International Journal of
Science and Engineering Investigations vol. 1, issue 10, November 2012
ISSN: 2251-8843

Body Mass Index and Army Physical Fitness Test Standards in ROTC Cadets

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***Abstract*-**The United States Army administers fitness tests and collects height and weight data for soldiers and cadets in order to determine a measure of physical readiness. This study examined individual test results from the U.S. Army's Physical Fitness Test (PFT) and respective Body Mass Index (BMI) to see if any association existed in male ROTC (Reserve Officer Training Corps**.)** cadets. If a correlation was found between BMI and PFT scores, then leaders could more accurately predict how an individual would perform on an upcoming fitness evaluation. 145 male (age 17-31) ROTC college students' PFT scores and BMI measurements were analyzed via a Pearson Correlation Coefficient to determine if a meaningful correlation existed between them. Raw and point adjusted (percentiles) scores were evaluated. There was no meaningful relationship found between BMI and an individual's respective scores on push-ups, sit-ups, or two mile run times. BMI is not an accurate predictor of Army PFT scores for male cadets in the age range of 17-31. Further studies are required to determine if an association exists between an individual's PFT scores and other anthropometric measurements as well as applicability to both genders and other age groups.

Keywords- *Body Mass Index; ROTC (Reserve Officer Training Corps.); PFT (Physical Fitness Test).*

I. INTRODUCTION

Ever since the world's first army was formed there arose a requirement for these soldiers to maintain a high level of physical fitness. The training for these soldiers had two conditions: it needed to effect results that were directly applicable to the soldier's duties and it could not require any extra equipment for the army to furnish. The trainings' design needed to incorporate methods that were not only effective, but also simplistic and required no extra implements for the army to purchase or carry as they moved. A standard was also set for all soldiers to attain; ensuring their level of physical fitness was at an acceptable level.

For millennia soldiers have exercised with rocks, ropes, and other items easily accessible to them. This has had a dual benefit of providing them with quality physical training while not allocating any of the army's precious resources. Current trends in the military now have reverted back to this simple yet effective method of training. The United States Army has recently adopted physical training activities such as the 'tire roll', where soldiers push a tire end over end and the sandbag carry. These exercises cost almost nothing, can be found pretty much anywhere and therefore, do not need to be packaged and moved, and are yet still effective training methods. Soldiers and athletes alike have similar physical movements to perform, and therefore require similar strength and conditioning preparation. The Army physical fitness test has applications to many athletes outside of the military.

Being extremely similar to combative sports, often the most important force a soldier can generate in any military engagement is simply body movement. Soldiers need to be able to lift themselves over a wall, climb a rope, pull themselves into a boat, or fight in hand-to-hand combat. All of these necessary movements are not one-time events. They are not slow and grinding 1RM attempts, but instead need to be fast and repeated quickly. This is the reason that a lot of military training is tailored more to endurance, than pure strength. Push-ups and sit-ups are exercises that depend solely on body movement and are endurance events, not pure strength exercises. Similarly, for the Army's running standard, a medium distance of two miles is used. This has a dual benefit of ensuring the soldier's running fitness is maintained, as well as reducing their body fat percentage.

While testing minimums for the push-up, sit-up, and two mile run are established, a standard method is also needed to gauge an individual's overall level of fitness and general health. One popular current method used to measure fitness and health is BMI, or Body Mass Index. This uses a person's height and mass to calculate a BMI value [1]. There are known health risks associated with an elevated BMI. BMI does not require any expensive equipment or specialized training, and is also extremely easy to calculate. Due to the military's scarce economic resources and the expense needed to train just one recruit, the use of BMI makes it an attractive tool for the United States Army, especially considering the fact that the data required to calculate BMI (height and weight) is already being measured. The use of Body Mass Index may be an

accurate predictor for an individual's physical fitness levels of push-ups, sit-ups, and two mile run.

