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Establishing Army Wellness Center Referral Guidelines for Injury Prevention Based on Aerobic Fitness and Body Composition

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14. ABSTRACT

Poor aerobic fitness and high or low body fat have frequently been identified as significant risk factors for military injuries. In order to systematically utilize Army Wellness Center (AWC) services to reduce Soldier injury risk and enhance readiness, the objective of this work was to establish AWC referral guidelines based on aerobic fitness and body composition. Using results from data-oriented assessments of Army Physical Fitness Test (APFT) 2-mile run times and body mass index (BMI), as well as Receiver Operating Characteristic (ROC) curves and sensitivity analyses for the same variables in four Army populations, AWC referral guidelines are recommended for men and women. Men who have an APFT 2-mile run time of less than 15 minutes and a BMI above the age-based Army regulation or a BMI below 19 should be referred to the AWC. Likewise, women who have an APFT 2-mile run time of less than 18 minutes and a BMI above the age-based Army regulation or a BMI below 21 should be referred. Interim referral guidelines that include Army Combat Fitness Test (ACFT) run times are also recommended.

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Contributing Authors

Anna Schuh-Renner, PhD[1]
Bruce H. Jones, MD, MPH[2]
L. Omar Rivera, PhD[3]
Michelle Canham-Chervak, PhD, MPH[1]

[1]Injury Prevention Division, Clinical Public Health and Epidemiology Directorate

[2]Office of the Director, Clinical Public Health and Epidemiology Directorate

[3]Public Health Assessment Division, Health Promotion and Wellness Directorate

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1 PURPOSE

To identify Soldiers at greatest risk for overuse injuries and recommend feasible operational guidelines for Army Wellness Center (AWC) referral based on aerobic fitness and body composition.

2 REFERENCES

Appendix A provides the references cited within this document.

3 INTRODUCTION

3.1 Motivation

Poor aerobic fitness and high or low body fat have frequently been identified as significant risk factors for military injuries (Jones and Hauschild, 2015; Jones et al., 2017; Rappole et al., 2017; Cowan et al., 2011; Hruby et al., 2016). While it is logical that those who are more aerobically fit can perform physically demanding tasks for longer durations with less fatigue and injury than those who are less fit (Knapik, 2015), the association between body composition and injury risk is less straightforward. It is important to investigate the effect of body composition on military injuries, as the proportions of overweight and obese recruits and Soldiers have increased over time (Hruby et al., 2015; Meyer and Cole, 2019).

AWCs are located at most Army installations and provide health assessment and education services to Soldiers and Army Civilians, including exercise testing, nutrition education, stress management counselling, wellness coaching, and tobacco cessation education. Research has shown that AWC clients experience significant improvements in body mass index (BMI), body fat percentage, aerobic fitness, muscle strength, flexibility, blood pressure, and perceived stress (Rivera et al., 2016; Rivera et al., 2018).

In order to systematically utilize AWC services to improve Soldier injury risk and enhance readiness, this work establishes AWC referral guidelines for Soldiers based on the Army Physical Fitness Test (APFT) 2-mile run time and BMI, calculated from height and weight data. Because body composition and aerobic performance are interconnected (Crawford et al., 2011; Friedl, 2012; Pierce et al., 2019; Sharp et al., 2008), strategies to improve one are likely to influence the other. It will be pragmatic that as many Soldiers at risk for injury be referred for AWC evaluation as possible; however, maximum AWC throughput capacity allows for approximately 10–25% of the installation Soldier population to be evaluated for injury risk improvement reasons (APHC AWC Operations Division Chief, personal communication with author, 2018). Therefore, this intervention is intended to reduce injuries in a targeted subset of the Active Duty Army population: those at the greatest risk for cumulative, micro-traumatic, “overuse” musculoskeletal (MSK) injuries.

Four populations were examined for the current analyses: (1) all Active Duty Army (Calendar Year (CY) 2017), (2) all Soldiers in U.S. Army Forces Command (FORSCOM) units (CY2017), (3) an airborne division at Fort Campbell (April 2015–June 2016), and (4) two infantry units at Fort Carson (2010–2011). For these analyses, members of the FORSCOM population, a subset of the Active Duty Army CY2017 population, were identified by their last unit identification code (UIC) for CY2017, consistent with established surveillance methodology (U.S. Army Public Health Center, 2018). The airborne and infantry data were obtained from self-reported questionnaires initially collected as part of prior injury investigations (U.S. Army Public Health Center, 2019a; U.S. Army Public Health Command, 2014).

3.2 Background: Data-oriented Cut-Point Determination

To establish AWC referral guidelines, data cut-points need to be determined for both the APFT 2-mile run time and BMI, beyond which injury risk increases significantly. A large variety of methodologies exist to determine cut-points in health data; these approaches are typically outcome-oriented or data-oriented (Kuo, 1997; Meyers and Mandrekar, 2015; Williams et al., 2006; O'Brien, 2004). One common data-oriented approach categorizes data into a finite number of distinct risk groups, such as quartiles, which allow for straightforward communication about findings (Meyers and Mandrekar, 2015).

Using a data-oriented approach applied to the four datasets, APFT 2-mile run time and BMI data were split into octiles, quartiles, or medians (depending on the size of the dataset); the injury risks among subgroups were compared by the combined cross-tabulations of these variables. AWC referral recommendations will be based on those subgroups of Soldiers falling within the combined run-time and BMI categories that have significantly higher than average injury risk. An example of another application using data-oriented analyses of Army injury data (quintiles) was a similar recent assessment of 2-mile run time and BMI data in a population of trainees (Jones et al., 2017).

3.3 Background: Receiver Operating Characteristic Curves for Identifying Cut- Points in Data Series

To provide additional confidence in the results of the data-oriented assessment, the sensitivity and specificity of cut-points identified by receiver operating characteristic (ROC) curves were also analyzed. A ROC curve is a tool used to evaluate the performance of dichotomous decision threshold tests, such as “Yes”/“No” diagnostic tests or “Type A”/“Type B” categorization (Brown and Davis, 2006; Park et al., 2004). The analysis was first used in World War II to ensure that military radar operators were correctly identifying friendly or hostile aircraft based on radar signals (Brown and Davis, 2006).

More recently, ROC curve analyses have been applied to decision thresholds in healthcare, (Park et al., 2004; Cotter and Peipert, 2005; Hajian-Tilaki, 2013; Szmukler et al., 2012), clinical research (Shi et al., 2019), and public health (Hajian-Tilaki, 2013; Cotter and Peipert, 2005). An example of a modern public health application of ROC curve analysis is evaluating the effectiveness of the Functional Movement Screening tool for predicting future musculoskeletal injuries in military members (Bushman et al., 2016) and athletes (Dorrel et al., 2018).

The basis of this methodology resides in a variety of decision measures, calculated in terms of how accurately the cut-point classifies an event (Zaletel-Kragelj and Bozikov, 2010; Brown and Davis, 2006). These values can be estimated by categorized data summarized in a decision matrix (see example in Table 1, described in terms of the current application of AWC referral guidelines for Soldiers at risk for injuries).

Table 1. Example Decision Matrix

	Injured	**Uninjured**	**Total**
Referred	# injured Soldiers referred by referral guideline (True positives)	# uninjured Soldiers referred by referral guideline (False positives)	Total referred by referral guideline
Not referred	# injured Soldiers not referred by referral guideline (False negatives)	# uninjured Soldiers not referred by referral guideline (True negatives)	Total not referred by referral guideline
Total	Total injured	Total uninjured	Total population

These decision measures include the following (Brown and Davis, 2006; Zaletel-Kragelj and Bozikov, 2010); the most common names are underlined for each:

Nosological <u>Sensitivity</u> or **True Positive Rate (TPR)** or **Correct Positive Fraction (CPF)**:
What proportion of injured Soldiers would have been correctly referred by the referral guidelines?

$$\frac{\#\ injured\ Soldiers\ referred}{\#\ all\ injured\ Soldiers\ (referred\ and\ not\ referred)} \quad \text{(Equation 1)}$$

Nosological <u>Specificity</u> or **True Negative Rate (TNR)** or **Correct Negative Fraction (CNF)**:

What proportion of uninjured Soldiers would have been correctly not referred by the referral guidelines?

$$\frac{\#uninjured\ Soldiers\ not\ referred}{\#\ all\ uninjured\ Soldiers\ (referred\ and\ not\ referred)} \quad \text{(Equation 2)}$$

False positive rate (FPR):
What proportion of uninjured Soldiers would have been incorrectly referred by the referral guidelines?

$$\frac{\#\ uninjured\ Soldiers\ referred}{\#\ all\ uninjured\ Soldiers\ (referred\ and\ not\ referred)} = 1 - sensitivity \quad \text{(Equation 3)}$$

False negative rate (FNR):
What proportion of injured Soldiers would have been incorrectly not referred by the referral guidelines?

$$\frac{\#\ injured\ Soldiers\ not\ referred}{\#\ all\ injured\ Soldiers\ (referred\ and\ not\ referred)} = 1 - specificity \quad \text{(Equation 4)}$$

Diagnostic Specificity or **Positive Predictive Value (PPV):**
What proportion of Soldiers who were injured would have been correctly referred using the referral guidelines?

$$\frac{\#\ injured\ Soldiers\ referred}{\#\ all\ referred\ Soldiers\ (injured\ \ and\ uninjured)} \quad \text{(Equation 5)}$$

Diagnostic Sensitivity or **Negative Predictive Value (NPV):**
What proportion of Soldiers who were not injured would not have been correctly not referred using the referral guidelines?

$$\frac{\#\ uninjured\ Soldiers\ not\ referred}{\#\ all\ Soldiers\ not\ referred\ (injured\ and\ uninjured)} \quad \text{(Equation 6)}$$

Classification Rate (CR):
What proportion of Soldiers were correctly referred or not referred based on injury status?

$$\frac{\#\ injured\ Soldiers\ referred + \#\ uninjured\ Soldiers\ not\ referred}{Total\ population} \quad \text{(Equation 7)}$$

A ROC curve is a smooth, fitted plot of sensitivity against FPR (1 – specificity). The curve is made up of multiple operating points; in this application, each operating point represents a Soldier with sensitivity and specificity values based on his/her individual referral and injury

statuses (Park et al., 2004). The Area Under the [ROC] Curve (AUC) is a common measure of the overall performance of a diagnostic test, interpreted as the average sensitivity for every possible value of specificity (Park et al., 2004). The AUC is a value between 0 and 1; the better the decision threshold is (i.e., the more accurately-classified operating points there are), the closer the AUC will be to 1. An AUC of 1 indicates that the decision rule perfectly discriminates between two conditions, and an AUC of 0.5 indicates no diagnostic capacity (Shi et al., 2019). The overall performance of two diagnostic tests can be compared using the AUC values of their respective ROC curves. If necessary, a partial AUC can be examined, corresponding to clinically relevant FPR values (Hajian-Tilaki, 2013).

The practitioner should use the decision measures that are best suited to identifying the optimal or best-performing cut-points in for a given application (Bewick et al., 2004; He et al., 2010). Frequently suggested methods include maximizing the sum of sensitivity and specificity (Hilden and Glasziou, 1996; Youden, 1950) or maximizing of the sum of PPV and NPV (Shiu and Gatsonis, 2008). In both of these methods, the two measures are complementary; as sensitivity increases, specificity decreases, and vice versa. PPV and NPV have the same relationship. Therefore, these interpretations of optimal performance seek to balance correct classifications of both positive and negative decisions. However, when the objective is to maximize the number of true positives and there is no negative consequence of false positives, the decision threshold with the maximum sensitivity should be selected (He et al., 2010; Chalmers et al., 2014). Since the current problem seeks to refer as many at-risk Soldiers to the AWC as possible (and there is no negative effect of referring lower-risk Soldiers to the AWC), maximum sensitivity is desired.

4 METHODS

4.1 Data Collection

Two-mile run-time performance on the APFT represents aerobic fitness among Soldiers, given its high correlation to VO_2 max, the most valid measure of aerobic fitness (U.S. Army Research Institute of Environmental Medicine, 1984; Knapik, 1989). Likewise, BMI values calculated from height and weight data are considered an acceptable representation of body composition in large populations where more precise body fat measurements may not be practical or cost effective (Grier et al., 2015).

The Armed Forces Health Surveillance Division (AFHSD) Army Satellite provided data for the Active Duty Army and FORSCOM populations. Height and weight data and APFT 2-mile run time within the same year were obtained from the Defense Training Management System (DTMS). Medical encounter injuries and date of birth (to calculate age) data were pulled from the Defense Medical Surveillance System (DMSS). Injury diagnoses were according to the published Army injury definition, which categorizes diagnosis codes from the International Classification of Diseases – 10th Clinical Modification (ICD-10-CM) according to causal energy mechanisms (U.S. Army Public Health Center, 2017; Hauschild et al., 2019). The subset of diagnoses resulting from cumulative micro-traumatic energy sources is referred to as “overuse” injuries in this report; these typically comprise over two-thirds of all Army injuries (U.S. Army Public Health Center, 2017; Hauschild et al., 2019; Schuh-Renner et al., 2019a).

