B. Symptoms:** please check the box for any symptoms you have or had experienced at rest, during or following exercise.

- [ ] Chest discomfort
- [ ] Cough or wheezing
- [ ] Dizziness, fainting, or blackouts
- [ ] Difficulty breathing
- [ ] Abnormal heart beats
**Musculoskeletal Symptoms:** please check the box for any symptoms you have or had experienced, locate and label the occurrence of each symptom on the figure below.

- [ ] Numbness
- [ ] Tingling
- [ ] Pain
- [ ] Swelling
- [ ] Burning
- [ ] Cramping

**Cardiovascular Health:** please check the box for any conditions applicable to you.

- [ ] Male over age 45 years
- [ ] Female over age 55 years
- [ ] Smoke or smoking cessation within the previous 6 months
- [ ] High blood pressure (greater than 140/90 mm Hg)
- [ ] Currently taking blood pressure medication
- [ ] High cholesterol (greater than 200 mg/dL)
- [ ] Family history of heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister)
- [ ] Physically inactive (less than 30 minutes of physical activity at least 3 days per week).
- [ ] Overweight

Explain all “Yes” answers here and any checked boxes:

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

Signature of Researcher/: __________________________  Date: _______________
The Effect of an Army ROTC Physical Training Program on Cardiorespiratory Endurance, Muscular Endurance, Body Composition, and Injury Risk

LEOI HISTORY QUESTIONNAIRE

Date: __________________________
Name: ____________________________ Class: ________________ (MS1, MS2, MS3, MS4)
Email: ____________________________
Age: ________ Height: _________ Weight: _________
Years in the Military (Include ROTC, if 1st year: 0): ________
Shoe brand/style: _________________________ Shoe Size: __________
Shoe Age (months): __________
Orthotics/inserts in Running Shoes: Y  N  Orthotic Type: __________

Training History:
I currently train _____ per week
   ____ 0-5 hours
   ____ 5-10 hours
   ____ 10-15 hours
   ____ 15-20 hours
   ____ Over 20 hours
I run an average of _____ per week
   ____ 0-5 miles
   ____ 5-10 miles
   ____ 10-15 miles
   ____ 15-20 miles
   ____ Over 20 miles
1. YES NO I have experienced pain in my left upper leg (above the knee and below the back) resulting from participating in training. (Circle “Yes” or “No” – DO NOT include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)

If YES, please answer questions a & b below. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b below REGARDING YOUR MOST RECENT INJURY.

If NO, skip to question 2.

a. The pain in my left upper leg occurred:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
</tr>
<tr>
<td>between 6 months and 1 year ago</td>
</tr>
<tr>
<td>between 1 and 2 years ago</td>
</tr>
<tr>
<td>more than 2 years ago</td>
</tr>
</tbody>
</table>

b. The pain in my left upper leg:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>was not serious enough to seek medical care or treatment from a physician or athletic trainer</td>
</tr>
<tr>
<td>was serious enough to get treatment (ice, taping, anti-inflammatory medication, etc.) from a physician or athletic trainer but NOT serious enough to require any change in training</td>
</tr>
<tr>
<td>required me to decrease my training (amount or intensity) but I did not have to completely miss or “sit-out” any of my training</td>
</tr>
<tr>
<td>required me to completely miss or “sit-out” some of my training</td>
</tr>
</tbody>
</table>

2. YES NO I have experienced pain in my left knee resulting from participating in training. (Circle Yes” or “No” – DO NOT include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)
If **YES**, please answer questions a & b below. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b BELOW REGARDING YOUR **MOST RECENT** INJURY.

If **NO**, skip to question 2 below.

a. The pain in my **left upper leg** occurred:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
</tr>
<tr>
<td>between 6 months and 1 year ago</td>
</tr>
<tr>
<td>between 1 and 2 years ago</td>
</tr>
<tr>
<td>more than 2 years ago</td>
</tr>
</tbody>
</table>

b. The pain in my **left upper leg**:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>required me to <strong>completely</strong> miss or “sit-out” some of my training</td>
</tr>
</tbody>
</table>

2. **YES**   **NO** I have experienced pain in my **left knee** resulting from participating in training. (Circle “Yes” or “No” – **DO NOT** include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)

If **YES**, please answer questions a & b on the next page. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b on the next page REGARDING YOUR **MOST RECENT** INJURY.

