

## Relationship between physical fitness and body mass index in military training in Republic of China --- a pilot study

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**Abstract: Purpose:** To demonstrate the relationship between weight mass index (BMI) and the physical fitness in ROC Army. **Methods:** 100 young male soldiers with mean age ( $20.5 \pm 0.8$  years old) were enrolled in this experiment. We checked their height and body weight and further transferred to the BMI of everybody. The, all the participants were asked to performed series of physical performance such as 2-min sit-up, 2- min push-up and 3000 meter run. We recorded the scores which were classified into 2 groups (BMI > 25 and BMI < 25 ). We compared the scores during the 2 groups with the standard score of the man aged 20 years. **Results:** There are 50 soldiers with normal body composition (BMI <25) and 50 military members with over-weight or obsess enrolled in this experiment. The lean soldiers (BMI < 25) had mean 68 sit-up in 2 minutes, 62 sit-up in 2 minutes and 12.5 minutes in 3000 m run. On the other hand, the soldiers with over-weight and obsess (BMI > 25) had mean 32 2-min push-up, 22 2-min sit-up and complete the 3000 m within average 21.5 min. When compared with the standard score, all the results showed significant findings. **Conclusion:** Soldiers must maintain high level of physical fitness to endurance demanding tasks, harsh deployment environments and military occupational specialty requirement. In our study, the fact that soldiers with obese and overweight (BMI > 25) had poor physical fitness. Hence body weight control and regular exercise was essential for the soldiers.

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### Introduction

Today, more and more soldiers are necessary for military operation, where environmental and physiologic condition may differ remarkable from the normal condition. Therefore, they may suffer from various stresses [ 1 ] .

Physical performance and personal physique in combat and military asserts has been of great importance for all the countries in the words. The military training programs in every county varies. For example, the physical fitness, height, and body-fat standards are enforced through military regulations under the Army Weight Control Program (Army Regulation 600-9). In the Republic of China Army, physical fitness is routinely measured through completion of the Army Physical Fitness Test (APFT). All the soldiers and even military pilots are required to take the APFT once a year. The tests consist of 3 events: 3000 meter long run, pull-up (in 2 min) and sit-up test (in 2 min). If the scores do not reach the standard level, it sometime may impact the promotion in their carrier. Therefore, everyone arrange the associated training programs every day by themselves for the purpose of improving muscle strength and

cardiorespiratory function. For example, the fighter pilots in ROC performed the weight training under the instruction from the flying surgeon and enhanced their G tolerance during military duties.

The APFT is the current method by which the Army measures the physical performance capabilities and general health and welling-being of service membrane [ 2 ] . As for the US Army, the APFT is a scored test and consists of three evaluated categories: the push-up, the sit-up, and the 2 mile-run. Each event is score of 0 to 100 for a total possible score of 300. To receive a passing evaluation, a soldier must complete each item with a minimum of 60 point. Depend on the age and sex of a soldier, there are normalized standards [ 3 ] . For example, a passing of 60 scores in each category for a 17- to 21-year old male would include 42 push-ups in 2 min, 53 sit-up in 2 min, and 2-mile 15 min 54 sec (with the required number of push-up and sit-up decreasing with age and in female, although allowable run time increase). Moreover, some conditions indeed may affect the performance during testing. For example, soldiers with open dorsal wrist ganglion excision s/p operation may suffer from painful sensation and followed by

local tenderness. In general, military service members are required to perform physical fitness testing twice annually in most of the countries in the world. In ROC (Taiwan), the testing standard is similar to the US Army. Therefore, Steed et al. thought that APFT is an accurate measurement of soldiers' health and physical performance. Moreover, comparison between soldiers' APFT score and their body composition (fat mass vs. fat-free mass) is one method of determining whether the APFT is a good measurement of physical health [1]. Hunt et al. also considered that the physical demand of military training is high and it is important that soldiers may possess the necessary physical capabilities to reduce their risks of injuries and promote their chance in war or military duties [4].

All of these tasks are physical and a certain level of physical fitness and a certain level of physical fitness is required to adequately perform each task. The excellent aerobic capacity is essential for various exercises [5]. For instance, 2 min push-ups and sit-ups belong to the muscular fitness, however, 3000 meters run is to test the metabolic fitness. Good physical fitness of the soldiers may endure the stress from different military activity which the lack of muscular strength and hypoxia during various condition. Military members are required to take regular rigorous physical trainings including endurance and resistance to maintain their outstanding fitness. Hence, how to reinforce the muscular strength, respiratory system and cardiovascular function is the main purpose of physical fitness [7].