All data for the airborne and infantry data sets were obtained via surveys administered to Soldiers in the units. APFT run time, height, weight, age, and injuries were based on self-reported data based on the 12 months preceding survey administration. Overuse injuries were identified as those recognized by the survey respondent as having arisen from overexertion or repetitive movement mechanisms. Past survey-reported data from Soldiers have been shown to be acceptably accurate when compared to sources of record (Schuh-Renner et al., 2019b; Martin et al., 2016).

4.2 Data Analysis

4.2.1 Data-Oriented Trend Assessments

For this analysis, a data-oriented approach was used, comparing the proportion of Soldiers injured among subgroups with various APFT 2-mile run time and BMI combinations. Subgroups were determined based on octiles, quartiles, or median values for both genders in each population, depending on population size. Subgroups with significantly higher injured proportions compared to the median value are targeted for AWC referral.

4.2.2 Sensitivity and Specificity Analyses

ROC curves were produced for seven models using the Statistical Package for Social Sciences, version 21 (IBM® SPSS®): run time alone, BMI alone, age alone, run time and BMI, run time and age, BMI and age, and all three variables for run time, BMI, and age combined. For the four models with multiple variables, injury risk probabilities were calculated based on logistic regression equations. Data for men and women were analyzed separately. Since physiological differences often lead to differing average aerobic fitness, body composition, and injury risk (Anderson et al., 2017; Grier et al., 2017), the recommended AWC referral guidelines were expected to differ between the two sexes. This assessment was conducted for the four populations noted above.

The retrospective data were used to identify referral guidelines that could potentially be applied as a prospective injury reduction strategy in the future. Guiding questions included—

- Which Soldiers from the prior populations of interest would have been referred to the AWC using the proposed referral guidelines?
- What proportion of injured Soldiers would have been referred (and therefore may have been affected by the intervention)?
- What proportion of the total population would have been referred? Can the AWCs handle the associated throughput?

In order to incorporate current Army guidance for body composition (Department of the Army, 2013), those Soldiers who were outside age-based height-for-weight guidelines were identified, including those who were below BMI recommendations (underweight) and those who were above them (overweight/obese). A BMI of 19 is the minimum acceptable BMI in Army Regulation 600–9 (Department of the Army, 2013). This underweight threshold was applied to men for these analyses. However, because a BMI lower than 21 showed increased injury risk

among women in a previous study (Jones et al., 2017), an underweight BMI threshold of 21 was used for women.

The use of these Regulation-based body composition thresholds has several benefits: the thresholds incorporate age as a factor, account for underweight BMI as a potential risk factor (Jones et al., 2017; Friedl, 2011), and isolated the APFT 2-mile run time for more straightforward ROC analysis. Among those outside Army BMI recommendations, AWC referral cut-points were investigated based on a range of APFT run times, 30 seconds apart, as long as the proportion of referred Soldiers was acceptable (10–25%).

Decision metrics (sensitivity, specificity, PPV, NPV, CR, and the proportion of the population identified for referral) were calculated for each population using Microsoft® Excel®, for the range of acceptable run times. The run time that produced the greatest sensitivity was considered optimal for this application.

This full analysis was applied to: (1) the most at-risk Soldiers with MSK injuries in a subset of data for the Active Duty Army, (2) all injuries (not just MSK), and (3) all Soldiers (not just those at high risk), to ensure widespread application and usefulness of the referral guidelines. Final recommendations for AWC referral guidelines also considered the 2-mile run standards and the Army body composition regulations; cited guidance is provided in Appendices B and C, respectively.

5 RESULTS

5.1 Trends in Injury Prevalence

The Active Duty Army dataset included 114,810 Soldiers with complete data (APFT 2-mile run time, height, weight, and age). Overall, 85% were men, the average BMI was 26.2, the average age was 28, and 63% were injured during CY2017. Over half (51%) were FORSCOM Soldiers.

Tables 2 and 3 show the proportions of Soldiers injured by APFT 2-mile run time and BMI for men and women, respectively, for the CY2017 Active Duty Army. Also shown are rate ratios (RRs) and 95% confidence intervals (95%CI) when compared to the median values.

As shown by the midpoint values in Tables 2 and 3, average run times for Active Duty Army Soldiers were 15.1 minutes (15:06) for men and 17.6 minutes (17:37) for women; the average BMI was 26.4 for men and 24.5 for women.

For both sexes, the proportion of injured Soldiers increased with slower run times and higher BMI. Analyses for the other three populations show similar trends, as seen in Appendix B. Therefore, the preliminary recommendation is to focus AWC referrals on Soldiers in these higher-risk groups. Further analyses (Section 5.2) refined this recommendation, while also considering the available AWC throughput. Army regulations for 2-mile run time performance standards (Department of the Army, 2012) and age-based regulations for high and low body fat (BMI>27.5 and BMI<19) (Department of the Army, 2013), provided in Appendices C and D respectively, were also incorporated.

Table 2. Percent with Diagnosed Injuries, by APFT Run Time and BMI; Subset of Active Duty Army*, CY2017, n=97,542 Men

%(n) RR (95%CI) p-value	**Run O1 ≤ 13.45 minutes**	**Run O2 13.46-14.13 minutes**	**Run O3 14.14-14.65 minutes**	**Run O4 14.66-15.10 minutes**	**Run O5 15.11-15.55 minutes**	**Run O6 15.56-16.02 minutes**	**Run O7 16.03-16.70 minutes**	**Run O8 ≥16.71 minutes**	**Total**
BMI O1 ≤22.86	51% (2,733) 0.88(0.84-0.92) p<0.01	54% (2,188) 0.91 (0.86-0.96) p<0.01	54% (1,893) 0.89(0.85-0.95) p<0.01	57% (1,658) 0.94 (0.88-1.00) p=0.06	57% (1,363) 0.94 (0.87-1.02) p=0.13	60% (1,089) 0.99 (0.90-1.08) p=0.80	61% (729) 1.04 (0.92-1.18) p=0.51	**67% (472) 1.25 (1.06-1.49) p<0.01**	56% (12,125)
BMI O2 22.87- 24.39	51% (2,625) 0.87 (0.83-0.92) p<0.01	53% (2,205) 0.90(0.84-0.93) p<0.01	55% (1,812) 0.91(0.85-0.96) p<0.01	57% (1,612) 0.94 (0.88-1.01) p=0.07	58% (1,443) 0.96 (0.89-1.03) p=0.28	59% (1,155) 0.98 (0.90-1.07) p=0.68	62% (858) 1.05 (0.94-1.18) p=0.36	**68% (570) 1.30 (1.12-1.51) p<0.01**	56% (12,280)
BMI O3 24.40- 25.52	53% (2,100) 0.92(0.84-0.94) p<0.01	55% (1,975) 0.93(0.87-0.97) p<0.01	56% (1,747) 0.92 (0.86-0.98) p=0.01	55% (1,613) 0.91 (0.85-0.97) p<0.01	60% (1,472) 1.00 (0.93-1.08) p=0.99	59% (1,329) 0.98 (0.90-1.06) p=0.61	63% (992) 1.09 (0.99-1.21) p=0.08	**69% (699) 1.31 (1.14-1.50) p<0.01**	57% (11,927)
BMI O4 25.53- 26.44	52% (1,742) 0.86 (0.81-0.92) p<0.001	54% (1,801) 0.90 (0.84-0.95) p<0.01	56% (1,701) 0.94(0.87-0.99) p=0.03	57% (1,661) 0.95(0.88-1.01) p=0.08	59% (1,568) 0.98 (0.92-1.06) p=0.64	62% (1,524) 1.04 (0.97-1.12) p=0.27	**66% (1,310) 1.15 (1.06-1.26) p<0.01**	**71% (932) 1.36 (1.22-1.53) p<0.01**	59% (12,239)
BMI O5 26.45- 27.39	54% (1,265) 0.88 (0.81-0.95) p<0.001	56% (1,443) 0.96(0.84-0.98) p=0.01	59% (1,707) 0.99 (0.92-1.05) p=0.68	60% (1,580) referent	62% (1,681) 1.05 (0.98-1.12) p=0.18	**65% (1,609) 1.10 (1.03-1.19) p<0.01**	**66% (1,599) 1.15 (1.06-1.23) p<0.01**	**70% (1,383) 1.29 (1.18-1.41) p<0.01**	62% (12,267)
BMI O6 27.40- 28.68	55% (954) 0.88 (0.80-0.98) p=0.02	56% (1,308) 0.97(0.83-0.98) p=0.01	59% (1,453) 0.98(0.91-1.06) p=0.59	60% (1,604) 0.99(0.93-1.07) p=0.87	**63% (1,701) 1.07 (1.00-1.15) p=0.05**	**64% (1,769) 1.09 (1.02-1.17) p=0.01**	**66% (1,853) 1.14 (1.06-1.22) p<0.01**	**76% (1,680) 1.46 (1.34-1.59) p<0.01**	63% (12,322)
BMI O7 28.69- 30.27	57% (561) 0.100 (0.78- 1.04) p=0.17	60% (974) 0.99 (0.90-1.10) p=0.90	59% (1,146) 0.97 (0.89-1.06) p=0.48	**64% (1,362) 1.09 (1.00-1.18) p=0.04**	**65% (1,741) 1.10 (1.03-1.18) p<0.01**	**65% (1,835) 1.11 (1.04-1.19) p<0.01**	**69% (2,175) 1.20 (1.13-1.28) p<0.01**	**76% (2,324) 1.39 (1.30-1.49) p<0.01**	66% (12,118)
BMI O8 ≥30.28	58% (225) 0.94 (0.73-1.70) p=0.61	**65% (480) 1.18 (1.00-1.39) p=0.05**	63% (740) 1.09 (0.97-1.24) p=0.15	**67% (1,006) 1.21 (1.09-1.35) p<0.01**	**69% (1,434) 1.25 (1.15-1.36) p<0.01**	**69% (1,802) 1.21 (1.13-1.30) p<0.01**	**72% (2,583) 1.23 (1.17-1.31) p<0.01**	**79% (3,994) 1.34 (1.28-1.41) p<0.01**	72% (12,264)
Total	53% (12,205)	55% (12,374)	57% (12,199)	59% (12,096)	62% (12,403)	63% (12,112)	67% (12,099)	75% (12,054)	61% (97,542)

Note: Cells in bold represent subgroups with injured proportions that are significantly higher than the referent value (p≤0.05).
*Subset includes all those with complete age, height, weight, and APFT run data

Table 3. Percent with Diagnosed Injuries, by APFT Run Time and BMI; Subset of Active Duty Army*, CY2017, n=17,268 Women

%(n) RR (95%CI) p-value	**APFT 2-mile run time ≤ 16.37 minutes % (n)**	**APFT 2-mile run time 16.37-17.62 minutes % (n)**	**APFT 2-mile run time 17.63-18.80 minutes % (n)**	**APFT 2-mile run time ≥18.81 minutes % (n)**	**Total**
BMI ≤22.62	62% (1,743) 0.83 (0.78-0.88) p<0.001	69% (1,189) 0.93 (0.85-1.01) p=0.08	72% (873) 0.99 (0.88-1.10) p=0.83	74% (509) 1.04 (0.88-1.23) p=0.63	67% (4,314)
BMI 22.63-24.53	62% (1,374) 0.81 (0.75-0.86) p<0.001	70% (1,240) 0.93 (0.86-1.01) p=.10	76% (1,023) 1.11 (0.99-1.23) p=0.06	**79% (707)** **1.23 (1.07-1.43)** **p=0.003**	70% (4,344)
BMI 24.54-26.43	67% (883) 0.86 (0.77-0.95) p=0.004	73% (1,121) referent	74% (1,118) 1.04 (0.95-1.14) p=0.38	**77% (1,084)** **1.13 (1.02-1.26)** **p=0.02**	73% (4,276)
BMI ≥26.44	71% (344) 0.93 (0.76-1.13) p=0.46	73% (762) 1.02 (0.90-1.16) p=0.71	**77% (1,238)** **1.13 (1.03-1.24)** **p=0.01**	**84% (1,990)** **1.33 (1.23-1.45)** **p<0.001**	79% (4,334)
Total	63% (4,344)	71% (4,312)	75% (4,322)	80% (4,290)	72% (17,268)

Notes:
Cells in bold represent subgroups with injured proportions that are significantly higher than the referent value (p≤0.05).
*Subset includes all those with complete age, height, weight, and APFT run data

5.2 Receiver Operating Characteristic Curve Analyses

To verify and refine the tentative referral guidelines determined by octile and quartile assessments, ROC sensitivity analyses were applied.