If **NO**, skip to question 3.
a. The pain in my left knee occurred:

<table>
<thead>
<tr>
<th>during the last 6 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>between 6 months and 1 year ago</td>
</tr>
<tr>
<td>between 1 and 2 years ago</td>
</tr>
<tr>
<td>more than 2 years ago</td>
</tr>
</tbody>
</table>

b. The pain in my left knee leg:

| was not serious enough to seek medical care or treatment from a physician or athletic trainer |
| was serious enough to get treatment (ice, taping, anti-inflammatory medication, etc.) from a physician or athletic trainer but NOT serious enough to require any change in training |
| required me to decrease my training (amount or intensity) but I did not have to completely miss or “sit-out” any of my training |
| required me to completely miss or “sit-out” some of my training |

3. **YES** **NO** I have experienced pain in my left lower leg resulting from participating in training. (Circle “Yes” or “No” – **DO NOT include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone**)

If **YES**, please answer questions a & b on the next page. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b BELOW REGARDING YOUR **MOST RECENT** INJURY.

If **NO**, skip to question 4.
a. The pain in my **left lower leg** occurred:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
</tr>
<tr>
<td>between 6 months and 1 year ago</td>
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<tr>
<td>between 1 and 2 years ago</td>
</tr>
<tr>
<td>more than 2 years ago</td>
</tr>
</tbody>
</table>

b. The pain in my **left lower leg**:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>was not serious enough to seek medical care or treatment from a physician or athletic trainer</td>
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<tr>
<td>required me to completely miss or “sit-out” some of my training</td>
</tr>
</tbody>
</table>

4. **YES**  **NO**  I have experienced pain in my **left foot** resulting from participating in training. (Circle “Yes” or “No” – **DO NOT** include pain that resulted from a **single specific injury episode such as a bruise, sprain or broken bone**)

If **YES**, please answer questions a & b on the next page. **IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b BELOW REGARDING YOUR **MOST RECENT** INJURY.**

If **NO**, skip to question 5.
a. The pain in my **left foot** occurred:

<table>
<thead>
<tr>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
</tr>
<tr>
<td>between 6 months and 1 year ago</td>
</tr>
<tr>
<td>between 1 and 2 years ago</td>
</tr>
<tr>
<td>more than 2 years ago</td>
</tr>
</tbody>
</table>

b. The pain in my **left foot**:

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>was not serious enough to seek medical care or treatment from a physician or athletic trainer</td>
</tr>
<tr>
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<tr>
<td>required me to completely miss or “sit-out” some of my training</td>
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</tbody>
</table>

5. **YES**  NO  I have experienced pain in my **right upper leg** (above the knee and below the back) resulting from participating in training. (Circle “Yes” or “No” – **DO NOT** include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)

If **YES**, please answer questions a & b on the next page. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b on the next page REGARDING YOUR **MOST RECENT** INJURY.

If **NO**, skip to question 6.
a. The pain in my **right upper leg** occurred:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
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b. The pain in my **right upper leg**:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

6. **YES**  **NO**  I have experienced pain in my **right knee** resulting from participating in training. (Circle “Yes” or “No” – **DO NOT** include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)

If **YES**, please answer questions a & b on the next page. **IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS 5 & 6 REGARDING YOUR MOST RECENT INJURY.**

If **NO**, skip to question 7.
a. The pain in my right knee occurred:

<table>
<thead>
<tr>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
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</tr>
</tbody>
</table>

b. The pain in my right knee:

<table>
<thead>
<tr>
<th>Nature of Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>was not serious enough to seek medical care or treatment from a physician or athletic trainer</td>
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</table>

7. **YES**  **NO**  I have experienced pain in my right lower leg resulting from participating in training. (Circle “Yes” or “No” – **DO NOT include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone**)

If **YES**, please answer questions a & b on the next page. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b REGARDING YOUR **MOST RECENT** INJURY.

If **NO**, skip to question 8.
a. The pain in my right lower leg occurred:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
<td></td>
</tr>
<tr>
<td>between 6 months and 1 year ago</td>
<td></td>
</tr>
<tr>
<td>between 1 and 2 years ago</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>

b. The pain in my right lower leg:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

8. YES   NO I have experienced pain in my right foot resulting from participating in training. (Circle “Yes” or “No” – DO NOT include pain that resulted from a single specific injury episode such as a bruise, sprain or broken bone)

If YES, please answer questions a & b on the next page. IF YOU HAVE EXPERIENCED MORE THAN 1 INJURY, ANSWER QUESTIONS a & b on the next page REGARDING YOUR MOST RECENT INJURY.