II. METHODS

Previously collected data was gathered for analysis from current ROTC (Reserve Officer Training Corps.) programs in the state of Utah, United States. The two universities who cooperated in providing almost 200 fitness test results were Southern Utah University and Brigham Young University. Both universities had a qualified Physical Fitness Test evaluator compile the results. IRB approval was obtained from Southern Utah University's Institutional Review Board for the use of Humans in Research prior to data gathering and analysis.

The Army physical fitness test (PFT) is comprised of four tests: the push-up, sit-up, the two mile run and the sit-and-reach test. The variables explored in this study were the push-up, sit-up, and the two mile run.

The push-up is a very common exercise used to increase one's strength in weaker individuals, and increase muscular endurance in stronger athletes [2]. While the standard push-up has the hands and feet on the ground, there is almost an endless possible variation that can be used to perform the exercise. This is a very practical exercise when training an athlete or soldier for upper-body muscular endurance; the individual becomes accustomed to moving their bodyweight quickly and repeatedly using their upper body strength. Due to the endurance nature of the exercise, push-ups are only moderately related to the bench press [3]. While appearing physiologically similar, the bench press is more of a pure strength exercise. The push-up variation that has produced the greatest GRF (ground reaction force) is with the feet elevated [2].

Push-ups have become the benchmark for not only the U.S. Army, but almost all organizations that need an easily obtained reference for upper-body muscular endurance. The Federal Bureau of Investigation has standards similar to the Army in push-ups, although less stringent [4]. The push-up also allows organizations to test all personnel regardless of sex. While females typically have to perform a fewer number of push-ups during a designated time period, they still perform the exercise the exact same way, meeting the same standard. Of all the push-up variations tested, there were no gender differences in response [2]. Push-ups have shown their effectiveness in military training, as soldiers are asked to carry heavier and heavier loads. The lack of ability to perform a minimum number of push-ups was one of four key determining factors for time-loss injuries in both men and women [5]. The push-up has proven itself to be practical, effective, and universal.

The sit-up is a very common exercise that is performed to improve abdominal strength. Having strong abdominal and lower back muscles is important for any individual, but even more so for a soldier that often is required to be on their feet for extended periods of time, all the while carrying heavy loads. The Army performs the sit-up test to determine the soldier's lower body muscular endurance [5]. While there have been many abdominal exercise devices introduced to the public, the military continues to perform variations of the sit-up unassisted. This requires no extra training devices, and performing abdominal crunches with these latest apparatuses has not shown to elicit any greater involvement of abdominal musculature than performing the same exercise unassisted [6]. Performing sit-ups to reduce abdominal obesity can be an effective method to reduce the health risks associated with a high BMI [7]. Similar to the push-up, the sit-up is a simple yet effective exercise for testing any individual.

The Army uses the two mile run to access the cardio respiratory endurance of their soldiers. While their respective cardio respiratory endurance could be tested using a stationary bike or rowing machine, the two mile run is preferred by the Army because soldiers need to be accustomed to marching/running to perform their duties. The Army has minimum times depending on age and gender. The British Army takes their run time minimums one more step by establishing minimums also for their specialty [8]. For example, a soldier in an elite Parachute Regiment has to complete their run over four minutes quicker than a soldier in the logistics field. While other distances such as 1.5 miles have been used to measure aerobic capacity, the two mile distance has proven to be a good distance for its soldiers. This distance is far enough to fully test the individual's cardio respiratory endurance, yet short enough to prevent fatigue and overuse injuries.

Body mass index is the independent variable in this study. BMI is a value that is calculated by using body mass adjusted for height (in kg/m^2) [1]. Many organizations around the world have standardized BMI cutoffs of 25 for overweight and 30 for obesity [9]. Each soldier's height and weight is taken before their physical fitness test. Because this data is recorded it allows us to determine if BMI is an accurate predictor of performance of the Army's fitness test.