Using logistic regression, injury prediction equations were generated for combinations of APFT 2-mile run time, BMI, and age. For example, the regression equation for overuse injuries among men in the All-Army population is shown in Equation 8. The APFT 2-mile run time contributed the greatest weight to the prediction equation.

$$\ln\frac{\widehat{p(x)}}{1-\widehat{p(x)}} = -2.697 + (0.093 \times APFT\ 2\ Mile\ Run\ Time) + (0.046 \times BMI) - (0.001 \times age) \quad \text{(Equation 8)}$$

Again applying the age-based Army regulations for high and low body fat (BMI > 27.5 and BMI <19) (Department of the Army, 2013), decision measures were considered for a range of APFT 2-mile run times.

To ensure broad usage of the referral guidelines identified by the ROC analyses for Soldiers at greatest risk for overuse injuries, the same process described above was applied to the other three Army subpopulations. Although these referral guidelines were intended to target prevention of overuse injuries among at-risk Soldiers, referral guidelines for all injuries (not just MSK) among all Soldiers (not just high-risk) were also analyzed. The ROC sensitivity analyses were applied to the following populations (all for men and women separately):

- Active Duty Army, CY2017 – At-risk population, diagnosed overuse injuries
- Active Duty Army, CY2017 – At-risk population, all diagnosed injuries
- Active Duty Army, CY2017 – All Soldiers, diagnosed overuse injuries
- Active Duty Army, CY2017 – All Soldiers, all diagnosed injuries

- FORSCOM, CY2017 – At-risk population, diagnosed overuse injuries
- FORSCOM, CY2017 – At-risk population, all diagnosed injuries
- FORSCOM, CY2017 – All Soldiers, diagnosed overuse injuries
- FORSCOM, CY2017 – All Soldiers, all diagnosed injuries

- Fort Campbell Infantry Units, 2016 – At-risk population, self-reported overuse injuries
- Fort Campbell Infantry Units, 2016 – At-risk population, all self-reported injuries
- Fort Campbell Infantry Units, 2016 – All Soldiers, self-reported overuse injuries
- Fort Campbell Infantry Units, 2016 – All Soldiers, all self-reported injuries

- Fort Carson Infantry Units, 2010-2011 – At-risk population, self-reported overuse injuries
- Fort Carson Infantry Units, 2010-2011 – At-risk population, all self-reported injuries
- Fort Carson Infantry Units, 2010-2011 – All Soldiers, self-reported overuse injuries
- Fort Carson Infantry Units, 2010-2011 – All Soldiers, all self-reported injuries

Tables 4 and 5 show the final results from the All-Army analyses for overuse injuries among the most at-risk men and women. Appendices E–H provide the ROC curve prediction performance data and sensitivity analysis decision metrics for all of the above-listed subgroups.

Table 4. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=23,394, Most At-Risk* Men, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside Regulation AND APFT run time x or slower:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total male population identified for referral
15:00	1.00	0	0.56	N/A	0.56	100%	24%
15:30	0.89	0.14	0.56	0.50	0.56	87%	21%
16:00	0.67	0.41	0.59	0.50	0.55	63%	15%

Notes:
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table 5. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=2,577, Most At-Risk* Women, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside Regulation AND APFT run time x or slower:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total female population identified for referral
17:30	1.00	0.00	0.67	N/A	0.67	100%	15%
18:00	0.92	0.10	0.68	0.38	0.65	91%	14%
18:30	0.76	0.31	0.69	0.38	0.61	74%	11%

Notes:
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

In each case, the same referral guidelines of APFT 2-mile run times of ≥15:00 for men and ≥18:00 for women, for men and women with high or low BMI, were acceptable. Appendix I provides a summary of results for all four populations.

6 DISCUSSION

6.1 Recommended Army Wellness Center Referral Guidelines

For both sexes in all four of the populations examined herein, the proportion of injured Soldiers increased with increasing BMI and increasing run time. Similar trends have been observed in many other Army subpopulations (Jones et al., 2017; Rappole et al., 2017; Jones and Hauschild, 2015). The predicted model that combined run time, BMI, and age was usually the best predictor of injury in the ROC and sensitivity analyses, with a greater AUC than any individual metric and most of the predicted models with two variables.

To incorporate all of these interconnected influencing factors, we recommend the final AWC referral guidelines shown in Table 6. BMI referral recommendations mirror published Army body composition regulations to ensure that age is also considered. Run time referral recommendations were rounded to full-minute values for easy socialization of guidelines.

Table 6. AWC Referral Guidelines by Sex, Based on APFT 2-Mile Run Performance, BMI, and Age

Sex	Age & BMI		Most Recent APFT 2-Mile Run Time
Male	Any age and BMI < 19 Age <21 and BMI ≥ 25.9 Age 21-27 and BMI ≥ 26.5 Age 28-39 and BMI ≥ 27.2 Age ≥ 40 and BMI ≥ 27.5	**AND**	≥ 15:00
Female	Any age and BMI < 21 Age <21 and BMI ≥ 25.0 Age 21-27 and BMI ≥ 25.3 Age 28-39 and BMI ≥ 25.6 Age ≥ 40 and BMI ≥ 26.0	**AND**	≥ 18:00

These proposed referral guidelines will be pilot tested at Fort Campbell as described in APHC PHRB Project Plan 18-666.

While these guidelines are intended to identify those Soldiers at greatest risk of overuse injuries who can potentially derive the greatest aerobic performance and body composition improvements by utilizing the AWC Services, all Soldiers may utilize AWC Services at any time. Leadership, medical professionals, and training commanders should emphasize AWC benefits to all Soldiers, even if they do not meet these fitness and body composition referral criteria. Leadership support for injury prevention efforts can influence Soldier behaviors and potentially reduce injuries (U.S. Army Public Health Center, 2019b).

6.2 Messaging for Women

Depending on the population being considered, APFT 2-mile run time thresholds ranging from 17:30 or 18:00 could have the best sensitivity for overuse injuries among at-risk women when combined with the age-based body composition regulations. However, when considering the Army 2-Mile Run Standards (Appendix B), cut-points of both 17:30 and 18:00 are well above the performance required to achieve the maximum APFT run score in several of the older-female age groups. Therefore, to discourage overtraining among any women, the current referral guidelines recommend the more conservative referral threshold of 18:00 or longer for women. Because gender-neutral Army fitness tests are now being emphasized (Foulis et al., 2015; Department of the Army, 2018), it should be noted that applying the men's 2-mile run time threshold (15:00) to women would not increase AWC throughput to an unacceptable level (see Table D-8 for example). However, messaging remains a concern; it is important that the referral guidelines not communicate that a run time longer than 15:00 is "bad" or "wrong," especially when it is above the maximum required to pass the test. A referral guideline of 15:00 would be faster than the highest passing score for all female age groups.

6.3 Limitations

This investigation focused on testing this methodology using past data, predominantly from FORSCOM populations; future studies would need to evaluate its effectiveness in other occupational specialties and trainee populations to ensure that Soldiers the most at risk for

injury are still being referred, and AWC throughput can be managed. Available AWC throughput may differ by installation due to facility size, equipment availability, and other AWC utilization initiatives.

The current analyses were limited to Soldiers with complete records for all relevant data points (run time, height, weight, and age). Poor data availability was particularly limiting in the DTMS. While the data used are believed to be representative of the overall populations, more robust ROC curve analyses could be completed in the future if run time, height, and weight data were better recorded in DTMS. When survey data are m feasible, electronic surveys should be used to encourage the best response rate.

Even with widespread application of this AWC referral approach to reduce overuse injuries among Soldiers at greatest risk, a statistically significant reduction in injuries for the overall population of interest may not be seen, given the relatively low percentage of Soldiers at highest risk. Furthermore, not all Soldiers who are identified for referral will be eligible for AWC evaluation as part of this initiative if they are already on an MSK profile or are already an AWC client.

It is recommended that future initiatives extend referrals to those Soldiers at moderate risk, such as all of those with slower-than-average run times, even if they have an acceptable BMI (Kime, 2019). Such an extension of referrals would increase the total number of Soldiers visiting the AWC and would have the greatest potential effect on decreasing the aggregate injury rate for a unit, installation, or command reporting unit. The extension of referrals to moderate-risk Soldiers is contingent on whether AWCs can manage greater throughput.

6.4 The New Army Combat Fitness Test

The Army Combat Fitness Test (ACFT), comprising six fitness test events, is expected to be fully operational in the near future (Department of the Army, 2018). The 2-mile run will remain as an ACFT event but will be completed after the other five events. Trend assessments and ROC curve and sensitivity analyses, including ACFT run time data when available, will need to be applied.

Preliminary pilot-test data indicate that ACFT 2-mile run times could be about 2 minutes longer on average for men and approximately 1.5 minutes longer for women, compared to current APFT performance (APHC unpublished data). Until data availability allows for analysis of actual ACFT data after the test's widespread implementation, an interim recommendation is to add 2 minutes to the APFT run-time AWC referral guidelines, without adjusting the age-based BMI recommendations. These interim ACFT referral guidelines are shown in Table 7.

Table 7. Interim AWC Referral Guidelines by Sex, Based on ACFT 2-Mile Run Performance, BMI, and Age

Sex	Age & BMI		Most Recent ACFT 2-Mile Run Time
Men	Any age and BMI < 19 Age <21 and BMI ≥ 25.9 Age 21–27 and BMI ≥ 26.5 Age 28–39 and BMI ≥ 27.2 Age ≥ 40 and BMI ≥ 27.5	**AND**	≥ 17:00
Women	Any age and BMI < 21 Age <21 and BMI ≥ 25.0 Age 21–27 and BMI ≥ 25.3 Age 28–39 and BMI ≥ 25.6 Age ≥ 40 and BMI ≥ 26.0	**AND**	≥ 19:30

7 CONCLUSIONS AND RECOMMENDATIONS

As in previous studies, Soldiers with a slower APFT 2-mile run time and high or low BMI were identified as being at greatest risk for injuries. Based on ROC curves and sensitivity analyses in four Army populations, the optimal referral run times to maximize the number of at-risk Soldiers referred to the AWC were identified as 15 minutes and longer for men and 18 minutes and longer for women, for those Soldiers whose BMI did not meet Army body fat standards. Additional analysis is recommended, especially in non-FORSCOM populations, to ensure widespread effectiveness of these recommendations.

Similar analyses should be conducted after the new ACFT fitness test is implemented. Interim ACFT referral guidelines can be considered, based on the average difference between APFT and preliminary ACFT run times. Men and women whose ACFT run times are longer than 17:00 and 19:30, respectively, and whose BMI does not meet Army body fat standards, should be referred to the AWC. Referral recommendations may be adjusted in the future to also include Soldiers at moderate injury risk if AWCs can manage the additional throughput.

8 POINT OF CONTACT

The APHC Injury Prevention Division is the point of contact for this project. Contact the Division via e-mail at usarmy.apg.medcom-phc.mbx.injuryprevention@mail.mil or by phone at 410-436-4655/DSN 584-4655. Specific questions may be directed to the authors listed at the front of this report.

Approved:

MICHELLE CANHAM-CHERVAK, PhD, MPH
Manager
Injury Prevention Program

Appendix A

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Appendix B
Data-based Quartile Assessments: Additional Populations

Table B-1. Percent with Diagnosed Injuries, by APFT Run Time and BMI; FORSCOM Soldiers*, CY2017, n=50,656 Men