If NO, you are finished.
a. The pain in my **right foot** occurred:

<table>
<thead>
<tr>
<th>Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>during the last 6 months</td>
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<tr>
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</tr>
<tr>
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</tbody>
</table>

b. The pain in my **right foot**:

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>was not serious enough to seek medical care or treatment from a physician or</td>
</tr>
<tr>
<td>athletic trainer</td>
</tr>
<tr>
<td>was serious enough to get treatment (ice, taping, anti-inflammatory medication,</td>
</tr>
<tr>
<td>etc.) from a physician or athletic trainer but NOT serious enough to require</td>
</tr>
<tr>
<td>any change in training</td>
</tr>
<tr>
<td>required me to decrease my training (amount or intensity) but I did not have</td>
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<tr>
<td><strong>completely</strong> miss or “sit-out” any of my training</td>
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<tr>
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</tbody>
</table>

9. Have you ever had any orthopedic surgery? What body part? When?

10. Have you had any injury to your back, hips, legs, knees, ankles, or feet in the past year that caused you to seek treatment from a physician or athletic trainer? What body part? When?
The Effect of an Army ROTC Physical Training Program on Maximal Oxygen Consumption, Body Composition, and Injury Risk in Cadets

**Circle one:** pre-semester or post-semester  
**Circle one:** injured group or uninjured group

**Data Collection Screening:**
Have you fasted the three hours prior to our collection? Y or N
Have you avoided carbonated and caffeinated beverages? Y or N
Have you avoided intense and vigorous exercise in the past 24 hours? Y or N
Did you refrain from wearing powders and perfumes? Y or N

### Skinfold Thickness Measurements

<table>
<thead>
<tr>
<th>MA SKF</th>
<th>Chest</th>
<th>Abdomen</th>
<th>Thigh</th>
<th>FM SKF</th>
<th>Triceps</th>
<th>Supra-ilium</th>
<th>Thigh</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td></td>
<td>T1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>T2</td>
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<td>T3</td>
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<td>Average</td>
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<td>Average</td>
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</tr>
</tbody>
</table>

### Circumference Measurements

<table>
<thead>
<tr>
<th>Neck (must be /w in 0.3 cm)</th>
<th>Knee (must be /w in 0.3 cm)</th>
<th>Biliac Breadth Males</th>
<th>Waist (must be /w in 1.0 cm)</th>
<th>Abdominal (must be /w in 1.0 cm)</th>
<th>Hip (FM only, must be /w in 1.0 cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>T1</td>
<td>T1</td>
<td>T1</td>
<td>T1</td>
<td>T1</td>
</tr>
<tr>
<td>T2</td>
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<td>Average:</td>
<td>Average:</td>
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<td>Average:</td>
</tr>
</tbody>
</table>
The Effect of an Army ROTC Physical Training Program on Maximal Oxygen Consumption, Body Composition, and Injury Risk in Cadets

Modified Astrand Treadmill Protocol

<table>
<thead>
<tr>
<th>Minutes</th>
<th>Treadmill Stage</th>
<th>Grade (%)</th>
<th>RPE</th>
<th>HR Watch (bpm)</th>
<th>HR Treadmill (bpm)</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 min</td>
<td>Stage 1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-5 min</td>
<td>Stage 2</td>
<td>2.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-7 min</td>
<td>Stage 3</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9 min</td>
<td>Stage 4</td>
<td>7.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-11 min</td>
<td>Stage 5</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11-13 min</td>
<td>Stage 6</td>
<td>12.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-15 min</td>
<td>Stage 7</td>
<td>15.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Physiological Assessments

<table>
<thead>
<tr>
<th>Self-Selected Treadmill Speed (must be /w in 5-8 mph):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Lactate Concentrations:</td>
</tr>
<tr>
<td>Post Lactate Concentrations:</td>
</tr>
<tr>
<td>Final RPE:</td>
</tr>
<tr>
<td>Total Time on Treadmill:</td>
</tr>
<tr>
<td>HR at Termination:</td>
</tr>
</tbody>
</table>
Screening Sheet

Inclusionary Criteria

1. Are you part of the Army ROTC program at UH at Manoa? Yes or No

2. Are you between 18 and 35 years old? Yes or No

3. Have you sustained any injury in the past 6 months? Yes or No
   (If YES explain)____________________________________

4. Have you had any surgery in the past 6 months? Yes or No
   (if YES, explain)____________________________________

5. Is this your first year in the Army ROTC program? Yes or No
   If this isn’t your first year what year are you? _____________

Exclusionary Criteria

6. Has your doctor ever told you that you should not participate in exercise, especially intense and vigorous exercise? Yes or No

7. Are you pregnant or is there a possibility that you may be pregnant? Yes or No

8. Do you feel pain in your chest when you do physical activity? Yes or No

9. In the past month, have you had chest pain when you were not doing physical activity? Yes or No

10. Do you lose your balance because of dizziness or do you ever lose consciousness? Yes or No

11. Do you have a bone or joint problem that could be made worse by a change in your physical activity? Yes or No

12. Is your doctor currently prescribing drugs for your blood pressure or a heart condition? Yes or No

13. Do you know of any other reason you should not do physical activity? Yes or No

14. Do you have any major health concerns that make you unfit for exercise? Yes or No
15. Have you ever participated in ranger training?  Yes or No