Body mass index (BMI) is a ratio of height and weight (weight in kilograms divided by height in meter square). It is an index used to predict cardio-metabolic risk. Although BMI does not measure body fat, it is strongly predictive of percent body fat among obese individuals. Among lean individuals, BMI's association with percent body fat can be imprecise (e.g.: muscular individuals with a high BMI but low adiposity vs individual with a normal BMI but increased adipose). On the basis of the MBI, individuals are placed in weight class categories (underweight < 18.5, normal 18.5 – 24.9, overweight 25 – 29.9 and obese > 30) [1,6]. In ROC Army, the soldier with the BMI > 30 does not necessarily be required to test because light or heavy depending on the levels of danger and associated risks.

In these studies, we will compare the relationship between BMI and the physical fitness. Furthermore, we will discover the scores of APFT in different BMI.

### Material and methods

There are 100 healthy male soldiers enrolled in this experiment and their ages are from 18 to 22 years

old. The subjects with any major traumatic and systemic disease such as hypertension, or DM history are rule out. In addition, the solders having major surgery on four extremities were also excluded.

At first, participants were required to undergo 2 indoor resistant exercise including 2-min push-up and 2-min sit-up and one outdoor endurance 3000-m non-bearing running exercise test in 2015. Both 2-min push up and 2-min sit-up measurement were recorded. The procedure of 2-min push-up was scored only when the participant' body upward movement achieving the initial resting set height levels of shoulder s shoulder and buttock simultaneous detected by infrared sensors. The test would be early aborted once either elbows or knees touched down on the ground before time out. Moreover, the program of 2-min sit-up was scored only if participants' body bended forward and elbows blew forward the touch sensors on both thighs. With regard to 3000-m non weight-bearing running exercise, whole course was checked by the trainers as well. All 3000-m non weight-bearing running exercise were only allowed to be held at 16:00 pm when the risk coefficient of heat stroke, the product of outdoor temperature (C) and relatively humidity (%) X 0.1, was less than 40 or it was not raining [8]. Individuals who run slower may be reflection of poor physical conditioning or undiagnosed pre-existing injuries. Similarly, push-up and sit-up performance would correlate to overall stamina and core muscle conditioning before military service [15].

The data (e.g. MBI) are corrected from Kaohsiung Armed Forced General Hospital and the subjected performed APFT at training field, ROC Military Academy. The subjects spent a longer time completing the 3000-m run and had few numbers of 2-min sit-up or 2-min push-up, reflecting their cardiorespiratory fitness and strength of lower extremities and psoas muscles being lower than those of the unaffected men. We checked the height and body weight of all the soldiers. Body weight index was calculated as weight in kilograms divided by height in meters squared (Kg/m<sup>2</sup>) [9]. The BMI of peoples greater than 25 revealed overweight which showed the men would own poor physical fitness. Furthermore, cardiorespiratory fitness and body muscles are also inversely associated with metabolic syndrome prevalence [10,11]. Therefore, we compared the results of physical performance (3 items) greater than and less than 25 (The cut line is BMI=25) (BMI > 25 presents the soldier with over-weight or obsess). In all experimental protocols were conducted in accordance with the Declaration of Helsinki. Ethical approval for this study was obtained from the institution review board of our hospitals (Kaohsiung

Armed Forced General Hospital, Kaohsiung City, Taiwan, ROC). Informed consent was obtained from each subject. The results are expressed as the mean  $\pm$  standard deviation. Statically analysis was performed using SPSS software (SPSS 12.0; SPSS Inc, Chicago). A paired t-test was applied to analyze the results. The *P* value less than 0.05 was accepted as significant.

### Results

There are 50 soldiers with normal body composition (BMI <25) and 50 military members with over-weight or obese enrolled in this experiment. The mean age is  $20.5 \pm 0.8$  years old.

The relatively normal body composition soldiers (BMI < 25) had mean 68 sit-up in 2 minutes, 62 sit-up in 2 minutes and 12.5 minutes in 3000 m run. On the other hand, the soldiers with over-weight and obese (BMI > 25) had mean 32 2-min push-up, 22 2-min sit-up and complete the 3000 m within average 21.5 min. When compared with the standard score of the soldier aged 20 years, all the results showed significant findings from APFT (Table 1).