%(n) RR (95%CI) p-value	**Run O1 ≤ 13.42 minutes**	**Run O2 13.43-14.08 minutes**	**Run O3 14.09-14.60 minutes**	**Run O4 14.61-15.05 minutes**	**Run O5 15.06-15.50 minutes**	**Run O6 15.50-15.95 minutes**	**Run O7 15.96-16.62 minutes**	**Run O8 ≥16.63 minutes**	**Total**
BMI O1 ≤22.81	52% (1,410) 0.91 (0.86-0.97) p=0.004	52% (1,137) 0.90 (0.84-0.97) p=0.007	53% (989) 0.92 (0.85-1.00) p=0.05	56% (927) 0.96 (0.88-1.04) p=0.30	56% (725) 0.96 (0.86-1.06) p=0.43	59% (568) 1.03 (0.91-1.17) p=0.67	64% (375) 1.18 (0.99-1.40) p=0.06	**70% (247) 1.51 (1.19-1.92) p<0.001**	51% (6,378)
BMI O2 22.82- 24.37	48% (1,337) 0.87 (0.82-0.93) p<0.001	51% (1,141) 0.89 (0.83-0.96) p=0.003	52% (978) 0.89 (0.82-0.97) p=0.006	55% (866) 0.94 (0.86-1.03) p=0.17	58% (746) referent	58% (580) 1.00 (0.88-1.13) p=0.98	62% (443) 1.03 (0.88-1.21) p=0.69	**69% (274) 1.43 (1.15-1.80) p=0.001**	54% (6,365)
BMI O3 24.38- 25.50	51% (1,149) 0.89 (0.83-0.95) p=0.001	53% (1,018) 0.91 (0.84-0.99) p=0.03	54% (909) 0.92 (0.85-1.01) p=0.07	55% (888) 0.94 (0.86-1.02) p=0.15	58% (803) 0.99 (0.90-1.09) p=0.88	58% (675) 0.99 (0.88-1.10) p=0.83	63% (517) 1.12 (0.97-1.28) p=0.11	**70% (343) 1.42 (1.17-1.73) p<0.001**	56% (6,302)
BMI O4 25.51- 26.43	49% (900) 0.85 (0.78-0.93) p<0.001	53% (905) 0.91 (0.83-0.99) p=0.04	54% (933) 0.92 (0.84-1.00) p=0.06	55% (854) 0.95 (0.86-1.04) p=0.24	56% (829) 0.95 (0.87-1.05) p=0.31	59% (740) 1.03 (0.93-1.14) p=0.62	**64% (674) 1.13 (1.01-1.27) p=0.03**	**73% (461) 1.55 (1.31-1.84) p<0.001**	57% (6,296)
BMI O5 26.44- 27.44	52% (683) 0.88 (0.79-0.98) p=0.02	51% (744) 0.86 (0.78-0.95) p=0.003	59% (907) 1.02 (0.93-1.11) p=0.67	58% (750) 0.99 (0.89-1.10) p=0.82	58% (899) 1.00 (0.91-1.09) p>0.99	62% (844) 1.08 (0.98-1.19) p=0.10	**66% (844) 1.18 (1.07-1.30) p<0.001**	**73% (687) 1.44 (1.27-1.64) p<0.001**	60% (6,358)
BMI O6 27.45- 28.73	52% (490) 0.85 (0.74-0.98) p=0.02	55% (669) 0.93 (0.83-1.04) p=0.19	56% (748) 0.95 (0.86-1.05) p=0.32	59% (826) 1.01 (0.92-1.11) p=0.87	61% (904) 1.05 (0.96-1.15) p=0.29	**64% (875) 1.11 (1.01-1.22) p=0.03**	**64% (977) 1.12 (1.03-1.23) p=0.007**	**76% (875) 1.49 (1.33-1.68) p<0.001**	62% (6,364)
BMI O7 28.74- 30.40	54% (262) 0.89 (0.72-1.09) p=0.26	56% (494) 0.94 (0.82-1.08) p=0.38	55% (622) 0.93 (0.83-1.05) p=0.24	61% (698) 1.06 (0.95-1.18) p=0.33	61% (897) 1.06 (0.97-1.16) p=0.21	**64% (988) 1.11 (1.02-1.21) p=0.02**	**69% (1,144) 1.21 (1.11-1.31) p<0.001**	**77% (1,239) 1.46 (1.33-1.60) p<0.001**	65% (6,344)
BMI O8 ≥30.41	55% (114) 0.90 (0.64-1.27) p=0.56	63% (213) 1.17 (0.91-1.49) p=0.22	61% (359) 1.08 (0.91-1.29) p=0.37	**64% (505) 1.16 (1.01-1.34) p=0.04**	**69% (729) 1.28 (1.14-1.44) p<0.001**	**68% (841) 1.24 (1.11-1.37) p<0.001**	**71% (1,364) 1.22 (1.14-1.32) p<0.001**	**80% (2,124) 1.38 (1.29-1.47) p<0.001**	72% (6,249)
Total	51% (6,345)	53% (6,321)	55% (6,445)	57% (6,314)	60% (6,532)	62% (6,111)	66% (6,338)	76% (6,250)	60% (50,656)

Legend: APFT = Army Physical Fitness Test; BMI = body mass index; CI = confidence interval; FORSCOM = U.S. Forces Command; RR = risk ratio
Note: Cells in bold represent subgroups with injured proportions that are significantly higher than the median referent value (p≤0.05).
*Includes all those with complete age, height, weight, and APFT run data

Table B-2. Percent with Diagnosed Injuries, by APFT Run Time and BMI; FORSCOM Soldiers*, CY2017, n=7,437 Women

%(n) RR (95%CI) p-value	**APFT 2-mile run time ≤16.35 minutes % (n)**	**APFT 2-mile run time 16.36-17.62 minutes % (n)**	**APFT 2-mile run time 17.63-18.75 minutes % (n)**	**APFT 2-mile run time ≥18.76 minutes % (n)**	**Total**
BMI ≤22.68	61% (745) 0.77 (0.70-0.84) p<0.001	74% (559) referent	75% (362) 1.02 (0.85-1.23) p=0.85	74% (213) 0.96 (0.74-1.24) p=0.74	69% (1,879)
BMI 22.69-24.66	61% (594) 0.75 (0.67-0.84) p<0.001	69% (522) 0.86 (0.76-0.98) p=0.03	75% (430) 1.00 (0.85-1.18) p=0.99	**81% (302)** **1.30 (1.02-1.65)** **p=0.03**	70% (1,848)
BMI 24.67-26.60	66% (388) 0.79 (0.68-0.92) p=0.004	72% (500) 0.92 (0.80-1.06) p=0.26	75% (500) 0.99 (0.86-1.15) p=0.92	**81% (476)** **1.21 (1.02-1.44)** **p=0.03**	74% (1,864)
BMI ≥26.61	66% (145) 0.73 (0.54-0.98) p=0.04	73% (295) 0.93 (0.75-1.14) p=0.46	76% (539) 1.05 (0.91-1.21) p=0.55	**85% (867)** **1.34 (1.17-1.52)** **p<0.001**	79% (1,846)
Total	62% (1,872)	72% (1,876)	75% (1,831)	82% (1,858)	73% (7,437)

Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
CI = confidence interval
FORSCOM = U.S. Forces Command
RR = risk ratio
Note: Cells in bold represent subgroups with injured proportions that are significantly higher than the median referent value (p≤0.05).
*Includes all those with complete age, height, weight, and APFT run data

Table B-3. Percent with Self-Reported Injuries, by APFT Run Time and BMI; Combined Infantry and Airborne Soldiers*, CY2017, n=9,574 Women

%(n) RR (95%CI) p-value	**APFT 2-mile run time ≤13.80 minutes % (n)**	**APFT 2-mile run time 13.81-14.72 minutes % (n)**	**APFT 2-mile run time 14.73-15.70 minutes % (n)**	**APFT 2-mile run time ≥15.71 minutes % (n)**	**Total**
BMI ≤23.67	27% (922) 0.88 (0.80-0.97) p=0.01	32% (696) 0.98 (0.88-1.09) p=0.70	33% (507) 1.00 (0.87-1.15) p=0.99	**43% (287)** **1.33 (1.10-1.62)** **p=0.004**	31% (2,412)
BMI 23.68-25.80	29% (772) 0.92 (0.82-1.02) p=0.10	33% (657) referent	33% (576) 1.00 (0.88-1.13) p=0.99	**48% (402)** **1.46 (1.26-1.70)** **p<0.001**	34% (2,407)
BMI 25.81-28.00	32% (514) 0.97 (0.85-1.12) p=0.68	34% (602) 1.02 (0.91-1.16) p=0.70	38% (637) 1.12 (1.00-1.25) p=0.06	**48% (609)** **1.37 (1.22-1.53)** **p<0.001**	38% (2,362)
BMI ≥28.01	31% (212) 0.94 (0.73-1.21) p=0.61	36% (425) 1.08 (0.93-1.26) p=0.32	**45% (669)** **1.28 (1.15-1.42)** **p<0.001**	**54% (1,087)** **1.37 (1.28-1.48)** **p<0.001**	46% (2,393)
Total	29% (2,420)	33% (2,380)	38% (2,389)	50% (2,385)	37% (9,574)

Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
CI = confidence interval

Table D-3 Legend (continued):RR = risk ratio
Note: Cells in bold represent subgroups with injured proportions that are significantly higher than the median referent value (p≤0.05).
*Includes all those with complete age, height, weight, and APFT run data

Table B-4. Percent with Self-Reported Injuries, by APFT Run Time and BMI; Combined Infantry and Airborne Soldiers*, CY2017, n=881 Women

%(n) RR (95%CI) p-value	**APFT 2-mile run time ≤17.49 minutes % (n)**	**APFT 2-mile run time ≥17.50 minutes % (n)**	**Total**
BMI ≤24.26	40% (288) referent	**51% (153)** **1.34 (1.04-1.73)** **p=0.03**	44% (441)
BMI ≥24.27	38% (155) 0.95 (0.73-1.24) p=0.70	**53% (285)** **1.30 (1.10-1.53)** **p=0.002**	48% (440)
Total	39% (443)	52% (438)	46% (881)

Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
CI = confidence interval
RR = risk ratio
Note: Cells in bold represent subgroups with injured proportions that are significantly higher than the median referent value (p≤0.05).
*Includes all those with complete age, height, weight, and APFT run data

Appendix C

Army 2-Mile Run Standards

Table C-1 presents the Army 2-Mile Run Standards, as shown in FM 7-22 (DA 2012).

Table C-1. Army 2-Mile Run Standards

2-MILE RUN STANDARDS																					
AGE GROUP	17-21		22-26		27-31		32-36		37-41		AGE GROUP	42-46		47-51		52-56		57-61		62+		AGE GROUP
Time	M	F	M	F	M	F	M	F	M	F	Time	M	F	M	F	M	F	M	F	M	F	Time
12:54											12:54											12:54
13:00	100		100								13:00											13:00
13:06	99		99								13:06											13:06
13:12	97		98								13:12											13:12
13:18	96		97		100		100				13:18											13:18
13:24	94		96		99		99				13:24											13:24
13:30	93		94		98		98				13:30											13:30
13:36	92		93		97		97		100		13:36											13:36
13:42	90		92		96		96		99		13:42											13:42
13:48	89		91		95		95		98		13:48											13:48
13:54	88		90		94		95		97		13:54											13:54
14:00	86		89		92		94		97		14:00											14:00
14:06	85		88		91		93		96		14:06	100										14:06
14:12	83		87		90		92		95		14:12	99										14:12
14:18	82		86		89		91		94		14:18	98										14:18
14:24	81		84		88		90		93		14:24	97		100								14:24
14:30	79		83		87		89		92		14:30	97		99								14:30
14:36	78		82		86		88		91		14:36	96		98								14:36
14:42	77		81		85		87		91		14:42	95		98		100						14:42
14:48	75		80		84		86		90		14:48	94		97		99						14:48
14:54	74		79		83		85		89		14:54	93		96		98						14:54
15:00	72		78		82		85		88		15:00	92		95		98						15:00
15:06	71		77		81		84		87		15:06	91		95		97						15:06
15:12	70		76		79		83		86		15:12	90		94		96						15:12
15:18	68		74		78		82		86		15:18	90		93		95		100				15:18
15:24	67		73		77		81		85		15:24	89		92		95		99				15:24
15:30	66		72		76		80		84		15:30	88		91		94		98				15:30
15:36	64	100	71	100	75		79		83		15:36	87		91		93		97				15:36
15:42	63	99	70	99	74		78		82		15:42	86		90		92		97		100		15:42
15:48	61	98	69	98	73	100	77		81		15:48	85		89		91		96		99		15:48
15:54	60	96	68	97	72	99	76	100	80		15:54	84		88		91		95		98		15:54
16:00	59	95	67	96	71	98	75	99	80		16:00	83		87		90		94		97		16:00
16:06	57	94	66	95	70	97	75	99	79		16:06	83		87		89		93		96		16:06
16:12	56	93	64	94	69	97	74	98	78		16:12	82		86		88		92		95		16:12
16:18	54	92	63	93	68	96	73	97	77		16:18	81		85		87		91		94		16:18
16:24	53	90	62	92	66	95	72	97	76		16:24	80		84		87		91		93		16:24
16:30	52	89	61	91	65	94	71	96	75		16:30	79		84		86		90*		93		16:30
16:36	50	88	60	90	64	93	70	96	74		16:36	78		83		85		89		92		16:36
16:42	49	87	59	89	63	92	69	94	74		16:42	77		82		84		88		91		16:42
16:48	48	85	58	88	62	91	68	94	73		16:48	77		81		84		87		90		16:48
16:54	46	84	57	87	61	91	67	93	72		16:54	76		80		83		86		89		16:54
17:00	45	83	56	86	60	90	66	92	71	100	17:00	75		80		82		85		88		17:00
17:06	43	82	54	85	59	89	65	92	70	99	17:06	74		79		81		84		87		17:06
17:12	42	81	53	84	58	88	65	91	69	99	17:12	73		78		80		83		86		17:12
17:18	41	79	52	83	57	87	64	90	69	98	17:18	72		77		80		83		85		17:18
17:24	39	78	51	82	56	86	63	90	68	97	17:24	71	100	76		79		82		84		17:24
17:30	38	77	50	81	55	86	62	89	67	96	17:30	70	99	76		78		81		83		17:30
17:36	37	76	49	80	54	85	61	88	66	96	17:36	70	99	75	100	77		80		82		17:36
17:42	35	75	48	79	52	84	60	88	65	95	17:42	69	98	74	99	76		79		81		17:42
17:48	34	73	47	78	51	83	59	87	64	94	17:48	68	97	73	99	76		78		80		17:48
17:54	32	72	46	77	50	82	58	86	63	94	17:54	67	97	73	98	75		77		80		17:54
18:00	31	71	44	76	49	81	57	86	63	93	18:00	66	96	72	97	74		77		79		18:00