All of the collected data was measured with the same methods. The instruments used were a calibrated scale to determine weight, wall chart to determine height, an instructor to count the number of push-ups and sit-ups, and another instructor with a stop watch at a pre-measured distance of exactly two miles to determine run times. Individuals taking the PFT are given a proper demonstration of a push-up and a sit-up and then each repetition of that exercise must be completed to that standard. For push-ups to be counted on the PFT the individual's back must be straight and they must descend to where their triceps muscles are parallel to the ground and rise fully locking the elbows. The standard for sit-ups requires the participant to touch their elbows to their knees while maintaining crossed arms across their upper chest.

All test data obtained from the Army ROTC commands was logged into and evaluated in Microsoft Excel. The Army PFT is scored out of 300 possible points, with each of the three categories (pushups, sit ups, and two mile run) accounting for 100 points. This is accomplished by placing raw scores for each event into a percentile ranking. For the purpose of this study, both raw scores and percentile ranks (Army PFT scoring points) were analyzed.

Pearson correlation coefficients (PCC) were calculated for each of the following comparisons with statistical significance

α=0.05. Raw scores and percentile points comparing BMI vs. push-ups, BMI vs. sit-ups, BMI vs. two mile run, and BMI vs. total score.

III. Results and Discussion

Of the almost 200 test results received, 145 were used in this study. There were only a few female scores in the group, providing too small a sample size, so those were excluded. This left only the male test results. The Army physical fitness test determines its results from age group brackets. These age groups are: 17-21, 22-26, 27-31, 32-36, 37-41, 42-46, 47-51, 52-56, 57-61, and 62+ [10]. There was also a very small sample size of results from individuals 32 and older. While the sliding age scale should compensate for any differences in raw scores, these few results were also omitted from the study. The required raw scores for the maximum 300 points are very similar for the age groups of 17-21, 22-26, and 27-31. Hence, all male 17-31 results have been combined together in Tables I and II.

Table III provides a correlation matrix of the relationships pertinent to this study. Significant relationships were determined for: BMI and Push-ups ($r= -0.11$: $p<0.05$), BMI and Sit-ups ($r= -0.15$: $p<0.05$), & BMI and 2-Mile Run ($r= 0.29$: $p<0.05$). While these relations were deemed significant via p-values (i.e. reliable) and statistical power (>80%), the relationships between variables were low. PCC values between 0 and ±0.19 are considered so small that it equates to relatively no meaningful relationship [11]. Further, the coefficient of determination ($CD=r^2$), a measure of common variance, ranged from 0.012-0.084. This would indicate 1.2-8.4% of PFT measures and BMI come from common factors. Conversely, this would indicate that 99.8-98.6% of PFT measures and BMI come from uncommon factors (i.e. unrelated factors) [11].

Analysis of percentiles scores for push-ups, sit-ups, and two mile run compared to BMI demonstrated further lack of meaningful correlation and are not reported. Hence, there was no meaningful correlation between a soldier's Body Mass Index and their respective Physical Fitness Test results (raw score or percentile score).

While this study was conducted using results from ROTC students in Utah, it effects soldiers/sailors/airmen, and more importantly their leaders, everywhere. The Army does not specifically calculate BMI for their fitness test, but they do record everybody's height and weight. These calculations can literally determine an individual keeping their job or not. Unfortunately, these height/weight charts have not been updated since 1987. The goal of this study was to determine if using these height and weight measurements to determine body mass index would be beneficial in predicting their physical fitness test results. If there was a correlation, then military leaders could use BMI (because semi-annual recording of height and weight is mandatory) to predict how their soldiers and commands will perform on the required fitness tests.

There were two main assumptions in this study. Both of these were due to the fact that the author did not personally witness or record the collection of scores. The first assumption is that all the recordings of height, weight, push-ups, sit-ups, and run times were accurately recorded. When testing a large group with only a handful of evaluators there can be errors in recording scores. However, only basic measurements such as height and weight were recorded. The second assumption is that all of the individuals being tested put forth a maximal effort. As all of these scores came from ROTC cadets who volunteer and desire a commission in the Army, maximal effort is shown to be the norm, rather than exception on physical fitness evaluations.