### Discussion

The career of soldiers in military organizations is characterized by an initial course during which they are called recruit recruits and pass through a period of military adaption, later being called soldiers. The recruits are prepared for a military career, ensuring the safety of military organization and society. Within this cortex, they must be physically fit to be able to perform the mission imposed [ 13 ]. Physical fitness is essential for soldiers because they may carry heavy external loads, such as body armor or equipment belts and weapons, can impair balance, hasten muscular fatigue, alter gait pattern, and affect postural alignment [32]. The physical fitness of individual soldiers is a critical element in military operation. Military historians have repeatedly emphasized the importance of a high level of physical capability for the occupational tasks that soldiers are required to perform. The current APFT consisting of the isometric push-up (muscular endurance), the sit-up exercise (muscular endurance) and 2 miles run (cardiovascular or metabolic function) measurement was introduced in 1980 and alternative tests for those with physical limitation in 1982. In ROC (Taiwan), we introduced the operation systems and modified some standards. The scores depend on different age and gender, therefore, the results of “qualification” also varied. For example, a soldier aged 20 years in ROC Army considered as “pass the examinations” should reach the below condition. The scores of sit-ups are around 42/2 min and 50 push-ups within 2 minutes at least. Besides, the soldier should complete 3000 meters within 14 minutes. Because of the close relationship

between physical fitness and regular time training, different countries own their various training programs and passing standards, for example USA, Brazil, Finland, Australia, South of Korea, Canada, NATO, Japan, Peoples’ Republic of China, Netherlands, India, Puerto Rico, Czech Republic, Italy, Turkey, Spain, France, Greece, United Kingdom, Germany [ 1,18,20,27, 28,31,34,35,43,54,55,59,60,66,68 ] .

Military physical fitness provides physical foundation necessary for successful physical activity engagement and makes the “stronger soldier” as possible in war and various military duties. It may also result in perfect and excellent military tasks even under difficult surroundings [ 12 ]. In regular time, the common peoples may also make use of the physical fitness. Oetega et al. reported that health-related physical fitness is a key indicator of health outcome [ 13 ] . Improvements in muscular strength and endurance and flexibility have a positive effect on skeletal health. Furthermore, it may provide physical for enjoyable physical activity in children and adolescent. A health level of cardiorespiratory endurance is positively associated with a health cardiovascular profile[ 14 ]. Therefore, the LTC Evans et al. in US Army Research Institute of Environmental Medicine demonstrated that military service members perform a wide variety of tasks that require a high level of fitness. To ensure that military members are adequately fit to train for these tasks, each branch of service conducts physical fitness testing on a regular basis. The fitness tests differ for each branch of service and test the cardiovascular fitness and muscular endurance of service members [ 16 ] .

3000 meters long distance run is an aerobic test. The advantage is due to ease of administration, low operation costs and the possibility of a large number of people being evaluate at the same time. The 3000 m long distance run assessment has been to correlate with measures of VO<sub>2</sub>max and cardiorespiratory endurance[ 61,62,63 ]. We observed faster 3000 m run times in a group of military membranes performing a lower extremities preventive training program warm-up as compared to a control group who performed the standard Army warm-up. A few other studies have also shown improvements in general cardiorespiratory endurance after a preventive training program [ 64,65 ] . It is ever reported that the relation between BMI and aerobic fitness was close [ 67,68 ] . Therefore, the soldier with lower BMI should have good physical fitness. It is ever found that cardiorespiratory fitness and lower extremities muscle strength were mainly evaluated by the 3000m time. Abdominal and psoas muscles strength was evaluated by the 2-min sit-up number. Upper extremity muscle

strength was evaluated by the 2-min push-up members.

The push-up fitness is a popular exercise among young athletes and the general population which is a reliable measure of one aspect of trunk strength. Besides, push-up assessment is an important component of military fitness which belongs to the muscle power test. Seitz et al. revealed that muscle power is considered to be one of the main determinants for many explosive [ 29 ]. Kaneko et al. found that during single joint movements, peak power was reported to be achieved at approximately 30% of maximal isometric strength or at 35% of one repetition maximum [ 30 ]. It is difficult to measure the “down” position. Hence, we could gain the correct data by sensors. The advantages of push-up measurements are its simplicity; no equipment or cost is involved, and it can be used for many different purposes. Shoulder, back and upper arm strengthening are among the main purposes of this exercise. In addition, it also trains neuromuscular coordination [ 22 ]. Many studies were concerned with the advantages of muscle activation during push-ups and improvisations to strength specific muscle around the shoulder with minor modification.

The sit-up exercise is to test the muscular flexibility, however, the push-ups is to measure the muscular endurance. In Japan, sit-ups are commonly incorporated in home-based exercise routine for improving muscular strength and mass of the abdominal and hip flexor muscle [ 56 ]. In general, it would be associated with the magnitude of muscularity of the abdominal and hip flexor muscles. Escamilla et al. also found that performing the sit-up may produce high levels of activation of the upper and lower rectus abdominis as well as the external oblique muscle [ 57 ]. Now, the sit-up test has been widely described as a test of abdominal muscle strength and endurance. A study investigation the relationship between sit-up performance and isokinetic abdominal muscle strength reported that there were weak correlations between sit-up physical fitness and absolute and relative abdominal peak torques in young adults [ 58 ]. Hence, excellent sit-up performance during APFT is good physical fitness in soldiers. The advantage of sit-up is that it belongs to a home-base exercise. Everyone may perform regular training daily at home without any equipment.