18:06	30	70	43	75	48	80	56	86	62	92	18:06	65	96	71	97	73		76		78		18:06
18:12	28	68	42	74	47	80	55	84	61	92	18:12	64	95	70	96	73		75		77		18:12
18:18	27	67	41	73	46	79	55	83	60	91	18:18	63	94	69	96	72		74		76		18:18
18:24	26	66	40	72	45	78	54	83	59	90	18:24	63	94	69	95	71		73		75		18:24
18:30	24	65	39	71	44	77	53	82	58	89	18:30	62	93	68	94	70		72		74		18:30
18:36	23	64	38	70	43	76	52	81	57	89	18:36	61	92	67	94	69		71		73		18:36
18:42	21	62	37	69	42	75	51	81	57	88	18:42	60	92	66	93	69		70		72		18:42
18:48	20	61	36	68	41	74	50	80	56	87	18:48	59	91	65	92	68		70		71		18:48
18:54	19	60	34	67	39	74	49	79	55	87	18:54	58	90	65	92	67		69		70		18:54
19:00	17	59	33	66	38	73	48	79	54	86	19:00	57	90	64	91	66	100	68		69		19:00
19:06	16	58	32	65	37	72	47	78	53	85	19:06	57	89	63	91	65	99	67		68		19:06
19:12	14	56	31	64	36	71	46	77	52	85	19:12	56	89	62	90	65	99	66		67		19:12
19:18	13	55	30	63	35	70	45	77	51	84	19:18	55	88	62	89	64	98	65		67		19:18
19:24	12	54	29	62	34	69	45	76	51	83	19:24	54	87	61	89	63	97	64		66		19:24
19:30	10	53	28	61	33	69	44	75	50	82	19:30	53	87	60	88	62	96	63		65		19:30
19:36	9	52	27	60	32	68	43	74	49	82	19:36	52	86	59	87	62	96	63		64		19:36
19:42	8	50	26	59	31	67	42	74	48	81	19:42	51	85	58	87	61	95	62	100	63		19:42
19:48	6	49	24	58	30	66	41	73	47	80	19:48	50	85	58	86	60	94	61	99	62		19:48
19:54	5	48	23	57	29	65	40	72	46	80	19:54	50	84	57	86	59	93	60	98	61		19:54
20:00	3	47	22	56	28	64	39	72	46	79	20:00	49	83	56	85	58	93	59	98	60	100	20:00
20:06	2	45	21	55	26	63	38	71	45	78	20:06	48	83	55	84	58	92	58	97	59	99	20:06
20:12	1	44	20	54	25	63	37	70	44	78	20:12	47	82	55	84	57	91	57	96	58	98	20:12
20:18	0	43	19	53	24	62	36	70	43	77	20:18	46	82	54	83	56	90	57	95	57	98	20:18
20:24		42	18	52	23	61	35	69	42	76	20:24	45	81	53	82	55	90	56	95	56	97	20:24
20:30		41	17	51	22	60	35	68	41	75	20:30	44	80	52	82	55	89	55	94	55	96	20:30
Time	M	F	M	F	M	F	M	F	M	F	Time	M	F	M	F	M	F	M	F	M	F	Time
AGE GROUP	17-21		22-26		27-31		32-36		37-41		AGE GROUP	42-46		47-51		52-56		57-61		62+		AGE GROUP

Appendix D

Army Body Composition Standards

Table D-1 presents the AR 600–9 (DA 2013) maximum allowable percent body fat standards, by age and sex, with calculated body mass index (BMI) equivalents (Grier et al., 2015).

Table D-1. Maximum Allowable Percent Body Fat Standards with BMI Equivalents

Age	Men	Women
<21	BMI 25.9 (body fat 20%)	BMI 25.0 (body fat 30%)
21–27	BMI 26.5 (body fat 22%)	BMI 25.3 (body fat 32%)
28–39	BMI 27.2 (body fat 24%)	BMI 25.6 (body fat 34%)
>40	BMI 27.5 (body fat 26%)	BMI 26.0 (body fat 36%)

Table D-2 presents the AR 600–9 (DA 2013) minimum allowable weight-for-height standards, by age and sex, with calculated BMI equivalents.

Table D-2. Minimum Allowable Weight-For-Height Standards with BMI Equivalents

Height (inches)	Minimum weight (pounds)	BMI
58	91	19.0
59	94	19.0
60	97	18.9
61	100	18.9
62	104	19.0
63	107	19.0
64	110	18.9
65	114	19.0
66	117	18.9
67	121	19.0
68	125	19.0
69	128	18.9
70	132	18.9
71	136	19.0
72	140	19.0
73	144	19.0
74	148	19.0
75	152	19.0
76	156	19.0
77	160	19.0
78	164	19.0
79	168	18.9
80	173	19.0

Appendix E

Receiver Operating Characteristic and Sensitivity Cut-Point Analyses: Active Duty Soldiers

E-1 Diagnosed Overuse Injuries, Most At-Risk, Active Duty Army

E-1.1 Men

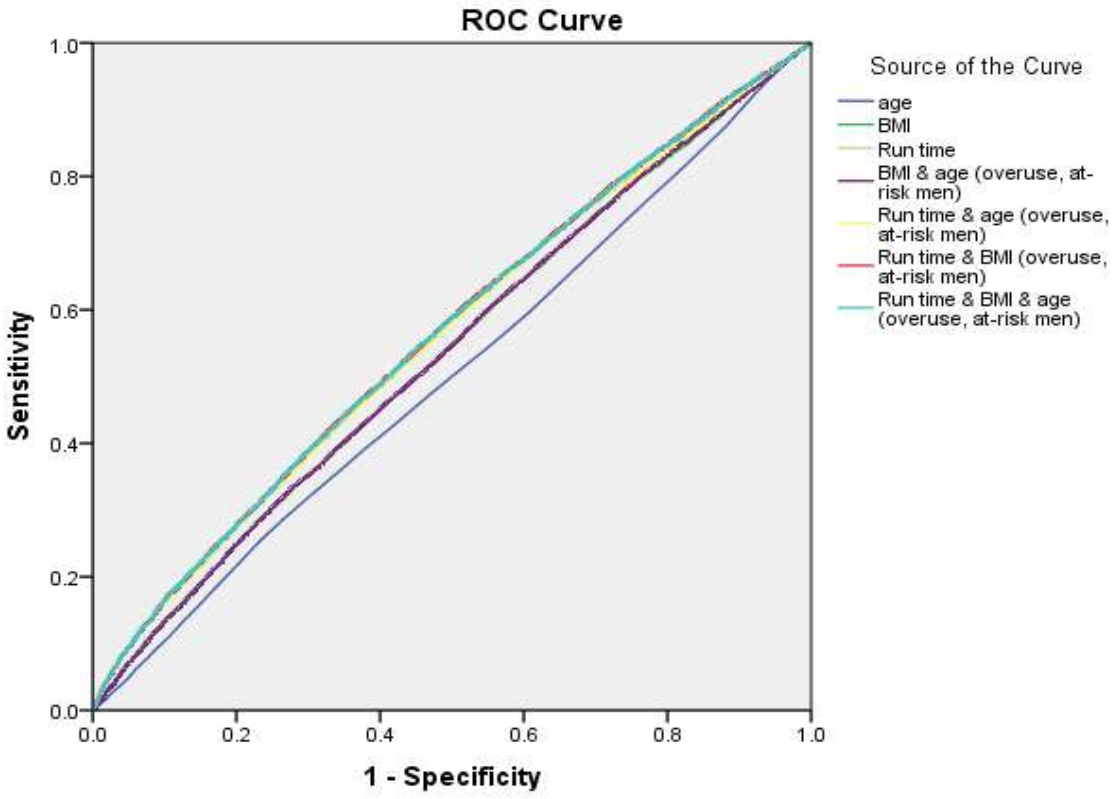

Figure E-1. Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=23,394, Most At-Risk Men, Active Duty Army, CY2017)

Table E-1. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk Based on Combinations of Fitness Test Performance, Body Composition, and Age (n=23,394, Most At-Risk* Men, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.502	.004	.569	.495	.510
BMI	.537	.004	.000	.530	.544
Run time	.559	.004	.000	.551	.566
BMI & age (overuse, at-risk men)	.537	.004	.000	.530	.545
Run time & age (overuse, at-risk men)	.558	.004	.000	.551	.566
Run time & BMI (overuse, at-risk men)	.564	.004	.000	.557	.571
Run time & BMI & age (overuse, at-risk men)	.564	.004	.000	.556	.571

The test result variable(s): age, BMI, Run time, BMI & age (overuse, at-risk men), Run time & age (overuse, at-risk men), Run time & BMI (overuse, at-risk men), Run time & BMI & age (overuse, at-risk men) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend: BMI = body mass index

*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table E-2. Decision Matrices for APFT Run Time Cut-Points Identified as Potentially Optimal (n=23,394, Most At-Risk* Men, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside Regulation AND APFT run time 15:00 or slower		Overuse Injury	No Overuse Injury	Total
Most At-risk* Soldiers	Identified for referral	12,986	10,408	*23,394*
	Not identified for referral	0	0	*0*
	Total	*12,986*	*10,408*	*23,394*
All Soldiers	Identified for referral	12,986	10,408	*23,394*
	Not identified for referral	32,723	41,425	*74,148*
	Total	*45,709*	*51,833*	*97,542*

Table E-2 (continued):
Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
*At-risk population defined as those slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)
Note: Highlighted cells emphasize those that would have been correctly categorized as injured or not injured, using the proposed referral guidelines.

E-1.2 Women

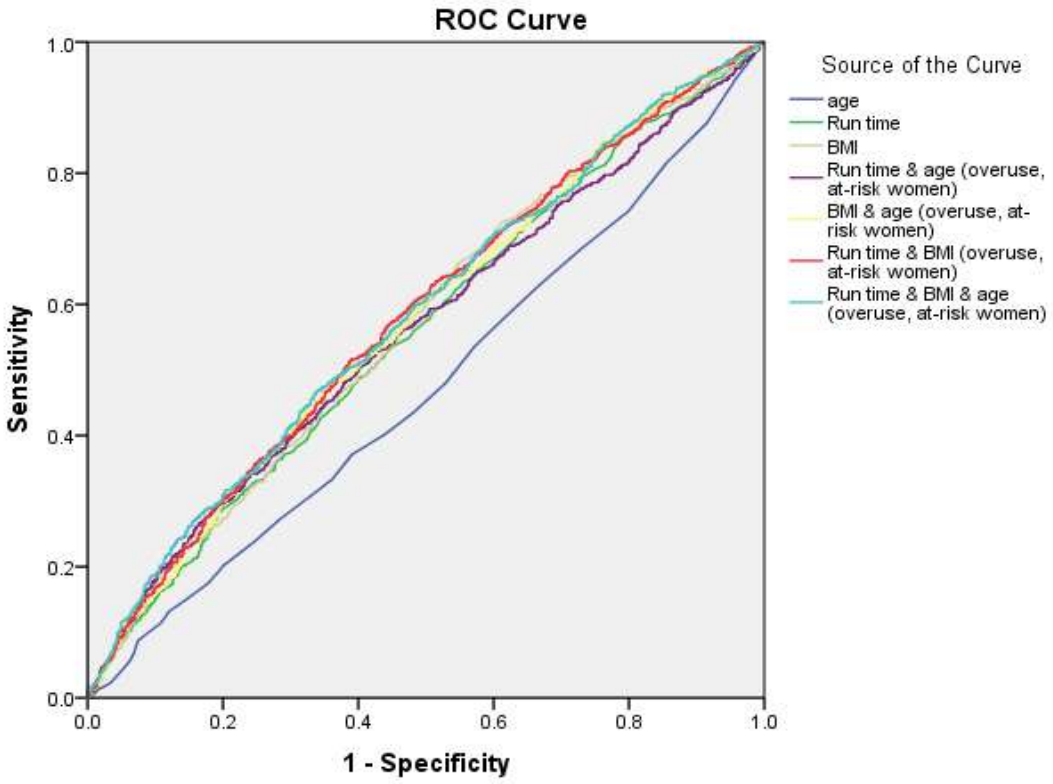

Figure E-2. Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=2,577, Most At-Risk Women, Active Duty Army, CY2017)

Table E-3. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=2,577, Most At-Risk* Women, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.474	.012	.032	.451	.497
Run time	.558	.012	.000	.535	.582
BMI	.570	.012	.000	.547	.593
Run time & age (overuse, at-risk women)	.560	.012	.000	.537	.583
BMI & age (overuse, at-risk women)	.574	.012	.000	.551	.597
Run time & BMI (overuse, at-risk women)	.580	.012	.000	.556	.603
Run time & BMI & age (overuse, at-risk women)	.582	.012	.000	.559	.605

The test result variable(s): age, Run time, BMI, Run time & age (overuse, at-risk women), BMI & age (overuse, at-risk women), Run time & BMI (overuse, at-risk women), Run time & BMI & age (overuse, at-risk women) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI above 27.5 or below 21).