There were two limitations in this study. First was the sample size of results. While almost 200 results have been obtained from two different universities, this is only a small portion when considering the number of soldiers on active duty, or in training such as reservists or college cadets. Ideally, more ROTC scores from universities across the country would be made available. A second limitation was the age group of subjects used. All testing results have come from college-aged students, ranging from 17-31. While this is the most common age group in the Army, there are also older soldiers that also are required to perform the same fitness test.

TABLE I. PARTICIPANT PHYSICAL CHARACTERISTICS

	Age (yrs)	Height (meters)	Mass (kg)	BMI (kg/m^2)
Male Army ROTC Cadets (n=145)	21.6 (2.9)	1.8 (0.1)	77.1 (10.4)	23.9 (2.9)

Note: Participant physical characteristics; mean (STD).

TABLE II. PARTICIPANT PHYSICAL FITNESS TEST SCORES

	Push-ups (repetitions)	Sit-ups (repetitions)	2-Mile Run (seconds)
Male Army ROTC Cadets (n=145)	58.3 (15.0)	67.8 (13.8)	838.8 (92.6)

Note: Participant fitness test scores; mean (STD).

TABLE III. PARTICIPANT PHYSICAL FITNESS TEST SCORES AND BMI CORRELATION MATRIX

	BMI	Push-ups	Sit-ups	2-Mile Run
BMI	1.0	-0.11*	-0.15*	0.29*
Push-ups	-0.11*	1.0	N/A	N/A
Sit-ups	-0.15*	N/A	1.0	N/A
2-Mile Run	0.29*	N/A	N/A	1.0

Note: Pearson correlation coefficients (PCC=r) where "*" indicates significance at the $p<0.05$. N/A-indicates that the PCC was not reported as it was not pertinent to the research question.

The delimitations of this study were the age of the subjects and the simplicity of testing requirements. As previously noted all the subjects were of college age. This is the age group of incoming soldiers, enlisted as well as officer, which the Army hopes to predict performance levels. If any correlation is found

in these ROTC subjects, the same correlation can be applied to those soldiers entering the Army by means other than ROTC. With regards to evaluating PFT scores, the age of the ROTC subjects is the age group the Army wants to look at most closely. The levels of fitness in ROTC cadets have been shown to be on average, or slightly above, when compared with active-duty soldiers [12]. The second delimitation was the simplicity of testing. Evaluators needed to simply count the number of push-ups and sit-ups from a clear standard (triceps parallel to ground at the bottom of the exercise), and look at the stopwatch to record run times. These are very simple guidelines to follow. In addition, all military unit physical fitness evaluators have attended a common training school. This ensures that two fitness tests administered by different evaluators in different locations will be extremely comparable. Due to the common evaluator training and simple nature of the fitness exam, the results obtained for this study from multiple universities are known to be extremely consistent with each other.

This study predicted that there would not be a meaningful correlation between BMI and two minutes of push-ups, two minutes of sit-ups, followed by a two-mile run. This is exactly what was found. BMI is not an accurate predictor for the Army's physical fitness test. The reasons for this might include focusing solely on BMI, specifically using the Army's PFT, and the subject population.

The first possible reason is that this study focused specifically on body mass index. Other studies have found that certain anthropometric measurements can be accurate predictors of an individual's capability to perform sit-ups or push-ups. However, these studies used not only body mass index, but also waist circumference and body fat percentages, amongst other variables. This study focused solely on BMI because this information is already obtained twice a year, in concurrence with the fitness test. Isolating BMI was also important due to the fact that these measurements can significantly alter one's career. Continual occurrences of the word 'overweight' on an individuals' fitness report can have severe consequences, such as lack of promotion or even discharge from the service. Leaders need to be educated regarding height and weight standards. Too often leaders make incorrect perceptions about individuals based on their height and weight (essentially BMI) without taking into account their actual test results.