16. Are you planning on participating in any ranger training in the future?  Yes or No

**Inclusionary Criteria:**

___ Cadet participating in Army ROTC Program

___ Aged 18-35 years

___ Injury Free/Surgery Free the past six months

___ Classified as Low-Risk by ACSM Standards

**Exclusionary Criteria:**

___ Physician indicates exercise is contraindicated

___ Pregnancy

___ Absolute contraindications to exercise as outlined by the ACSM

___ Participation in Army ROTC Ranger Program

YES/NO

Print name: __________________________ Date: ______________

Signature/Title: ________________________________

IF YES, scheduled for data collection:

Date: ________________________________  Time: ______________
The Effect of an Army ROTC Physical Training Program on Aerobic Fitness, Muscular Endurance, Body Composition, and Injury Risk

Procedure Checklist

1. **Lab Set Up**
   - Get out skinfold calipers
   - Get out measuring tape
   - Get out marker for marking skin
   - Get out HR monitor wet
   - Fit watch to Treadmill
   - Calibrate and get out lactate analyzer Cart
   - Set up towel and water for cadets
   - Find the RPE scale and set it by the treadmill to utilize during treadmill test
   - Turn on treadmill

2. **Subject Arrival**
   - Greet Subject, consent
   - Have subject sit down to rest for resting heart rate (HR) and resting blood pressure (BP)
   - Measure resting BP two times with a two minute break in between
   - Record height and weight (shoes off)
   - Record two skinfold (SKF) thickness measurements (record three if not within 2 or more mm)
     - Measure on the right side of the body
     - Grasp the skin by placing the thumb and index finger 8cm apart
     - Female SKF
       - Triceps- vertical fold half way between the lateral projection of acromion and olecranon
       - Supra-ilium- diagonal fold above the iliac crest along the anterior axillary line
       - Thigh- vertical fold half way between the inguinal crease and patella (all weight shifted to the left leg)
     - Male SKF
       - Chest- diagonal fold half way between the armpit and nipple
       - Abdomen- vertical fold 2cm right of the umbilicus
       - Thigh- vertical fold half way between the inguinal crease and patella (all weight shifted to the left leg)
   - Use alcohol pad to wipe off finger for pre-lactate concentration
   - Prick finger, and wipe off first blood sample
   - Squeeze finger, and take Pre-lactate concentration
☐ Put subject on treadmill to pick speed. Volentary warm up and stretch.
☐ Explain the Astrand Treadmill Protocol
☐ Explain the Borg’s treadmill protocol
☐ Treadmill Protocol
☐ Select starting speed for the treadmill protocol
☐ Once speed selected begin treadmill protocol
☐ Start Stage 1 at a 0% grade and at the selected speed
☐ Stay on Stage 1 for 3 minutes
☐ 30 seconds before stage 1 is over ask what Borgs RPE is, and record down HR
☐ Increase grade and speed by 2.5 percent
☐ Begin Stage 2
☐ 30 seconds before stage 2 is completed ask what Borg’s RPE is, and record HR
☐ Increase grade and speed by 2.5 percent
☐ Do this until the subject cannot go any further
☐ Set treadmill at 0 grade and at walking speed (1.7mph)
☐ Five to seven minute cool-down once subject reaches volatile exhaustion
☐ After seven minutes wash hands, wipe finger with alcohol prep pad
☐ Prick finger and wipe away blood
☐ Squeeze finger and take post-lactate concentrations
☐ Farewell to cadet

3. **Upon subject departure**
☐ Clean disinfect treadmill, and set treadmill back to zero grade
☐ Put all equipment away, Clean and organize equipment
☐ Wash and clean HR monitor
☐ Put data into data in data base
Borg Rating of Perceived Exertion

6  No exertion at all
7  Extremely light
8
9  Very light
10
11 Light
12
13 Somewhat hard
14
15 Hard (heavy)
16
17 Very hard
18
19 Extremely hard
20 Maximal exertion
### Modified Astrand Graded Treadmill Protocol

<table>
<thead>
<tr>
<th>Stage</th>
<th>Time (minutes)</th>
<th>Incline (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>0-3</td>
<td>0%</td>
</tr>
<tr>
<td>Stage 2</td>
<td>3-5</td>
<td>2.5%</td>
</tr>
<tr>
<td>Stage 3</td>
<td>5-7</td>
<td>5.0%</td>
</tr>
<tr>
<td>Stage 4</td>
<td>7-9</td>
<td>7.5%</td>
</tr>
<tr>
<td>Stage 5</td>
<td>9-11</td>
<td>10.0%</td>
</tr>
<tr>
<td>Stage 6</td>
<td>11-13</td>
<td>12.5%</td>
</tr>
</tbody>
</table>
REFERENCES