Table E-4. Decision Matrices for APFT Run Time Cut-Points Identified as Potentially Optimal (n=2,577, Most At-Risk* Women, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside Regulation AND APFT run time 17:30 or slower:		Overuse Injury	No Overuse Injury	Total
Most at-risk* Soldiers	Identified for referral	1,730	847	*2,577*
	Not identified for referral	0	0	*0*
	Total	*1,730*	*847*	*2,577*
All Soldiers	Identified for referral	1,730	847	*2,577*
	Not identified for referral	8,347	6,344	*14,691*
	Total	*10,077*	*7,191*	*17,268*

Table E-4 (continued):
Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)
Note: Highlighted cells emphasize those that would have been correctly categorized as injured or not injured, using the proposed referral guidelines.

E-2 All Diagnosed Injuries, Most At-Risk, Active Duty Army

E-2.1 Men

Table E-5. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=23,394, Most At-Risk* Men, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.529	.004	.000	.522	.537
BMI	.540	.004	.000	.532	.548
Run time	.572	.004	.000	.564	.579
BMI & age (at-risk men)	.556	.004	.000	.548	.564
Run time & BMI (at-risk men)	.577	.004	.000	.569	.585
Run time & age (at-risk men)	.579	.004	.000	.571	.587
Run time & BMI & age (at-risk men)	.585	.004	.000	.577	.593

The test result variable(s): age, BMI, Run time, BMI & age (at-risk men), Run time & BMI (at-risk men), Run time & age (at-risk men), Run time & BMI & age (at-risk men) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
APFT = Army Physical Fitness Test
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table E-6. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=23,394, Most At-Risk* Men, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.000	0	0.709	N/A	0.71	100%	24%
15:30	0.883	0.147	0.716	0.341	0.67	87%	21%
16:00	0.657	0.430	0.737	0.340	0.59	63%	15%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

E-2.2 Women

Table E-7. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=2,577, Most At-Risk* Women, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.474	.014	.073	.447	.501
Run time	.589	.014	.000	.562	.617
BMI	.590	.014	.000	.562	.618
BMI & age (at-risk women)	.586	.014	.000	.559	.614
Run time & age (at-risk women)	.589	.014	.000	.562	.616
Run time & BMI (at-risk women)	.609	.014	.000	.582	.636
Run time & BMI & age (at-risk women)	.607	.014	.000	.580	.634

The test result variable(s): age, Run time, BMI, BMI & age (at-risk women), Run time & age (at-risk women), Run time & BMI (at-risk women) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table E-8. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=2,577, Most At-Risk* Women, Active Duty Army, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.81	N/A	0.81	100%	15%
18:00	0.91	0.11	0.82	0.24	0.76	91%	14%
18:30	0.76	0.34	0.83	0.25	0.68	74%	11%

Table E-8 (continued):
Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

E-3 Diagnosed Overuse Injuries, Active Duty Army

E-3.1 Men

Table E-9. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=97,542, Men, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.531	.002	.000	.528	.535
BMI	.555	.002	.000	.551	.558
Run time	.571	.002	.000	.568	.575
BMI & age (men, overuse)	.560	.002	.000	.556	.564
Run time & age (men, overuse)	.575	.002	.000	.571	.578
Run time & BMI (men, overuse)	.577	.002	.000	.573	.581
Run time & BMI & age (men, overuse)	.579	.002	.000	.575	.583

The test result variable(s): age, BMI, Run time, BMI & age (men, overuse), Run time & age (men, overuse), Run time & BMI (men, overuse), Run time & BMI & age (men, overuse) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table E-10. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=97,542, Men, Active Duty Army, CY2017) †

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:30	0.28	0.81	0.56	0.56	0.56	23%
16:00	0.21	0.87	0.58	0.55	0.56	17%
16:30	0.14	0.92	0.61	0.55	0.55	11%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

E-3.2 Women

Table E-11. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk Based on Combinations of Fitness Test Performance, Body Composition, and Age (n=17,268, Women, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.483	.004	.000	.474	.492
BMI	.553	.004	.000	.544	.562
Run time	.587	.004	.000	.579	.596
BMI & age (women, overuse)	.554	.004	.000	.545	.563
Run time & age (women, overuse)	.589	.004	.000	.581	.598
Run time & BMI (women, overuse)	.589	.004	.000	.580	.598
Run time & BMI & age (women, overuse)	.591	.004	.000	.583	.600

The test result variable(s): age, BMI, Run time, BMI & age (women, overuse), Run time & age (women, overuse), Run time & BMI (women, overuse), Run time & BMI & age (women, overuse) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table E-12. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=17,268, Women, Active Duty Army, CY2017) †

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.25	0.83	0.67	0.44	0.49	22%
18:30	0.20	0.87	0.69	0.44	0.48	17%
19:00	0.18	0.95	0.83	0.45	0.50	13%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

E-4 All Diagnosed Injuries, Active Duty Army

E-4.1 Men

Table E-13. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=97,542, Men, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.549	.002	.000	.545	.552
BMI	.564	.002	.000	.560	.567
Run time	.579	.002	.000	.576	.583
BMI & age (men)	.575	.002	.000	.572	.579
Run time & BMI (men)	.587	.002	.000	.583	.590
Run time & age (men)	.589	.002	.000	.585	.592
Run time & BMI & age (men)	.593	.002	.000	.590	.597

The test result variable(s): age, BMI, Run time, BMI & age (men), Run time & BMI (men), Run time & age (men), Run time & BMI & age (men) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table E-14. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=97,542, Men, Active Duty Army, CY2017) †

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:30	0.27	0.82	0.71	0.42	0.49	23%
16:00	0.20	0.89	0.73	0.41	0.46	17%
16:30	0.13	0.93	0.76	0.40	0.44	11%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

E-4.2 Women

Table E-15. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=17,268, Women, Active Duty Army, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.485	.005	.003	.476	.495
BMI	.565	.005	.000	.556	.574
Run time	.595	.005	.000	.585	.604
BMI & age (women)	.565	.005	.000	.556	.575
Run time & age (women)	.596	.005	.000	.587	.605
Run time & BMI (women)	.599	.005	.000	.589	.608
Run time & BMI & age (women)	.600	.005	.000	.591	.610

The test result variable(s): age, BMI, Run time, BMI & age (women), Run time & age (women), Run time & BMI (women), Run time & BMI & age (women) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table E-16. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=17,268, Women, Active Duty Army, CY2017) †

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.24	0.85	0.81	0.30	0.41	22%
18:30	0.20	0.89	0.82	0.30	0.39	18%
19:00	0.15	0.92	0.83	0.29	0.36	13%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

Appendix F

Receiver Operating Characteristic and Sensitivity Cut-Point Analyses: U.S. Forces Command Soldiers

F-1 Diagnosed Overuse Injuries, Most At-Risk, U.S. Forces Command

F-1.1 Men

Table F-1. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=12,129, Most At-Risk* Men, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.508	.005	.116	.498	.519
BMI	.543	.005	.000	.533	.553
Run time	.575	.005	.000	.565	.585
BMI & age (at-risk men, overuse, FORSCOM)	.546	.005	.000	.536	.556
Run time & age (at-risk men, overuse, FORSCOM)	.576	.005	.000	.566	.586
Run time & BMI (at-risk men, overuse, FORSCOM)	.581	.005	.000	.571	.591
Run time & BMI & age (at-risk men, overuse, FORSCOM)	.582	.005	.000	.572	.592

The test result variable(s): age, BMI, Run time, BMI & age (at-risk men, overuse, FORSCOM), Run time & age (at-risk men, overuse, FORSCOM), Run time & BMI (at-risk men, overuse, FORSCOM), Run time & BMI & age (at-risk men, overuse, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index;
FORSCOM = U.S. Forces Command
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table F-2. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=12,129, Most At-Risk* Men, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0.00	0.56	N/A	0.56	100%	24%
15:30	0.89	0.15	0.57	0.52	0.56	87%	21%
16:00	0.66	0.43	0.60	0.51	0.56	62%	15%
16:30	0.46	0.65	0.62	0.49	0.54	41%	10%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

F-1.2 Women

Table F-3. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=1,173, Most At-Risk* Women, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.465	.018	.053	.431	.500
Run time	.574	.017	.000	.540	.608
BMI	.578	.018	.000	.543	.612
Run time & age (at-risk women, overuse, FORSCOM)	.578	.017	.000	.544	.612
BMI & age (at-risk women, overuse, FORSCOM)	.583	.017	.000	.548	.617
Run time & BMI (at-risk women, overuse, FORSCOM)	.596	.017	.000	.562	.630
Run time & BMI & age (at-risk women, overuse, FORSCOM)	.596	.017	.000	.562	.630

The test result variable(s): age, Run time, BMI, Run time & age (at-risk women, overuse, FORSCOM), BMI & age (at-risk women, overuse, FORSCOM), Run time & BMI (at-risk women, overuse, FORSCOM), Run time & BMI & age (at-risk women, overuse, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table F-4. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=1,173, Most At-Risk* Women, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.67	N/A	0.67	100%	16%
18:00	0.92	0.10	0.68	0.40	0.65	91%	15%
18:30	0.76	0.32	0.70	0.39	0.61	73%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

F-2 All Diagnosed Injuries, Most At-Risk, FORSCOM

F-2.1 Men

Table F-5. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=12,129, Most At-Risk* Men, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.530	.006	.000	.519	.541
BMI	.547	.006	.000	.536	.558
Run time	.589	.005	.000	.578	.600
BMI & age (at-risk men, FORSCOM)	.562	.006	.000	.551	.573
Run time & age (at-risk men, FORSCOM)	.595	.005	.000	.584	.606
Run time & BMI (at-risk men, FORSCOM)	.596	.005	.000	.586	.607
Run time & BMI & age (at-risk men, FORSCOM)	.602	.005	.000	.592	.613

The test result variable(s): age, BMI, Run time, BMI & age (at-risk men, FORSCOM), Run time & age (at-risk men, FORSCOM), Run time & BMI (at-risk men, FORSCOM), Run time & BMI & age (at-risk men, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table F-6. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=12,129, Most At-Risk* Men, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0.00	0.704	N/A	0.70	100%	24%
15:30	0.88	0.16	0.71	0.37	0.67	87%	21%
16:00	0.65	0.46	0.74	0.36	0.60	62%	15%
16:30	0.45	0.68	0.67	0.54	0.52	41%	10%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

F-2.2 Women

Table F-7. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=1,173, Most At-Risk* Women, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.464	.020	.100	.424	.505
BMI	.576	.021	.000	.535	.617
Run time	.595	.021	.000	.555	.636
BMI & age (at-risk women, FORSCOM)	.573	.021	.001	.532	.613
Run time & age (at-risk women, FORSCOM)	.596	.020	.000	.556	.636
Run time & BMI (at-risk women, FORSCOM)	.600	.020	.000	.560	.640
Run time & BMI & age (at-risk women, FORSCOM)	.603	.020	.000	.563	.643

The test result variable(s): age, BMI, Run time, BMI & age (at-risk women, FORSCOM), Run time & age (at-risk women, FORSCOM), Run time & BMI (at-risk women, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table F-8. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=1,173, Most At-Risk* Women, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk* population identified for referral	% at-risk population identified for referral
17:30	1.00	0.00	0.81	N/A	0.81	100%	16%
18:00	0.80	0.28	0.83	0.24	0.70	78%	12%
18:30	0.75	0.36	0.84	0.25	0.68	73%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

F-3 Diagnosed Overuse Injuries, FORSCOM

F-3.1 Men

Table F-9. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=50,656, Men, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.531	.003	.000	.526	.536
BMI	.558	.003	.000	.553	.563
Run time	.584	.003	.000	.579	.589
BMI & age (men, overuse, FORSCOM)	.563	.003	.000	.558	.568
Run time & age (men, overuse, FORSCOM)	.587	.003	.000	.582	.592
Run time & BMI (men, overuse, FORSCOM)	.588	.003	.000	.583	.593
Run time & BMI & age (men, overuse, FORSCOM)	.590	.003	.000	.585	.595

The test result variable(s): age, BMI, Run time, BMI & age (men, overuse, FORSCOM), Run time & age (men, overuse, FORSCOM), Run time & BMI (men, overuse, FORSCOM), Run time & BMI & age (men, overuse, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command