According to the CDC, BMI is a fairly reliable indicator of body fatness for most. Therefore, soldiers with higher BMIs will most likely have larger amounts of excessive of body fat [ 44 ]. MBI was calculated from the accession height and weight which is an index used to predict cardio-metabolic risk. Body composition is measured in athletes

because physical performance often increases as muscles and body fat decreases. Most of the people with higher BMI mean that they look “fat”. Although BMI does not measure body fat, it is strongly predictive of percent body fat among obese individuals. It is highly likely that overweight and obese adolescent suffer from obesity and other related illness such as diabetes, heart disease, high blood pressure, etc during their adulthood [ 39 ]. Obesity has become a public problem even in countries that have encouraging public and private initiatives to fight against such as taxing food and drinks high in fat and/or sugar. On the other hand, obesity is a complex disease linked to several genetic physiological and socioeconomic factors [ 40 ]. Physical active people present a lower body fat percentage, decreased risk of cardiovascular diseases, and better academic performance [ 41 ]. A elevated fat mass negatively influences athletic performances that involve movement or projection of the body, such as running, jumping and vaulting [ 42 ]. Besides, Reynolds and his coworkers demonstrated that during APFT, high risk of injury was associated with a BMI of 25 or more [ 46 ].

In our studies, we found that the military physical performance from the normal MBI. Therefore, many studies have investigated strategies for the treatment and prevention of excessive weight gain that involved decreased and physical activity and exercise [ 47,48 ]. Furthermore, poor physical fitness is associated with a higher prevalence of chronic diseases such as coronary artery disease and metabolic syndrome, even resulting in higher overall mortality rates. Hence, excessive weight is a major risk factor for poor fitness, chronic diseases and death [ 49,50 ]. Wei et al. reported that compared to normal-weight individuals, obese people generally have lower levels of physical fitness [ 51 ]. Our results are similar to So’s studies. They emphasized that soldiers with good BMI may comprises health-related physical fitness and motor-related physical fitness including excellent cardiovascular endurance, muscular endurance, muscular strength and flexibility, power, agility and balance [ 52 ]. Therefore, the ones with normal BMI may get higher physical performance in push-up, sit-up and 3000 m run.

Although the APFT was originally intended to ensure that soldiers possessed a basic level of fitness, excessive repetition of sit-ups and high-volume running, in attempt to the test, may contribute to the large number of overuse injuries after APFT. The incidence of overuse injuries was reported to be 75% and the majority of injuries occurring in the low back and lower body [ 16 ]. Hence, three tests sometime may induce the associated injuries and adverse

outcome. The major problems are heat stroke and stress fracture while 3000 meters run. Besides, some rare complications are reported. For example, push-ups may result in thrombosis of the subcalvian vein in young women (deep venous thrombosis of upper extremities), bilateral brachial rhabdomyolysis, stress fracture of the metacarpal bone, neck pain, back pain and palm and wrist pain [ 19,23,24,25,33 ] . During performance of the push-up exercise, vertebral joint stiffness occurred [ 20 ] . Besides, sit-ups event has been association with acute injury, specifically to the back and neck [ 36 ] . Evans et al. observed that a greater number of all injuries related to the sit-up event than to the push-up and long distance run events. Smith et al. showed that musculoskeletal injuries are leading cause of hospitalization [ 45 ] . Therefore, we must pay attention to the exercises during and after APFT. Moreover, continuous training is better than interval training. Soldiers with a previous injury or lower fitness level might be at elevated risk for injury during APFT.

#### Conclusion:

Soldiers must maintain high level of physical fitness to endurance demanding tasks, harsh deployment environments and military occupational specialty requirement. In our study, the fact that soldiers with obese and overweight (BMI > 25) had poor physical fitness. Hence body weight control and regular exercise was essential for the soldiers who must perform vigorous military duties in war.

In the future, will the raider system will be implemented in the ROC Army. We will develop knowledge, skills, physical, and psychological attributes common in all soldering duties. Moreover, we will emphasize that the importance of lower BMI and good fitness which may be used to screen the excellent military members for difficult military duties.

Table 1: The results of 3 various physical fitness tests

BMI	< 25	>25	P value
2-min sit-up	68	32	< 0.05
2-min push-up	62	22	< 0.05
3000 m Run	12.5 min	21.5 min	< 0.05

All the results compared with the standards of PAFT when the soldier is 20 years old. When *P* value < 0.05, the data showed significantly.

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