The second reason that this study found BMI is not an accurate predictor could be because the Army's Physical Fitness Test (PFT) was specifically targeted. Other studies simply evaluated the individual's capability to perform sit-ups, push-ups, or run short to medium distances. This study looked at one specific test which measures muscular endurance, not just simply the ability to perform one repetition. An individual performing a few sit-ups is very different than a soldier that has to perform those sit-ups with almost perfect form over a 120 second period. This study wanted to determine if any correlation existed with the PFT, not general fitness.

The third possible reason, and of most significance, that this study found BMI to not be an accurate predictor for the PFT dealt with the subject population. Almost all BMI studies look at either general public populations or groups with medical conditions, as BMI is used commonly to predict overall general health status. With trained athletes, this is not a concern as their overall health is typically far superior to the average individual. Athletes have been shown to have a higher BMI than non-athletes [13]. In addition, as athletes train harder for an upcoming season, their BMI tends to increase [14]. Even master's athletes have demonstrated higher than expected BMI given their excellent health status [15, 16, 17, 18, 19, 20, 21]. We must place soldiers in this category with trained athletes because of their initial intense training and continual adherence to physical fitness programs. The average soldier is not in the same health and fitness category as the average worker.

The main reason a soldiers' BMI is different than the average person is the addition of lean body mass. Most soldiers perform physically challenging tasks on a daily basis as well as carrying heavy external loads, increasing their muscle mass. Additionally, many soldiers participate in off-duty exercise programs. Some of these activities, such as bodybuilding, will obviously increase the individuals' bodyweight. These athletes may be 'overweight' when looking at height/weight chart, but they are actually in excellent physical condition and can easily pass the PFT. Even those participating in events that are more endurance related, such as a basketball league, will still have an increase in weight, and subsequent BMI measurement. Due to their unique job requirements and healthy lifestyles, soldiers need to be placed in the trained athlete category. This requires careful consideration when attempting to infer results of studies from the general population to active soldiers.

This study found no meaningful correlation between BMI and the Army's PFT. While BMI can still be useful in other areas, it is not to be used as a predictor for the standardized fitness test. Future studies are required to determine if other anthropometric measurements, teamed with BMI, might actually be beneficial as predictors for the PFT. For now, each soldier's height and weight will still be measured twice a year, but these measurements are not helpful outside of adherence to the chart's standards.

REFERENCES

[1] Gallagher, D., Heymsfield, S. B., Heo, M., Jebb, S. A., Murgatroyd, P. R., & Sakamoto, Y. (2000). Healthy percentage body fat ranges: An approach for developing guidelines based on body mass index. The American Journal of Clinical Nutrition, 72(3), 694-701.

[2] Ebben, W. P., Wurm, B., VanderZanden, T. L., Spadavecchia, M. L., Durocher, J. J., Bickham, C. T., & Petushek, E. J. (2011). Kinetic analysis of several variations of push-ups. Journal of Strength and Conditioning Research, 25(10), 2891-4.

[3] Mayhew, J. L., Ball, T. E., Arnold, M. D., & Bowen, J. C. (1991). Push-ups as a measure of upper body strength. The Journal of Applied Sport Science Research, 5(1), 272.

[4] FBI special agent physical lfitness test scoring scale. (n.d.). Retrieved October 9, 2011, from Federal Bureau of Investigation: http://www.fbijobs.gov

[5] Henning, P. C., Khamouri, A. V., & Brown, L. E. (2011). Preparatory strength and endurance training for U.S. Army basic combat training. Strength and Conditioning Journal, 33(5), 48-57.

[6] Whiting, W. C., Rugg, S., Coleman, A., & Vincent, W. J. (1999). Muscle activity during sit-ups using abdominal exercise devices. Journal of Strength and Conditioning Research, 13(4), 339-45.