Table F-10. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=50,656, Men, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:30	0.29	0.81	0.56	0.58	0.57	24%
16:00	0.21	0.88	0.59	0.57	0.57	16%
16:30	0.15	0.93	0.62	0.56	0.57	11%

Legend:
APFT = Army Physical Fitness test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population

F-3.2 Women

Table F-11. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=7,437, Women, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.482	.007	.009	.469	.496
BMI	.551	.007	.000	.537	.564
Run time	.595	.007	.000	.582	.609
BMI & age (women, overuse, FORSCOM)	.552	.007	.000	.538	.565
Run time & BMI (women, overuse, FORSCOM)	.595	.007	.000	.582	.608
Run time & age (women, overuse, FORSCOM)	.596	.007	.000	.583	.609
Run time & BMI & age (women, overuse, FORSCOM)	.596	.007	.000	.583	.609

The test result variable(s): age, BMI, Run time, BMI & age (women, overuse, FORSCOM), Run time & BMI (women, overuse, FORSCOM), Run time & age (women, overuse, FORSCOM), Run time & BMI & age (women, overuse, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command

Table F-12. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=7,437, Women, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.29	0.80	0.67	0.44	0.50	26%
18:30	0.23	0.85	0.69	0.43	0.48	20%
19:00	0.17	0.90	0.71	0.43	0.47	14%

Table F-12 (continued):
Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
[†]Results shown for acceptable '% referred' values, 10-25% of population

F-4 All Diagnosed Injuries, FORSCOM

F-4.1 Men

Table F-13. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=50,656, Men, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.541	.003	.000	.536	.546
BMI	.563	.003	.000	.558	.568
Run time	.590	.003	.000	.585	.595
BMI & age (men, FORSCOM)	.571	.003	.000	.566	.576
Run time & BMI (men, FORSCOM)	.594	.003	.000	.589	.599
Run time & age (men, FORSCOM)	.596	.003	.000	.591	.601
Run time & BMI & age (men, FORSCOM)	.599	.003	.000	.594	.604

The test result variable(s): age, BMI, Run time, BMI & age (men, FORSCOM), Run time & BMI (men, FORSCOM), Run time & age (men, FORSCOM), Run time & BMI & age (men, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command

Table F-14. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=50,656, Men, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:30	0.28	0.83	0.71	0.44	0.50	24%
16:00	0.20	0.89	0.74	0.43	0.48	16%
16:30	0.14	0.94	0.77	0.42	0.46	11%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population

F-4.2 Women

Table F-15. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=7,437, Women, FORSCOM, CY2017)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.484	.007	.030	.469	.498
BMI	.558	.007	.000	.544	.573
Run time	.608	.007	.000	.593	.622
BMI & age (women FORSCOM)	.558	.007	.000	.544	.572
Run time & age (women, FORSCOM)	.607	.007	.000	.593	.622
Run time & BMI (women, FORSCOM)	.608	.007	.000	.593	.622
Run time & BMI & age (women, FORSCOM)	.608	.007	.000	.594	.622

The test result variable(s): age, BMI, Run time, BMI & age (women FORSCOM), Run time & age (women, FORSCOM), Run time & BMI (women, FORSCOM), Run time & BMI & age (women, FORSCOM) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
FORSCOM = U.S. Forces Command

Table F-16. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=7,437, Women, FORSCOM, CY2017)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.26	0.84	0.81	0.30	0.42	23%
18:30	0.21	0.88	0.83	0.29	0.39	18%
19:00	0.15	0.92	0.84	0.29	0.37	13%

Legend:
APFT = Army Physical Fitness Test

Table F-16 Legend (continued):
AR = Army Regulation
BMI = body mass index
FORSCOM = U.S. Forces Command
†Results shown for acceptable "% referred" values, 10–25% of population

Appendix G

Receiver Operating Characteristic and Sensitivity Cut-Point Analyses: Airborne Division, Fort Campbell, Kentucky

G-1 Self-Reported Overuse Injuries, Most At-Risk, Airborne Division, Fort Campbell

G-1.1 Men

Table G-1. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and age (n=844, Most At-Risk* Men, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.517	.023	.470	.471	.562
Run time	.544	.022	.058	.500	.588
age	.592	.022	.000	.549	.635
Run time & BMI (at-risk men, overuse, Campbell)	.544	.023	.056	.500	.588
Run time & age (at-risk men, overuse, Campbell)	.592	.022	.000	.549	.636
BMI & age (at-risk men, overuse, Campbell)	.593	.022	.000	.550	.636
Run time & BMI & age (at-risk men, overuse, Campbell)	.592	.022	.000	.549	.635

The test result variable(s): BMI, Run time, age, Run time & BMI (at-risk men, overuse, Campbell), Run time & age (at-risk men, overuse, Campbell), BMI & age (at-risk men, overuse, Campbell), Run time & BMI & age (at-risk men, overuse, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table G-2. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=844, Most At-Risk* Men, Airborne Division, Fort Campbell, April 2015–July 2016)[†]

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0	0.25	N/A	0.29	100%	16%
15:30	0.92	0.10	0.25	0.80	0.31	90%	14%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
[†]Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table G-3. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=69, Most At-Risk* Women, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.498	.077	.980	.346	.650
age	.551	.074	.481	.406	.696
Run time	.559	.076	.421	.410	.707
BMI & age (at-risk women, overuse, Campbell)	.503	.078	.965	.351	.655
Run time & BMI (at-risk women, overuse, Campbell)	.559	.076	.421	.410	.707
Run time & age (at-risk women, overuse, Campbell)	.558	.076	.424	.410	.706
Run time & BMI & age (at-risk women, overuse, Campbell)	.559	.076	.417	.411	.707

The test result variable(s): BMI, age, Run time, BMI & age (at-risk women, overuse, Campbell), Run time & BMI (at-risk women, overuse, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table G-4. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=69, Most At-Risk* Women, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.64	N/A	0.64	100%	13%
18:00	1.00	0.08	0.66	1.00	0.67	97%	13%
18:30	0.77	0.24	0.64	0.38	0.58	77%	10%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

G-2 All Self-Reported Injuries, Most At-Risk, Airborne Division, Fort Campbell

G-2.1 Men

Table G-5. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=844, Most At-Risk* Men, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.545	.020	.024	.506	.584
BMI	.558	.020	.003	.519	.597
Run time	.589	.020	.000	.551	.627
BMI & age (at-risk men, Campbell)	.561	.020	.002	.522	.599
Run time & age (at-risk men, Campbell)	.587	.020	.000	.549	.625
Run time & BMI (at-risk men, Campbell)	.599	.019	.000	.560	.637
Run time & BMI & age (at-risk men, Campbell)	.592	.019	.000	.554	.631

The test result variable(s): age, BMI, Run time, BMI & age (at-risk men, Campbell), Run time & age (at-risk men, Campbell), Run time & BMI (at-risk men, Campbell), Run time & BMI & age (at-risk men, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table G-6. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=844, Most At-Risk* Men, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0.00	0.500	N/A	0.50	100%	16%
15:30	0.92	0.12	0.51	0.60	0.52	90%	14%

Legend:
APFT = Army Physical Readiness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

G-2.2 Women

Table G-7. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=69, Most At-Risk* Women, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.466	.071	.627	.325	.606
age	.559	.071	.405	.420	.698
Run time	.584	.069	.238	.448	.719
BMI & age (at-risk women, Campbell)	.526	.071	.711	.387	.665
Run time & age (at-risk women, Campbell)	.586	.069	.226	.450	.721
Run time & BMI (at-risk women, Campbell)	.596	.069	.177	.461	.731
Run time & BMI & age (at-risk women, Campbell)	.595	.069	.181	.460	.730

The test result variable(s): BMI, age, Run time, BMI & age (at-risk women, Campbell), Run time & age (at-risk women, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table G-8. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=69, Most At-Risk* Women, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.58	N/A	0.58	100%	13%
18:00	0.95	0.00	0.57	0.00	0.55	97%	13%
18:30	0.73	0.17	0.55	0.31	0.49	77%	10%

Legend:
APFT = Army Physical Fitness Test

Table G-8 Legend (continued):
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

G-3 Self-Reported Overuse Injuries, Airborne Division, Fort Campbell

G-3.1 Men

Table G-9. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=5,315 Men, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.572	.011	.000	.551	.593
Run time	.593	.010	.000	.572	.613
age	.616	.010	.000	.596	.636
Run time & BMI (men, overuse, Campbell)	.602	.010	.000	.582	.622
BMI & age (men, overuse, Campbell)	.620	.010	.000	.600	.640
Run time & age (men, overuse, Campbell)	.633	.010	.000	.614	.653
Run time & BMI & age (men, overuse, Campbell)	.634	.010	.000	.615	.654

The test result variable(s): BMI, Run time, age, Run time & BMI (men, overuse, Campbell), BMI & age (men, overuse, Campbell), Run time & age (men, overuse, Campbell), Run time & BMI & age (men, overuse, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table G-10. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=5,315 Men, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:00	0.32	0.80	0.24	0.85	0.71	22%
15:30	0.25	0.84	0.24	0.85	0.74	17%
16:00	0.16	0.91	0.26	0.84	0.78	10%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

G-3.2 Women

Table G-11. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=516 Women, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.516	.029	.569	.459	.574
Run time	.563	.029	.026	.507	.620
age	.572	.029	.012	.515	.629
Run time & BMI (women, overuse, Campbell)	.563	.029	.027	.506	.620
BMI & age (women, overuse, Campbell)	.571	.029	.013	.514	.628
Run time & age (women, overuse, Campbell)	.589	.028	.002	.533	.644
Run time & BMI & age (women, overuse, Campbell)	.588	.028	.002	.532	.643

The test result variable(s): BMI, Run time, age, Run time & BMI (women, overuse, Campbell), BMI & age (women, overuse, Campbell), Run time & age (women, overuse, Campbell) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table G-12. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=516 Women, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.28	0.77	0.32	0.74	0.64	24%
18:30	0.23	0.83	0.34	0.74	0.66	19%
19:00	0.19	0.90	0.60	0.60	0.59	14%

Legend:
APFT = Army Physical Fitness Test

Table G-12. Legend (continued):
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

G-4 All Self-Reported Injuries, Airborne Division, Fort Campbell

G-4.1 Men

Table G-13. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=5,315 Men, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.584	.008	.000	.568	.601
age	.598	.008	.000	.582	.614
Run time	.609	.008	.000	.593	.625
BMI & age (men)	.614	.008	.000	.598	.629
Run time & BMI (men)	.618	.008	.000	.602	.634
Run time & age (men)	.634	.008	.000	.619	.650
Run time & BMI & age (men)	.637	.008	.000	.621	.653

The test result variable(s): BMI, age, Run time, BMI & age (men), Run time & BMI (men), Run time & age (men), Run time & BMI & age (men) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table G-14. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=5,315 Men, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:00	0.31	0.82	0.48	0.69	0.64	22%
15:30	0.25	0.87	0.50	0.68	0.65	17%
16:00	0.16	0.93	0.54	0.68	0.66	10%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

G-4.2 Women

Table G-15. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=516 Women, Airborne Division, Fort Campbell, April 2015–July 2016)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.530	.026	.242	.479	.581
age	.557	.026	.026	.507	.608
Run time	.603	.025	.000	.554	.653
BMI & age (women)	.554	.026	.037	.503	.604
Run time & BMI (women)	.604	.025	.000	.555	.654
Run time & age (women)	.613	.025	.000	.564	.662
Run time & age & BMI (women)	.615	.025	.000	.566	.664

The test result variable(s): BMI, age, Run time, BMI & age (women), Run time & BMI (women), Run time & age (women) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table G-16. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=516 Women, Airborne Division, Fort Campbell, April 2015–July 2016)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:00	0.28	0.77	0.55	0.61	0.59	24%
18:30	0.23	0.83	0.56	0.60	0.59	19%
19:00	0.19	0.90	0.60	0.60	0.59	14%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

Appendix H

Receiver Operating Characteristic and Sensitivity Cut-Point Analyses: Infantry Division, Fort Carson, Colorado

H-1 Self-Reported Overuse Injuries, Most At-Risk, Infantry Division, Fort Carson

H-1.1 Men

Table H-1. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=750, Most At-Risk* Men, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Run time	.527	.022	.218	.484	.571
BMI	.531	.022	.165	.487	.574
age	.573	.022	.001	.531	.616
Run time & BMI (at-risk men, overuse, Carson)	.537	.022	.096	.494	.580
Run time & age (at-risk men, overuse, Carson)	.565	.022	.003	.522	.607
BMI & age (at-risk men, overuse, Carson)	.580	.022	.000	.538	.622
Run time & BMI & age (at-risk men, overuse, Carson)	.568	.022	.002	.526	.611

The test result variable(s): Run time, BMI, age, Run time & BMI (at-risk men, overuse, Carson), Run time & age (at-risk men, overuse, Carson), BMI & age (at-risk men, overuse, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table H-2. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=750, Most At-Risk* Men, Infantry Division, Fort Carson 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0.00	0.36	N/A	0.36	100%	18%
15:30	0.92	0.08	0.43	0.62	0.38	92%	16%
16:00	0.72	0.30	0.36	0.66	0.45	71%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

H-1.2 Women

Table H-3. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=59, Most At-Risk* Women, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.529	.078	.709	.376	.681
Run time	.572	.082	.351	.413	.732
BMI	.593	.078	.231	.440	.746
BMI & age (at-risk women, overuse, Carson)	.591	.079	.244	.436	.746
Run time & BMI (at-risk women, overuse, Carson)	.596	.079	.217	.441	.751
Run time & age (at-risk women, overuse, Carson)	.598	.079	.208	.442	.753
Run time & BMI & age (at-risk women, overuse, Carson)	.610	.078	.157	.458	.762

The test result variable(s): age, Run time, BMI, Run time & BMI (at-risk women, overuse, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table H-4. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=59, Most At-Risk* Women, Infantry Division, Fort Carson, 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.39	N/A	0.39	100%	17%
18:00	1.00	0.08	0.41	1.00	0.44	95%	16%
18:30	0.70	0.25	0.37	0.56	0.42	73%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

H-2 All Self-Reported Injuries, Most At-Risk, Infantry Division, Fort Carson

H-2.1 Men

Table H-5. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=750, Most At-Risk* Men, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Run time	.517	.021	.433	.475	.558
BMI	.524	.021	.258	.483	.565
age	.565	.021	.002	.524	.606
Run time & BMI (at-risk men, Carson)	.527	.021	.205	.485	.568
Run time & age (at-risk men, Carson)	.550	.021	.018	.509	.591
BMI & age (at-risk men, Carson)	.568	.021	.001	.527	.610
Run time & BMI & age (at-risk men, Carson)	.553	.021	.012	.512	.595

The test result variable(s): Run time, BMI, age, Run time & BMI (at-risk men, Carson), Run time & age (at-risk men, Carson), BMI & age (at-risk men, Carson), Run time & BMI & age (at-risk men, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

Table H-6. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=750, Most At-Risk* Men, Infantry Division, Fort Carson, 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
15:00	1.00	0.00	0.53	N/A	0.53	100%	18%
15:30	0.91	0.07	0.53	0.40	0.52	92%	16%
16:00	0.71	0.30	0.54	0.48	0.52	71%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those with slower than the average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

H-2.2 Women

Table H-7. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=59, Most At-Risk* Women, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Run time	.550	.076	.508	.400	.700
age	.578	.075	.304	.432	.725
BMI	.626	.074	.097	.481	.772
BMI & age (at-risk women, Carson)	.602	.074	.181	.456	.747
Run time & BMI (at-risk women, Carson)	.609	.074	.150	.465	.754
Run time & age (at-risk women, Carson)	.615	.074	.132	.469	.760
Run time & BMI & age (at-risk women, Carson)	.624	.074	.104	.480	.768

The test result variable(s): Run time, age, BMI, Run time & BMI (at-risk women, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index
*At-risk population defined as those with slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

Table H-8. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=59, Most At-Risk* Women, Infantry Division, Fort Carson, 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% at-risk population* identified for referral	% total population identified for referral
17:30	1.00	0.00	0.54	N/A	0.54	100%	17%
18:00	0.97	0.07	0.55	0.67	0.56	95%	16%
18:30	0.72	0.26	0.54	0.44	0.51	73%	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population
*At-risk population defined as those slower than the average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

H-3 Self-Reported Overuse Injuries, Infantry Division, Fort Carson

H-3.1 Men

Table H-9. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=4,261 Men, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.552	.010	.000	.532	.572
age	.571	.010	.000	.552	.591
Run time	.586	.010	.000	.566	.606
Run time & BMI (men, overuse, Carson)	.555	.010	.000	.535	.575
BMI & age (men, overuse, Carson)	.571	.010	.000	.551	.591
Run time & age (men, overuse, Carson)	.597	.010	.000	.577	.617
Run time & BMI & age (men, overuse, Carson)	.575	.010	.000	.555	.595

The test result variable(s): BMI, age, Run time, Run time & BMI (men, overuse, Carson), BMI & age (men, overuse, Carson), Run time & age (men, overuse, Carson), Run time & BMI & age (men, overuse, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table H-10. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=4,261 Men, Infantry Division, Fort Carson, 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:00	0.31	0.78	0.32	0.77	0.66	24%
15:30	0.25	0.84	0.34	0.77	0.69	18%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

H-3.2 Women

Table H-11. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Overuse Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=356 Women, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.488	.033	.723	.423	.554
Run time	.535	.032	.288	.472	.597
BMI	.555	.033	.092	.491	.619
Run time & age (women, overuse, Carson)	.537	.032	.256	.475	.600
BMI & age (women, overuse, Carson)	.555	.032	.091	.492	.619
Run time & BMI (women, overuse, Carson)	.555	.033	.094	.491	.619
Run time & BMI & age (women, overuse, Carson)	.551	.032	.116	.488	.615

The test result variable(s): age, Run time, BMI, Run time & age (women, overuse, Carson), BMI & age (women, overuse, Carson), Run time & BMI (women, overuse, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table H-12. Decision Measures for a Range of APFT Run Time Cut-Points for Overuse Injury Risk (n=356 Women, Infantry Division, Fort Carson, 2010–2011)[†]

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:30	0.20	0.82	0.35	0.68	0.62	19%
19:00	0.15	0.84	0.30	0.67	0.61	16%
19:30	0.13	0.86	0.37	0.68	0.64	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
[†]Results shown for acceptable "% referred" values, 10–25% of population

H-4 All Self-Reported Injuries, Fort Carson Infantry Division

H-4.1 Men

Table H-13. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=4,261 Men, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
BMI	.550	.009	.000	.532	.567
age	.560	.009	.000	.543	.578
Run time	.579	.009	.000	.561	.596
BMI & age (men, Carson)	.570	.009	.000	.553	.588
Run time & BMI (men, Carson)	.581	.009	.000	.563	.598
Run time & age (men, Carson)	.586	.009	.000	.569	.604
Run time & BMI & age (men, Carson)	.587	.009	.000	.570	.605

The test result variable(s): BMI, age, Run time, BMI & age (men, Carson), Run time & BMI (men, Carson), Run time & age (men, Carson), Run time & BMI & age (men, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table H-14. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=4,261 Men, Infantry Division, Fort Carson, 2010–2011)[†]

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
15:00	0.29	0.79	0.48	0.62	0.58	24%
15:30	0.23	0.85	0.50	0.62	0.59	18%
16:00	0.18	0.89	0.51	0.61	0.60	14%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
[†]Results shown for acceptable "% referred" values, 10–25% of population

H-4.2 Women

Table H-15. Area Under the Curve for Receiver Operating Characteristic Curves, Predicted Injury Risk based on Combinations of Fitness Test Performance, Body Composition, and Age (n=356 Women, Infantry Division, Fort Carson, 2010–2011)

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
age	.481	.031	.533	.421	.541
BMI	.529	.031	.337	.469	.589
Run time	.564	.030	.037	.504	.623
BMI & age (women, Carson)	.540	.031	.188	.481	.600
Run time & age (women, Carson)	.565	.030	.035	.505	.624
Run time & BMI (women, Carson)	.565	.030	.033	.506	.625
Run time & BMI & age (women, Carson)	.562	.030	.044	.502	.621

The test result variable(s): age, BMI, Run time, BMI & age (women, Carson), Run time & age (women, Carson), Run time & BMI (women, Carson) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Legend:
BMI = body mass index

Table H-16. Decision Measures for a Range of APFT Run Time Cut-Points for Injury Risk (n=356 Women, Infantry Division, Fort Carson, 2010–2011)†

Referral guidelines: BMI Outside AR 600-9 AND APFT run time greater than:	Sensitivity	Specificity	PPV (%)	NPV (%)	CR	% identified for referral
18:30	0.20	0.83	0.53	0.52	0.52	19%
19:00	0.16	0.84	0.48	0.51	0.50	16%
19:30	0.12	0.90	0.51	0.51	0.51	12%

Legend:
APFT = Army Physical Fitness Test
AR = Army Regulation
BMI = body mass index
†Results shown for acceptable "% referred" values, 10–25% of population

Appendix I

Receiver Operating Characteristic and Sensitivity Cut-Point Analyses: Summary

Table I-1. Receiver Operating Characteristic and Sensitivity Run Time Cut-Point Summary, Four Populations, Most At-Risk[a] Men

	Active Duty Army CY2017	FORSCOM CY2017	Airborne Division 2015–2016	Infantry Division 2010–2011
Total population included[b]	97,542	50,656	5,315	4,261
Population most at-risk	23,394 (24% of total)	12,129 (24% of total)	884 (17% of total)	750 (18% of total)
Proportion of at-risk population with overuse injury	56%[c]	56%[c]	25%[d]	36%[d]
Optimal[e] run-time cut-point combined with high or low BMI	***15:00***	***15:00***	***15:00***	***15:00***
Sensitivity	100% of at-risk with a diagnosed overuse injury would have been identified for referral	100% of at-risk with a diagnosed overuse injury would have been identified for referral	100% of at-risk with a self-reported overuse injury would have been identified for referral	100% of at-risk with a self-reported overuse injury would have been identified for referral
Specificity	0% of at-risk without diagnosed overuse injuries would not be identified for referral	0% of at-risk without overuse injuries would not be identified for referral	0% of at-risk without overuse injuries would not be identified for referral	0% of at-risk without overuse injuries would not be identified for referral
Positive Predictive Value	56% identified for referral had a diagnosed overuse injury	56% identified for referral had a diagnosed overuse injury	25% identified for referral had a self-reported overuse injury	43% identified for referral had a diagnosed overuse injury
Negative Predictive Value	N/A	N/A	N/A	N/A
% total male population referred	24%	24%	16%	18%

Legend:
BMI = body mass index
N/A = not applicable

[a] At-risk population defined as those with slower than the Active Duty Army average run time (>15:13) AND with extreme BMI (above 27.5 or below 19)

[b] Soldiers included in analyses were required to have all pertinent data points: APFT 2-mile run time; height and weight to calculate BMI; and age at time of injury.

[c] Proportion with at least one diagnosis meeting the definition of cumulative micro-traumatic injury in accordance with the Army injury definition (U.S. Army Public Health Center, 2017)

[d] Proportion who identified (within survey responses) at least one self-reported injury as resulting from overuse

[e] "Optimal" refers to the run time cut-point with highest sensitivity when combined with high and low BMI, and correctly referring at-risk Soldiers with overuse injuries.

Table I-2. Receiver Operating Characteristic and Sensitivity Run Time Cut-Point Summary, Four Populations, Most At-Risk[a] Women

	Active Duty Army CY2017	FORSCOM CY2017	Airborne Division 2015–2016	Infantry Division 2010–2011
Total population[b]	17,268	7,437	516	356
Population most at-risk	2,577 (15% of total)	1,173 (16% of total)	69 (13% of total)	59 (17% of total)
Proportion of at-risk population with overuse injury	67%[c]	67%[c]	36%[d]	39%[d]
Optimal[e] run-time cut-point combined with high or low BMI	***17:30***	***17:30***	***17:30***	***17:30***
Sensitivity	100% of at-risk with a diagnosed overuse injury would have been identified for referral	100% of at-risk with a diagnosed overuse injury would have been identified for referral	100% of at-risk with a self-reported overuse injury would have been identified for referral	100% of at-risk with a self-reported overuse injury would have been identified for referral
Specificity	0% of at-risk without diagnosed overuse injuries would not be identified for referral	0% of at-risk without overuse injuries would not be identified for referral	8% of at-risk without overuse injuries would not be identified for referral	10% of at-risk without overuse injuries would not be identified for referral
Positive Predictive Value	56% identified for referral had a diagnosed overuse injury	67% identified for referral had a diagnosed overuse injury	66% identified for referral had a self-reported overuse injury	41% identified for referral had a self-diagnosed overuse injury
Negative Predictive Value	N/A	N/A	100% not identified for referral did not have a self-reported overuse injury	100% not identified for referral did not have a self-reported overuse injury
% total female population referred	15%	16%	13%	17%

Legend:
BMI = body mass index
N/A = not applicable

[a] At-risk population defined as those with slower than the Active Duty Army average run time (>17:45) AND with extreme BMI (above 27.5 or below 21)

[b] Soldiers included in analyses were required to have all pertinent data points: APFT 2-mile run time; height and weight to calculate BMI; and age at time of injury

[c] Proportion with at least one diagnosis meeting the definition of cumulative micro-traumatic injury in accordance with the Army injury definition (U.S. Army Public Health Center, 2017)

[d] Proportion who identified (within survey responses) at least one self-reported injury as resulting from overuse.

[e] "Optimal" refers to the run time cut-point with highest sensitivity when combined with high and low BMI, and correctly referring at-risk Soldiers with overuse injuries.