[7] Wong, S. L., Katzmarzyk, P. T., Nichaman, M. Z., Church, T. S., Blair, S. N., & Ross, R. (2004). Cardiorespiratory fitness is associated with lower abdominal fat independent of body mass index. Medicine & Science in Sports & Exercise, 36(2), 286-91.

[8] Fit for the Army. (n.d.). Retrieved October 4, 2011, from The British Army Website: http://www.army.mod.uk/join

[9] Stevens, J., Juhaeri, Cai, J., & Jones, D. W. (2002). The effect of decision rules on the choice of a body mass index cutoff for obesity: examples from African American and white women. The American Journal of Clinical Nutrition, 75, 986-92.

[10] Army, D. O. (2010). Army Physical Readiness Training. Washington, D.C.

[11] Safrit, M. J., & Wood, T. M. (1995). Introduction to measurement in physical education and exercise science. (pp.71). Maryland Heights: Mosby.

[12] Thomas, D. Q., Lumpp, S. A., Schreiber, J. A., & Keith, J. A. (2004). Physical fitness profile of Army ROTC Cadets. Journal of Strength and Conditioning Research, 18(4), 904-7.

[13] Russell, A.R., Esco, M.R., Lizana, S.N., Williford, H.N., Olson, M.S., Kim, H. (2011). The accuracy of a BMI-based equation in predicting percent body fat in college-age female athletes. The Journal of Strength and Conditioning Research, 25(1), 35-36.

[14] Silvestre, R., Kraemer, W.J., West, C., Judelson, D.A., Spiering, B.A., Vingren, J.L., Hatfield, D.L., Anderson, J.M., Maresh, C.M. (2006). Body composition and physical performance during a national collegiate athletic association Division I men's soccer season. The Journal of Strength and Conditioning Research, 20(4), 962-70.

[15] Walsh, J., Climstein, M., Heazlewood, I.T., Burke, S., Kuttunen, J., Adams, K.J., & DeBeliso, M. (2011). Variations in body mass index with age in masters athletes (World Masters Games). Journal of the World Academy of Science, Engineering and Technology. 7(77), 1115-1119.

[16] Walsh, J., Climstein, M., Heazlewood, IT., DeBeliso, M., Adams, KJ., Burke, S., & Juttunen, J (2011). Obesity prevalence in World Masters Games basketball players. Medicina Sportiva. VII(4), 1700-1705.

[17] Walsh, J., Heazlewood, I.T., Climstein, M., Burke, S., Adams, K.J., DeBeliso, M., & Kettunen, J. (2011). Body mass index for Australian athletes participating in rugby union, soccer and touch football at the World Masters games. Journal of the World Academy of Science, Engineering and Technology. 7(77), 1119-1123.

[18] DeBeliso, M., Walsh, J., Adams, K.J., Climstein, M., Heazlewood, I.T., Burke, S., & Kettunen, J. (2012). Body mass index of North American participants at the World Masters Games. Medicine & Science in Sports & Exercise, 44(5), S143.

[19] Walsh, J., Climstein, M., Burke, S., Kettunen, J., Heazlewood, I.T., DeBeliso, M., & Adams, K. J. (2012). Obesity prevalence for athletes participating in soccer at the World Masters Games. International SportMed Journal, (13):2.

[20] Walsh, J., Climstein, M., Heazlewood, I.T., Kettunen, J., DeBeliso, M., & Adams, K. J. Body mass index for athletes participating in swimming at the World Masters Games. Journal of Sports Medicine and Physical Fitness. (In Press).

[21] DeBeliso, M., Walsh, J., Adams, K.J., Climstein, M., Heazlewood, I.T., Sevene, T., & Kettunen, J. (2012). World Masters Games North American body mass index profile. Journal of Science and Medicine in Sport, 15(6), S320.

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